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Rendez-vous of Hands and Mind
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CAMPT Canadian Academy of
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Since its founding in Montreal, Canada in 1974, the International Federation of Orthopaedic Manipulative Physical Therapists (IFOMPT) has been providing orthopaedic and manual therapists from around the world with the highest-quality learning opportunities through a conference held every 4 years. In 2012, IFOMPT is partnering with The International Private Practitioners Association (IPPA) to host this prestigious event in Québec City, Canada. As more than 51% of the Canadian Physiotherapy Association membership is working in private practice, this adds even greater value to this quadrennial event. This conference emulates best-evidence practice in the

marriage of research and clinical excellence by pulling together some of the best and brightest hands and minds in orthopaedic physiotherapy.

The call for papers and proposals for this year's programming embraced the mission of IFOMPT: promotion of clinical and academic standards for manual/musculoskeletal physiotherapists. Three streams were created: research, knowledge translation, and clinical excellence. First, the necessity of having a strong research base follows up on the recent past successes of meetings in Rotterdam, Cape Town, and Perth, with high-quality peer-reviewed research presentations expected by the IFOMPT membership. Second, there is increasing attention being paid to the transfer of research findings into clinical practice. Best-evidence practice, the mission of every accredited education institution in the world, requires that clinicians stay abreast of an ever-growing

mountain of journal publications to find the information that will inform their practice. Knowledge translation opportunities are why IFOMPT conferences are renowned. Finally, clinical excellence integrates the art and the science of physiotherapy by using the best evidence available and applying knowledge from many areas, such as anatomy, pathology, and physiology, that have been shaped by clinical experience. Also, clinical excellence can and should reinvigorate the research cycle by providing researchers with important clinical insight and clinically relevant questions. Through a call for proposals that equally emphasized research, clinical excellence, and the knowledge translation link between the two, the IFOMPT mandate of clinical and academic excellence has been kept at the forefront of this year's conference.

The keynote speakers in this year's conference were chosen to represent our 5 program tracks. First, the track of

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Neuroscience explores pain, motor control, and research that links neurophysiological effects to manual physiotherapy through analysis of neuroplasticity (how the brain learns/changes in response to input) and neurophysiology (how brain functions are affected by pathology and treatment). David Butler challenges us with how traditional manual physical therapists can continue to have relevance within a dynamic neural system in his talk, titled “Manual Therapy in a Neuroplastic World.” Peter O’Sullivan re-emphasizes motor control with a new twist to the stability of the spine paradigm by asking, Is it time to change how we manage back pain? Building on knowledge of pain and motor control as interventions to break the pain cycle are 2 of the most important contemporary areas of investigation in clinical neuroscience.

In the second track, Biomechanics and the Study of Movement, Shirley Sahrman discusses the biomechanical connection between the hip and the lumbar spine in her address, “The Hip as a Factor in Low Back Pain: Evidence Why Relative Flexibility Is Key.” Mechanical load and one’s ability to adapt to loading are key features in the development of injury and pathology. Dr Sahrman’s research and clinical experience in movement of the hip and the lumbar spine resonate with the clinician and represent her success as a knowledge translator. In addition, Annelies Pool continues to build on the Biomechanics track through her look at lumbopelvic pathology by breaking down posture, movement, and muscle adaptation to pain in her talk, “Adaptation in Patients With Lumbopelvic Pain, for Better or for Worse?”

The third theme, Manual Therapy and Exercise—Assessment and Diagnosis, focuses on the practice of orthopaedic manual physical therapy from patient interaction, clinical evaluation, and planning for interventions. Several keynote speakers address manual therapy and exercise in their talks. For example, in his talk, “Physiotherapists/Physical Therapists’ Role in Exercise Prescription and Exercise Is Medicine,” Karim Khan offers an in-depth look at the role of exercise in tendon pathology and the important role that exercise plays in rehabilitation.

Interventions and Outcome Measures, our fourth track, is highlighted by 2 world-renowned researchers. First, in her talk, “Management of Cervical Spine Disorders: Where to Now?” Gwen Jull makes suggestions about the potential future for the treatment of chronic neck pain. Second, Joy MacDermid, from McMaster University, the home of evidence-based practice, discusses outcome measures and knowledge translation by asking this question: Are we there yet? Moving evidence into physiotherapy practice. Joy’s work in knowledge translation and outcome measures research is enviable in both volume and quality, as represented by her

numerous publications in several leading scientific health-related journals.

Our fifth track is Global Issues. The scope of physiotherapy practice is changing rapidly. That change in Canada and in other areas of the world has been driven by the need to contain costs. This means providing the same or better quality of care for less money. When we look at the healthcare model, it is often more cost-effective to prevent injury and disease than to treat it once it has manifested. Gray Cook looks at injury prevention in his talk, “What Is Our Baseline for Movement? The Clinical Need for Movement Screening and Assessment.” Through the analysis of movement and follow-up, trends are beginning to develop that may help us identify people at risk for movement-related disorders, which may bring cost-effective movement screening into mainstream medicine. Furthermore, in the IPPA keynote address, Stuart Gowland discusses the future of professional education and collaboration in his talk, “Knowledge Transfer in the Age of Technology.”

In the planning for the conference, the integration of knowledge translation and clinical excellence was further enhanced through a call for proposals unique to IFOMPT. A venue for focused symposia and workshop presentations was created this year for IFOMPT 2012. Focused symposia are composed of 3 to 4 research papers, all focused on a particular clinical subject, that are tied together by a moderator and a roundtable discussion format. This allows for learning in an interactive environment with unique perspectives from experts in targeted subject areas. We were pleased to have 21 focused symposia submissions accepted, including topics such as vascular incidents following manual therapy in the cervical spine, obstructive sleep apnea, and tennis elbow. The workshops provide another venue for knowledge translation. This style of presentation actively engages participants using a range of formats that require more active audience interaction. We were pleased to have 23 workshops, ranging from interactive taping techniques to exploring the physio-wiki online. These learning formats, combined with over 140 podium presentations and over 160 posters, show that we have responded in a meaningful way to ongoing requests by IFOMPT conference attendees to integrate clinical excellence with a strong research-based program.

As physiotherapists move into primary care roles and expand their roles as consultants and leaders in disease prevention, the profession will only succeed if supported by a growing body of evidence to justify the necessity of our expanded roles. The *Rendez-Vous* of Hands and Minds of IFOMPT 2012 provides a venue for physiotherapists to continue to expand their contributions to patient care in health systems around the world.

Keynote Addresses

MANAGEMENT OF CERVICAL SPINE DISORDERS: WHERE TO NOW?

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Neck pain is prevalent in modern society and has a significant socioeconomic impact.^{10,35} Considerable heterogeneity exists in patient presentations, which is one explanation for the modest to moderate treatment effects for various interventions.²⁹ A challenge not unique to neck pain is coping with this heterogeneity toward improved, consistent, and predictable treatment outcomes. Subgrouping of similar patients via prescribed criteria is seen as one potential way. For low back pain, there are at least 5 physiotherapy classification systems,^{12,51,57,58,61} and research is progressing to evaluate whether definitive benefit is gained from subgrouping.⁴⁸ Headway for neck pain disorders is not as hearty. Two methods have been proposed, 1 with a movement-based focus and 1 where patient presentations are classified into 5 subgroups that reflect the primary goal of treatment.^{7,33} As subgrouping is topical within physiotherapy internationally and in its infancy for neck pain disorders, it is timely to reflect on whether a subgrouping system is feasible for cervical disorders.

In low back pain, subgrouping of patients has been largely based on identifying clusters of patients who present with specific patterns of movement, respond to repeated loading, or have some basic clinical features that lead clinicians to predict that they will respond similarly to an intervention. The contention is that subgrouping systems akin to those for low back pain are unlikely to be suitable for cervical disorders. Cervical disorders have unique features across biopsychosocial domains that stress the need to consider the individual patient in a clinically reasoned assessment approach. Exemplars are highlighted to stimulate thought about whether subgrouping for cervical spine disorders is manageable or is a futile objective.

SYMPTOMOLOGY

Pain is the most common concern of patients presenting for management of neck disorders. Identifying pain mechanisms is a vital aspect of any patient evaluation. Treatment approaches for pain that is primarily associated with peripheral nociception are quite distinct from those for neuropathic pain and/or when augmented pain processing in the central nervous system is present.^{6,31,37,68,71} In the presence of central

nervous system sensitization, any treatment must be applied painlessly to avoid further wind-up of the sensitized central nervous system. Furthermore, evidence suggests that physiotherapy care alone has marginal effects for such patients,⁴³ and management may be better in association with other medical pain management strategies. Consideration of pain mechanisms must be a first priority for subgrouping. Other moderators/mediators of pain must also be considered. For example, in the case of whiplash, the presence of substantive and nonabating symptoms of posttraumatic stress has been shown to moderate pain⁶⁹ and may require specific psychological care. For appropriate treatment directives, pain mechanisms must be a primary feature of a subgrouping system and, to direct management approaches, subgroups within pain subgroups based on other mechanistic variables need to be considered.

The neck may refer pain into the arm, as the back refers pain into the leg. The neck also refers pain into the head. Headache requires a different evaluation approach. Many patients with headache seek physiotherapy care, but the presence of neck pain with headache gives no indication that the headache is cervicogenic in origin or whether it is likely to be responsive to physiotherapy care. Between 60% and 80% of people with migraine and tension-type headaches report neck pain in association with headache.^{25,30,40} Headache after whiplash also provides no indication that the headache is cervicogenic in origin. Estimates of a true cervicogenic headache arising directly from a whiplash injury appear to number less than 20% at best.^{13,59} Attempts to subgroup patients with headache who present with associated neck pain on any physiotherapy-based scheme are flawed. There are quite different classification criteria, both symptomatic and physical, to subgroup/classify headaches.^{36,64} An inefficient double-classification/-subgrouping process is required for patients presenting with headache.

Although pain is the most common symptom, cervical disorders can present with an array of symptoms. Dizziness, light-headedness, unsteadiness, or visual disturbances are common. The cervical muscles have major proprioceptive functions with reflex connections between the neck, visual, and vestibular systems.^{5,9,34,63} Dizziness/light-headedness attributable to abnormal cervical afferent input can present in patients with acute and chronic whiplash disorders and cervicogenic headache, and as a primary symptom of cervical vertigo.^{46,60,81} As with headache, dizziness symptoms require a different approach to differential diagnosis, to determine

whether dizziness is of vestibular, cervical, or vascular origin, before there can be any thought of incorporating these symptoms into a neck pain subgrouping scheme. When symptoms are cervicogenic in origin, any or all of kinesthetic, balance, or ocular-motor disturbances may present. If subgrouping is to guide treatment, these may need sub-subclassification in their own right.

PHYSICAL FUNCTION

Motion restriction is pathognomic of cervical disorders,^{11,32,40,85} and responses to movement tests may aid in subgrouping neck disorders. Nevertheless, this is not the only consideration. Altered movement performance has been demonstrated particularly in whiplash, namely, reduced acceleration and velocity of neck movement, reduced smoothness, and irregular axes of neck movement.^{1,27,28,66,84} These appear to relate to altered proprioception,⁶⁵ as such pathological patterns seem not to be moderated by compensation, fear avoidance beliefs, or volition factors.^{1,27,28,66,84} Reduced velocity of neck movement is thought to have greater impact than range of movement on functional activities. The presence of variables in movement performance requires consideration to direct appropriate interventions in addition to directional responses to movement tests to avoid risk of another flaw in a subgrouping scheme.

Evaluation of the muscle system cannot be excluded from any group of a subgrouping system. Substantive research indicates that neck pain can be associated with widespread changes in neuromuscular function. Changes in the cervical muscle system are not tied to any 1 cervical disorder.^{4,8,18,38,40,42,54} Pain results in reorganization of motor control strategies, including spatial and temporal relationships between activity of a range of muscles. Altered spatial relationships have been demonstrated within both the cervical extensor and flexor groups.^{4,24,39,40,42,62} In relation to temporal behavior, the neck flexor muscles have delayed onset in response to perturbations induced by rapid arm flexion and extension.^{18,44} This has significance for activities of daily living when considering the strains induced on the cervical segments with upper-limb function.^{2,15,76,77} Changes occur in feedback mechanisms with disturbances in cervical kinesthetic sense, eye movement control, and balance, linked to symptoms of pain, dizziness, or unsteadiness.^{50,78-80}

Neck pain is associated with a lack of directional specificity of muscle activation,²¹ and increased coactivation of multiple muscles with pain and with functional activities.^{15,38,49} Likewise, the muscles display delayed offsets.¹⁵ Changes in the pattern of activation have also been measured in the axioscapular muscles,^{15,38,52,53,83} and this risks adverse loading on cervical structures. The neck muscles lose strength and endurance. Endurance is lost not only at maximum contractions but at lower contraction intensities,⁵⁶ which have greater relevance for daily functional activities. Electromyographic

measures display neck flexor, extensor, and axioscapular muscle (upper trapezius) fatigue in neck pain disorders.^{19,23,26}

On the weight of evidence, neuromuscular and sensorimotor evaluation cannot be discarded from any subgrouping scheme for neck pain disorders that intends to direct intervention selection. Yet, not all impairments present in every patient, and within an impairment there is wide variability in the degree of dysfunction between patients.^{14,22} A battery of explicit tests is required to reveal the presence, nature, and degree of neuromuscular and sensorimotor impairments in each patient to direct patient-specific rehabilitative exercise programs. That is, rather than a simplified subgrouping approach, it is contended that treatment is likely to be better individualized on the basis of a sound clinical reasoning approach. This is necessary because evidence indicates that particular impairments are best addressed by particular exercise techniques.^{16,17,20,41,44,55} Making assumptions of the presence of neuromuscular and sensorimotor and arbitrary decisions about treatment is not best practice, especially considering the evidence that muscle function in patients with neck disorders does not recover automatically with pain relief.⁷² Its persistence between episodes of pain may underpin the propensity for neck pain to recur.

Other features can influence a subgrouping scheme. As examples, working postures may be a major driver of symptoms and can be improved by a motor relearning program,²⁰ an important feature from a societal perspective, where the cost of neck pain in the work environment often relates to loss of work productivity because of presenteeism (continuing to work with pain but with reduced efficacy).⁷⁴ The nervous system and the presence of nerve tissue mechanosensitivity must be considered in any subgrouping system to direct treatment. Neural tissue mechanosensitivity should have primacy in treatment decisions when it is a feature of a patient's neck pain presentation.³¹ How and when should patients be subgrouped in relation to psychological responses to neck pain disorders^{3,47,75} to guide specific interventions? Many responses resolve or lessen as pain decreases or is alleviated.^{67,73,82} For subgrouping, should attention focus on responses that signal a potential psychopathology requiring specific treatment, as in the case of highly elevated scores for symptoms of posttraumatic stress following a whiplash injury?⁷⁰ Timing of assessment and formal intervention are important.⁴⁵ Subgrouping would need to be time flexible.

This brief reflection on the potential scope of dysfunctions across biopsychosocial domains for the heterogeneous group of patients with neck pain disorders has aimed to stimulate thought about the challenges that need to be faced if a subgrouping system is seen as the preferred option to direct treatment and improve patient outcomes. Such a subgrouping system must be able to withstand critical scrutiny and comprehensively incorporate and cope with the presence and magnitude of contributing dysfunctions in all systems across

all domains, as well as their interrelationships and disparities. Subgrouping to a small number of narrowly defined clusters of patients may not be the best option to direct treatment. First, a prohibitive and unmanageable number of subgroups are likely to be required to cope with all factors. Second, knowledge is incomplete regarding the interrelationships between different features across different domains (drivers, moderators, mediators) to fulfill a subgrouping aim of provision of definitive treatment directions. Third, although dysfunctions have been documented across biopsychosocial domains, research is still progressing to evaluate both their prognostic significance and, indeed, whether their treatment has any effect on the course of the neck pain disorder. Thus, to mandate a certain subgroup-directed treatment approach is perhaps too inflexible at this time.

It is reasoned that in the short to medium future, at least, the best way to cope with neck pain patient heterogeneity in clinical practice is to continue a clinically reasoned assessment of the individual patient. Such an assessment can inform options for patient-specific management based on current knowledge of possible impairments/reactions. Patient heterogeneity could be dealt with using an algorithmic approach, which systematically acknowledges and embraces all features across biopsychosocial domains and includes or dismisses their presence toward informing treatment for the individual patient. The clinical reasoning approach is flexible. It can embrace current knowledge and be responsive. It can incorporate new knowledge of mechanisms and system responses to neck pain, prognostic indicators for treatment outcomes, or the course of the disorder, which will further mold assessment and management to enhance patient outcomes.

CONCLUSION

Neck pain is a substantive burden on society and is characterized by its heterogeneity. Sequelae of neck pain of either idiopathic or traumatic origin are being increasingly understood across biopsychosocial domains. It has been argued that physiotherapy outcomes can be improved and can become more consistent if the impairments of individual patients across domains are fully revealed through a clinically reasoned comprehensive examination, and management programs are individualized for the patient.

REFERENCES

1. Baydal-Bertomeu JM, Page AF, Belda-Lois JM, Garrido-Jaén D, Prat JM. Neck motion patterns in whiplash-associated disorders: quantifying variability and spontaneity of movement. *Clin Biomech (Bristol, Avon)*. 2011;26:29-34. <http://dx.doi.org/10.1016/j.clinbiomech.2010.08.008>
2. Behrsin J, Maguire K. Levator scapulae action during shoulder movement: a possible mechanism for shoulder pain of cervical origin. *Aust J Physiother*. 1986;32:101-106.
3. Buitenhuis J, de Jong PJ. Fear avoidance and illness beliefs in post-trau-

- matic neck pain. *Spine (Phila Pa 1976)*. 2011;36:S238-S243. <http://dx.doi.org/10.1097/BRS.0b013e3182388400>
4. Cagnie B, Dolphens M, Peeters I, Achten E, Cambier D, Danneels L. Use of muscle functional magnetic resonance imaging to compare cervical flexor activity between patients with whiplash-associated disorders and people who are healthy. *Phys Ther*. 2010;90:1157-1164. <http://dx.doi.org/10.2522/ptj.20090351>
5. Chan YS, Kasper J, Wilson VJ. Dynamics and directional sensitivity of neck muscle spindle responses to head rotation. *J Neurophysiol*. 1987;57:1716-1729.
6. Chien A, Eliav E, Sterling M. Whiplash (grade II) and cervical radiculopathy share a similar sensory presentation: an investigation using quantitative sensory testing. *Clin J Pain*. 2008;24:595-603. <http://dx.doi.org/10.1097/AJP.0b013e31816ed4fc>
7. Childs JD, Fritz JM, Piva SR, Whitman JM. Proposal of a classification system for patients with neck pain. *J Orthop Sports Phys Ther*. 2004;34:686-700. <http://dx.doi.org/10.2519/jospt.2004.1451>
8. Chiu TT, Law EY, Chiu TH. Performance of the craniocervical flexion test in subjects with and without chronic neck pain. *J Orthop Sports Phys Ther*. 2005;35:567-571. <http://dx.doi.org/10.2519/jospt.2005.2055>
9. Corneil BD, Olivier E, Munoz DP. Neck muscle responses to stimulation of monkey superior colliculus. I. Topography and manipulation of stimulation parameters. *J Neurophysiol*. 2002;88:1980-1999.
10. Côté P, Kristman V, Vidmar M, et al. The prevalence and incidence of work absenteeism involving neck pain: a cohort of Ontario lost-time claimants. *Spine (Phila Pa 1976)*. 2008;33:S192-S198. <http://dx.doi.org/10.1097/BRS.0b013e3181644616>
11. Dall'Alba PT, Sterling MM, Treleaven JM, Edwards SL, Jull GA. Cervical range of motion discriminates between asymptomatic persons and those with whiplash. *Spine (Phila Pa 1976)*. 2001;26:2090-2094.
12. Delitto A, Erhard RE, Bowling RW. A treatment-based classification approach to low back syndrome: identifying and staging patients for conservative treatment. *Phys Ther*. 1995;75:470-485; discussion 485-489.
13. Drottning M, Staff PH, Sjaastad O. Cervicogenic headache (CEH) after whiplash injury. *Cephalalgia*. 2002;22:165-171.
14. Edmondston S, Björnsdóttir G, Pálsson T, Solgård H, Ussing K, Allison G. Endurance and fatigue characteristics of the neck flexor and extensor muscles during isometric tests in patients with postural neck pain. *Man Ther*. 2011;16:332-338. <http://dx.doi.org/10.1016/j.math.2010.12.005>
15. Falla D, Bilenkij G, Jull G. Patients with chronic neck pain demonstrate altered patterns of muscle activation during performance of a functional upper limb task. *Spine (Phila Pa 1976)*. 2004;29:1436-1440.
16. Falla D, Jull G, Hodges P. Training the cervical muscles with prescribed motor tasks does not change muscle activation during a functional activity. *Man Ther*. 2008;13:507-512. <http://dx.doi.org/10.1016/j.math.2007.07.001>
17. Falla D, Jull G, Hodges P, Vicenzino B. An endurance-strength training regime is effective in reducing myoelectric manifestations of cervical flexor muscle fatigue in females with chronic neck pain. *Clin Neurophysiol*. 2006;117:828-837. <http://dx.doi.org/10.1016/j.clinph.2005.12.025>
18. Falla D, Jull G, Hodges PW. Feedforward activity of the cervical flexor muscles during voluntary arm movements is delayed in chronic neck pain. *Exp Brain Res*. 2004;157:43-48. <http://dx.doi.org/10.1007/s00221-003-1814-9>
19. Falla D, Jull G, Rainoldi A, Merletti R. Neck flexor muscle fatigue is side specific in patients with unilateral neck pain. *Eur J Pain*. 2004;8:71-77. [http://dx.doi.org/10.1016/S1090-3801\(03\)00075-2](http://dx.doi.org/10.1016/S1090-3801(03)00075-2)
20. Falla D, Jull G, Russell T, Vicenzino B, Hodges P. Effect of neck exercise on sitting posture in patients with chronic neck pain. *Phys Ther*. 2007;87:408-417. <http://dx.doi.org/10.2522/ptj.20060009>
21. Falla D, Lindstrøm R, Rechter L, Farina D. Effect of pain on the modulation in discharge rate of sternocleidomastoid motor units with force direction. *Clin Neurophysiol*. 2010;121:744-753. <http://dx.doi.org/10.1016/j.clinph.2009.12.029>
22. Falla D, O'Leary S, Farina D, Jull G. The change in deep cervical flexor activity after training is associated with the degree of pain reduction in patients with chronic neck pain. *Clin J Pain*. 2012;28:628-634. <http://dx.doi.org/10.1097/BRS.0b013e3181644616>

- org/10.1097/AJP0b013e31823e9378
23. Falla D, Rainoldi A, Merletti R, Jull G. Myoelectric manifestations of sternocleidomastoid and anterior scalene muscle fatigue in chronic neck pain patients. *Clin Neurophysiol*. 2003;114:488-495.
 24. Falla DL, Jull GA, Hodges PW. Patients with neck pain demonstrate reduced electromyographic activity of the deep cervical flexor muscles during performance of the craniocervical flexion test. *Spine (Phila Pa 1976)*. 2004;29:2108-2114.
 25. Fishbain DA, Cutler R, Cole B, Rosomoff HL, Rosomoff RS. International Headache Society headache diagnostic patterns in pain facility patients. *Clin J Pain*. 2001;17:78-93.
 26. Gogia PP, Sabbahi MA. Electromyographic analysis of neck muscle fatigue in patients with osteoarthritis of the cervical spine. *Spine (Phila Pa 1976)*. 1994;19:502-506.
 27. Grip H, Sundelin G, Gerdle B, Karlsson JS. Cervical helical axis characteristics and its center of rotation during active head and upper arm movements—comparisons of whiplash-associated disorders, non-specific neck pain and asymptomatic individuals. *J Biomech*. 2008;41:2799-2805. <http://dx.doi.org/10.1016/j.jbiomech.2008.07.005>
 28. Grip H, Sundelin G, Gerdle B, Karlsson JS. Variations in the axis of motion during head repositioning – a comparison of subjects with whiplash-associated disorders or non-specific neck pain and healthy controls. *Clin Biomech (Bristol, Avon)*. 2007;22:865-873. <http://dx.doi.org/10.1016/j.clinbiomech.2007.05.008>
 29. Gross AR, Goldsmith C, Hoving JL, et al. Conservative management of mechanical neck disorders: a systematic review. *J Rheumatol*. 2007;34:1083-1102.
 30. Hagen K, Einarsen C, Zwart JA, Svebak S, Bovim G. The co-occurrence of headache and musculoskeletal symptoms amongst 51 050 adults in Norway. *Eur J Neurol*. 2002;9:527-533.
 31. Hall T, Briffa K, Hopper D. Clinical evaluation of cervicogenic headache: a clinical perspective. *J Man Manip Ther*. 2008;16:73-80.
 32. Hall TM, Robinson KW, Fujinawa O, Akasaka K, Pyne EA. Intertester reliability and diagnostic validity of the cervical flexion-rotation test. *J Manipulative Physiol Ther*. 2008;31:293-300. <http://dx.doi.org/10.1016/j.jmpt.2008.03.012>
 33. Hefford C. McKenzie classification of mechanical spinal pain: profile of syndromes and directions of preference. *Man Ther*. 2008;13:75-81. <http://dx.doi.org/10.1016/j.math.2006.08.005>
 34. Hirai N, Hongo T, Sasaki S, Yamashita M, Yoshida K. Neck muscle afferent input to spinocerebellar tract cells of the central cervical nucleus in the cat. *Exp Brain Res*. 1984;55:286-300.
 35. Hogg-Johnson S, van der Velde G, Carroll LJ, et al. The burden and determinants of neck pain in the general population: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976)*. 2008;33:S39-S51. <http://dx.doi.org/10.1097/BRS.0b013e31816454c8>
 36. The International Classification of Headache Disorders: 2nd edition. *Cephalalgia*. 2004;24 suppl 1:9-160.
 37. Johnston V, Jimmieson NL, Jull G, Souvlis T. Quantitative sensory measures distinguish office workers with varying levels of neck pain and disability. *Pain*. 2008;137:257-265. <http://dx.doi.org/10.1016/j.pain.2007.08.037>
 38. Johnston V, Jull G, Darnell R, Jimmieson NL, Souvlis T. Alterations in cervical muscle activity in functional and stressful tasks in female office workers with neck pain. *Eur J Appl Physiol*. 2008;103:253-264. <http://dx.doi.org/10.1007/s00421-008-0696-8>
 39. Johnston V, Jull G, Souvlis T, Jimmieson NL. Neck movement and muscle activity characteristics in female office workers with neck pain. *Spine (Phila Pa 1976)*. 2008;33:555-563. <http://dx.doi.org/10.1097/BRS.0b013e3181657d0d>
 40. Jull G, Amiri M, Bullock-Saxton J, Darnell R, Lander C. Cervical musculoskeletal impairment in frequent intermittent headache. Part I: subjects with single headaches. *Cephalalgia*. 2007;27:793-802. <http://dx.doi.org/10.1111/j.1468-2982.2007.01345.x>
 41. Jull G, Falla D, Treleaven J, Hodges P, Vicenzino B. Retraining cervical joint position sense: the effect of two exercise regimens. *J Orthop Res*. 2007;25:404-412. <http://dx.doi.org/10.1002/jor.20220>
 42. Jull G, Kristjansson E, Dall'Alba P. Impairment in the cervical flexors: a comparison of whiplash and insidious onset neck pain patients. *Man Ther*. 2004;9:89-94. [http://dx.doi.org/10.1016/S1356-689X\(03\)00086-9](http://dx.doi.org/10.1016/S1356-689X(03)00086-9)
 43. Jull G, Sterling M, Kenardy J, Beller E. Does the presence of sensory hypersensitivity influence outcomes of physical rehabilitation for chronic whiplash? – A preliminary RCT. *Pain*. 2007;129:28-34. <http://dx.doi.org/10.1016/j.pain.2006.09.030>
 44. Jull GA, Falla D, Vicenzino B, Hodges PW. The effect of therapeutic exercise on activation of the deep cervical flexor muscles in people with chronic neck pain. *Man Ther*. 2009;14:696-701. <http://dx.doi.org/10.1016/j.math.2009.05.004>
 45. Jull GA, Söderlund A, Stemper BD, et al. Toward optimal early management after whiplash injury to lessen the rate of transition to chronicity: discussion paper 5. *Spine (Phila Pa 1976)*. 2011;36:S335-S342. <http://dx.doi.org/10.1097/BRS.0b013e3182388449>
 46. Jull GA, Stanton WR. Predictors of responsiveness to physiotherapy management of cervicogenic headache. *Cephalalgia*. 2005;25:101-108. <http://dx.doi.org/10.1111/j.1468-2982.2004.00811.x>
 47. Kenardy J, Dunne R. Traumatic injury and traumatic stress. *Spine (Phila Pa 1976)*. 2011;36:S233-S237. <http://dx.doi.org/10.1097/BRS.0b013e3182387fcd>
 48. Kent P, Mjøsund HL, Petersen DH. Does targeting manual therapy and/or exercise improve patient outcomes in nonspecific low back pain? A systematic review. *BMC Med*. 2010;8:22. <http://dx.doi.org/10.1186/1741-7015-8-22>
 49. Lindström R, Schomacher J, Farina D, Rechter L, Falla D. Association between neck muscle coactivation, pain, and strength in women with neck pain. *Man Ther*. 2011;16:80-86. <http://dx.doi.org/10.1016/j.math.2010.07.006>
 50. Madeleine P, Nielsen M, Arendt-Nielsen L. Characterization of postural control deficit in whiplash patients by means of linear and nonlinear analyses – a pilot study. *J Electromyogr Kinesiol*. 2011;21:291-297. <http://dx.doi.org/10.1016/j.jelekin.2010.05.006>
 51. McKenzie R, May S. *The Lumbar Spine: Mechanical Diagnosis and Therapy*. 2nd ed. Waikanae, New Zealand: Spinal Publications; 2003.
 52. Nederhand MJ, Hermens HJ, IJzerman MJ, Turk DC, Zilvold G. Cervical muscle dysfunction in chronic whiplash-associated disorder grade 2: the relevance of the trauma. *Spine (Phila Pa 1976)*. 2002;27:1056-1061.
 53. Nederhand MJ, IJzerman MJ, Hermens HJ, Batens CT, Zilvold G. Cervical muscle dysfunction in the chronic whiplash associated disorder grade II (WAD-II). *Spine (Phila Pa 1976)*. 2000;25:1938-1943.
 54. O'Leary S, Cagnie B, Reeve A, Jull G, Elliott JM. Is there altered activity of the extensor muscles in chronic mechanical neck pain? A functional magnetic resonance imaging study. *Arch Phys Med Rehabil*. 2011;92:929-934. <http://dx.doi.org/10.1016/j.apmr.2010.12.021>
 55. O'Leary S, Jull G, Kim M, Uthairkup S, Vicenzino B. Training mode-dependent changes in motor performance in neck pain. *Arch Phys Med Rehabil*. 2012;93:1225-1233. <http://dx.doi.org/10.1016/j.apmr.2012.02.018>
 56. O'Leary S, Jull G, Kim M, Vicenzino B. Cranio-cervical flexor muscle impairment at maximal, moderate, and low loads is a feature of neck pain. *Man Ther*. 2007;12:34-39. <http://dx.doi.org/10.1016/j.math.2006.02.010>
 57. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Man Ther*. 2005;10:242-255. <http://dx.doi.org/10.1016/j.math.2005.07.001>
 58. Petersen T, Laslett M, Thorsen H, Manniche C, Ekdhahl C, Jacobsen S. Diagnostic classification of non-specific low back pain. A new system integrating patho-anatomic and clinical categories. *Physiother Theory Pract*. 2003;19:213-237. <http://dx.doi.org/10.1080/09593980390246760>
 59. Radanov BP, Di Stefano G, Augustiny KF. Symptomatic approach to post-traumatic headache and its possible implications for treatment. *Eur Spine J*. 2001;10:403-407.
 60. Reid SA, Rivett DA, Katekar MG, Callister R. Sustained natural apophyseal glides (SNAGs) are an effective treatment for cervicogenic dizziness. *Man*

Ther. 2008;13:357-366. <http://dx.doi.org/10.1016/j.math.2007.03.006>

61. Sahrmann S. *Diagnosis and Treatment of Movement Impairment Syndromes*. St Louis, MO: Mosby; 2002.
62. Schomacher J, Petzke F, Falla D. Localised resistance selectively activates the semispinalis cervicis muscle in patients with neck pain. *Man Ther.* In press. <http://dx.doi.org/10.1016/j.math.2012.05.012>
63. Shinoda Y, Sugiuchi Y, Futami T, Ando N, Kawasaki T, Yagi J. Synaptic organization of the vestibulo-colic pathways from six semicircular canals to motoneurons of different neck muscles. *Prog Brain Res.* 1993;97:201-209.
64. Sjaastad O, Fredriksen TA, Pfaffenrath V. Cervicogenic headache: diagnostic criteria. The Cervicogenic Headache International Study Group. *Headache.* 1998;38:442-445.
65. Sjölander P, Johansson H, Djupsjöbacka M. Spinal and supraspinal effects of activity in ligament afferents. *J Electromyogr Kinesiol.* 2002;12:167-176.
66. Sjölander P, Michaelson P, Joric S, Djupsjöbacka M. Sensorimotor disturbances in chronic neck pain—range of motion, peak velocity, smoothness of movement, and repositioning acuity. *Man Ther.* 2008;13:122-131. <http://dx.doi.org/10.1016/j.math.2006.10.002>
67. Smith AD, Sterling M, Jull G, Schneider G, Frizzell B, Hooper RA. Reducing peripheral nociception in individuals with chronic whiplash symptoms, following successful cervical radiofrequency neurotomy, results in immediate improvements in all physical and some psychological impairments. *International Association for the Study of Pain 14th World Congress on Pain*; August 27-31, 2012; Milan, Italy.
68. Sterling M. A proposed new classification system for whiplash associated disorders—implications for assessment and management. *Man Ther.* 2004;9:60-70. <http://dx.doi.org/10.1016/j.math.2004.01.006>
69. Sterling M, Hendrikz J, Kenardy J. Compensation claim lodgement and health outcome developmental trajectories following whiplash injury: a prospective study. *Pain.* 2010;150:22-28. <http://dx.doi.org/10.1016/j.pain.2010.02.013>
70. Sterling M, Hendrikz J, Kenardy J. Similar factors predict disability and posttraumatic stress disorder trajectories after whiplash injury. *Pain.* 2011;152:1272-1278. <http://dx.doi.org/10.1016/j.pain.2011.01.056>
71. Sterling M, Jull G, Vicenzino B, Kenardy J. Sensory hypersensitivity occurs soon after whiplash injury and is associated with poor recovery. *Pain.* 2003;104:509-517.
72. Sterling M, Jull G, Vicenzino B, Kenardy J, Darnell R. Development of motor system dysfunction following whiplash injury. *Pain.* 2003;103:65-73.
73. Sterling M, Kenardy J, Jull G, Vicenzino B. The development of psychologi-

cal changes following whiplash injury. *Pain.* 2003;106:481-489.

74. Stewart WF, Ricci JA, Chee E, Morganstein D, Lipton R. Lost productive time and cost due to common pain conditions in the US workforce. *JAMA.* 2003;290:2443-2454. <http://dx.doi.org/10.1001/jama.290.18.2443>
75. Sullivan MJ, Adams H, Martel MO, Scott W, Wideman T. Catastrophizing and perceived injustice: risk factors for the transition to chronicity after whiplash injury. *Spine (Phila Pa 1976).* 2011;36:S244-S249. <http://dx.doi.org/10.1097/BRS.0b013e3182387fed>
76. Szeto GP, Straker LM, O'Sullivan PB. EMG median frequency changes in the neck-shoulder stabilizers of symptomatic office workers when challenged by different physical stressors. *J Electromyogr Kinesiol.* 2005;15:544-555. <http://dx.doi.org/10.1016/j.jelekin.2005.06.004>
77. Takasaki H, Hall T, Kaneko S, Iizawa T, Ikemoto Y. Cervical segmental motion induced by shoulder abduction assessed by magnetic resonance imaging. *Spine (Phila Pa 1976).* 2009;34:E122-E126. <http://dx.doi.org/10.1097/BRS.0b013e31818a26d9>
78. Treleaven J, Jull G, LowChoy N. The relationship of cervical joint position error to balance and eye movement disturbances in persistent whiplash. *Man Ther.* 2006;11:99-106. <http://dx.doi.org/10.1016/j.math.2005.04.003>
79. Treleaven J, Jull G, LowChoy N. Smooth pursuit neck torsion test in whiplash-associated disorders: relationship to self-reports of neck pain and disability, dizziness and anxiety. *J Rehabil Med.* 2005;37:219-223. <http://dx.doi.org/10.1080/16501970410024299>
80. Treleaven J, Jull G, LowChoy N. Standing balance in persistent whiplash: a comparison between subjects with and without dizziness. *J Rehabil Med.* 2005;37:224-229. <http://dx.doi.org/10.1080/16501970510027989>
81. Treleaven J, Jull G, Sterling M. Dizziness and unsteadiness following whiplash injury: characteristic features and relationship with cervical joint position error. *J Rehabil Med.* 2003;35:36-43.
82. Wallis BJ, Lord SM, Bogduk N. Resolution of psychological distress of whiplash patients following treatment by radiofrequency neurotomy: a randomised, double-blind, placebo-controlled trial. *Pain.* 1997;73:15-22.
83. Wegner S, Jull G, O'Leary S, Johnston V. The effect of a scapular postural correction strategy on trapezius activity in patients with neck pain. *Man Ther.* 2010;15:562-566. <http://dx.doi.org/10.1016/j.math.2010.06.006>
84. Woodhouse A, Stavadahl O, Vasseljen O. Irregular head movement patterns in whiplash patients during a trajectory task. *Exp Brain Res.* 2010;201:261-270. <http://dx.doi.org/10.1007/s00221-009-2033-9>
85. Zwart JA. Neck mobility in different headache disorders. *Headache.* 1997;37:6-11.

KNOWLEDGE TRANSLATION IN ORTHOPAEDIC PHYSICAL THERAPY

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“Knowledge, if it does not determine action, is dead to us.” —Plotinus, Roman philosopher (205 CE-270 CE)

To achieve evidence-based physical therapy,^{11,13} 5 steps must be enacted: define a clinical question, find the research evidence, determine which evidence is best, make an evidence-informed decision, and evaluate the outcomes. These 5 steps of evidence-based practice focus on decision making, not on implementation. Implementation is neither automatic nor simple.

Knowledge translation refers to the complex process whereby evidence is moved into practice,¹⁴ and is known by many different names. Knowledge translation as a recognized

discipline is relatively new but builds on traditions, theories, and research from many different areas that have focused on improving practice. For example, quality assurance, at least conceptually, deals with ensuring that best practice is implemented. More than 100 terms and definitions have been identified to describe what we call knowledge translation, often referred to as “KT” (<http://whatiskt.wikispaces.com/KT+Terms>).¹⁶ But knowledge translation simply means to put research evidence into practice.

When knowledge is available and is not used, we say there is a gap between knowledge and action, or evidence and practice. This includes failure to “do what works” and failure to stop doing things that “don’t work.” The result of these gaps is that the overall effectiveness of healthcare is reduced, and care is delivered at a higher cost than necessary. Large studies have demonstrated these gaps: 30% to 45% of patients are not receiving care according to evidence, and 20% to 50% of the care provided is not needed or potentially harmful.^{3,15,19}

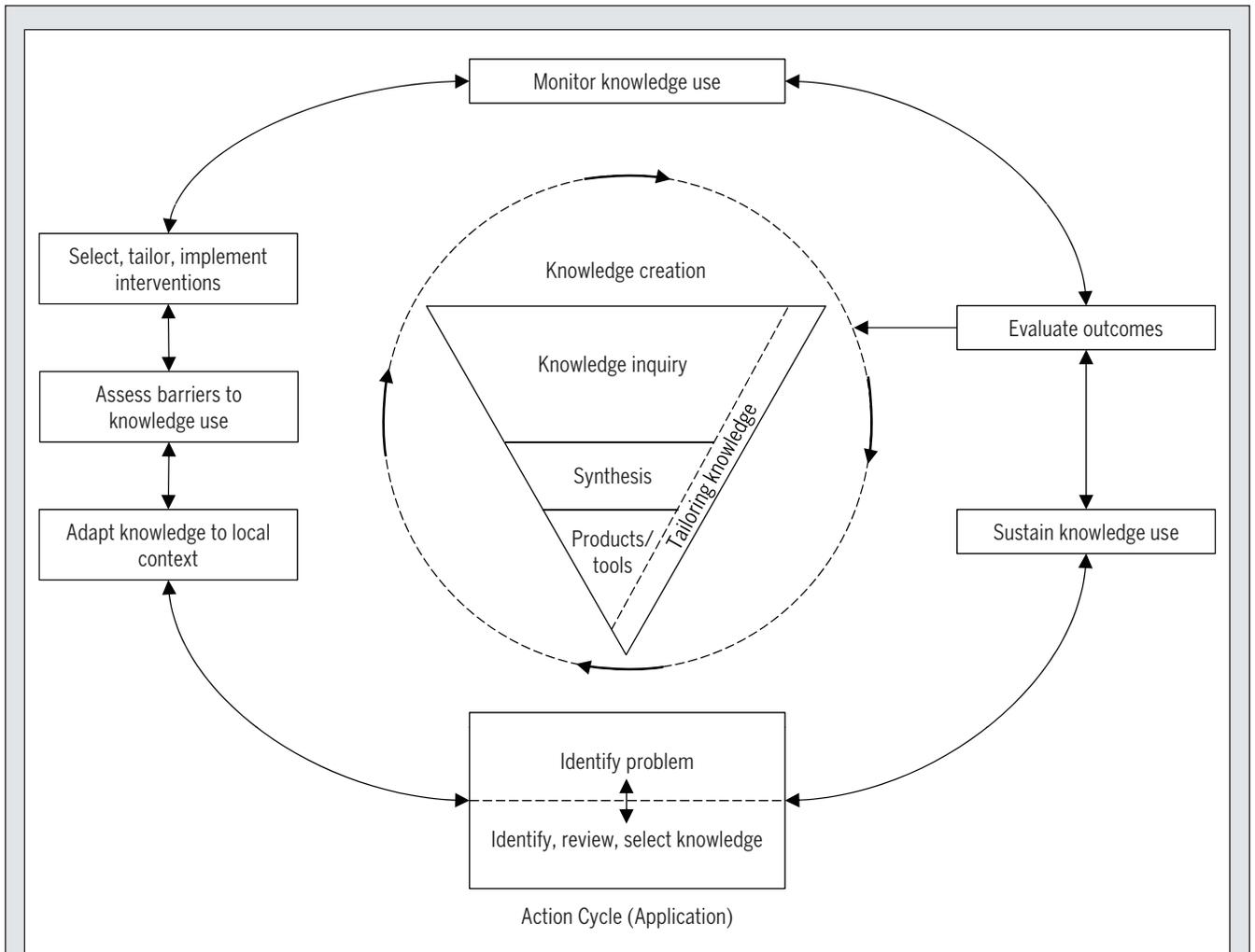


FIGURE 1. Knowledge-to-action cycle. Adapted with permission from Graham et al.⁸ Copyright © 2006 Wiley Periodicals, Inc.

Stroke rehabilitation is highly supported by results of randomized controlled trials. Yet, compliance with clinical practice guidelines is less than 70%.⁷

“Don’t say you don’t have enough time. You have exactly the same number of hours per day that were given to Helen Keller, Pasteur, Michelangelo, Mother Teresa, Leonardo da Vinci, Thomas Jefferson, and Albert Einstein.” —H. Jackson Brown, Jr.

The most common reason given for not changing our clinical behavior is that we don’t have enough time. Time is really a surrogate for other issues and usually indicates a lack of motivation to change what is currently being done. Thus, it is important to understand what underlies “lack of time.” Attitudinal barriers, lack of knowledge of evidence, and lack of resources or decision latitude required to do the right thing often are the underlying reasons why there is insufficient time to implement new practices.

We should be familiar with attitudinal barriers, as we see them in our patients every day. It is no easier to change our own behaviors than it is to change our patients’ behaviors.

Clinicians tend to want to implement interventions that they are comfortable with and look for where those are appropriate for their patients. Challenging these assumptions can be difficult. As our patient base evolves in an aging society with more complex chronic diseases, a broad view of health and a greater focus on self-management will be required. We must increasingly challenge our previous attitudes and professional boundaries to ensure that we are implementing best practices as patients’ needs and health systems continue to evolve.

The ability to access and appraise evidence has been a longstanding and well-documented barrier for clinicians who want to implement evidence in practice. Knowledge translation has moved forward rapidly in this area. Syntheses that summarize the best evidence now often include executive summaries and even patient (lay) versions. Instead of searching for literature, we can sign up for push-out services such as McMaster PLUS (http://hiru.mcmaster.ca/hiru/HIRU_McMaster_PLUS_Projects.aspx) and the version tailored to rehabilitation (<http://plus.mcmaster.ca/rehab/>

TABLE

KEY CHARACTERISTICS OF AN INNOVATION THAT CONTRIBUTES TO ITS IMPLEMENTATION

Characteristic of the Innovation	Diffusion of Innovation Definition
Relative advantage	The extent to which the innovation is better than the current accepted standard practice
Compatibility	The extent to which the innovation is consistent with existing values, past experiences, and needs
Complexity	The difficulty in understanding and using the innovation
Trialability	The extent to which the intervention can be experimented with on a limited basis
Observability	The extent to which a visible result occurs

Default.aspx). These services allow you to have high-quality evidence related to your area of practice delivered directly to you.

Knowledge translation is an emerging and complex field; thus, conceptual frameworks provide a structure to discuss and apply our evolving understanding. We recently did a scoping review on the use of theory in knowledge translation and focused on 3 predominant theories that take on different perspectives⁵ that provide insight into specific dimensions of knowledge translation.

THE KNOWLEDGE-TO-ACTION CYCLE

The knowledge-to-action cycle (FIGURE 1) provides an excellent overview of how research knowledge is developed, distilled, and then applied. It emphasizes that the application of knowledge leads to new questions that should reinvigorate the next wave of research. The knowledge-to-action cycle is composed of an inner circle of knowledge creation and an outer cycle that addresses application/implementation. Knowledge creation begins with individual research studies and eventually leads to synthesis of knowledge across different studies in the knowledge “funnel.” New knowledge is ready to be moved into action if evidence synthesis indicates that there is sufficient (not perfect) evidence about “the right thing to do.” Because we know it requires substantial resources to change practice, we should be confident in what changes are needed before we act. The implementation stage of the knowledge-to-action cycle focuses on making knowledge usable by adapting it to context and a specific target audience. It also emphasizes the importance of practice-based evidence to reinvigorate the knowledge-creation cycle.

THE THEORY OF DIFFUSION OF INNOVATIONS

The diffusion-of-innovations theory focuses on characteristics of the innovation and the target audience, and addresses the process of implementation.¹⁸ The theory relies on a sociological perspective where innovation is communicated “through particular channels, over time, among the mem-

bers of the social system.”¹⁸ Under this theory, innovations are passed through specific stages of decision/adoption: awareness/knowledge, interest/persuasion, evaluation/decision, trial/implementation, and adoption/confirmation. Innovations in physical therapy can include new tests, interventions, programs, or methods of health-service delivery. When thinking about implementing a new intervention, it can be helpful to think about stages of adoption and how the target audience might be supported to move through these changes.

When trying to change practice of a group of people, there will be different subgroups. The diffusion-of-innovations theory identifies different adopter categories. These are called innovators, early adopters, early majority, late majority, and laggards, based on their characteristics with respect to adoption.

In addition, characteristics of the innovation itself highly influence how uptake occurs and how much effort is required (TABLE). These elements are factors that we should attempt to optimize when trying to influence change.

THE THEORY OF PLANNED ACTION/BEHAVIOR

The theory of planned behavior^{1,2} (FIGURE 2) was the most commonly used knowledge translation framework in our scoping review.⁵ This framework assumes that behavior is determined by a cognitive process that governs our intentions (<http://people.umass.edu/aizen/index.html>). Behavioral intentions are assumed to arise as a function of attitudes/beliefs about that specific behavior, the subjective norms (professional, cultural, and expectations) that relate to the performance of that behavior, and the individual’s perception of his/her ability to control the process. An advantage of this framework is that it provides a structure to disentangle components of attitudes and beliefs that affect people’s behavior.

For example, if we think about exercise and adherence, getting people to perform their exercises is really knowledge translation, with patients as the target. We know that some patients fear exercise and others believe it is a critical component of their identity. Subjective norms deal with what “important” people think about exercise and whether it matters. For example, it is more common for people who exercise to have friends who exercise. Conversely, other people know their family thinks they should be exercising but do not value these norms. Finally, people are only motivated to change their behavior if they believe they have control over that behavior. There is evidence in the exercise literature that attitudes and control beliefs affect our intention and behavior with respect to exercise, whereas normative beliefs are less influential.^{4,6,9,12,17,20} We can use this information when structuring our exercise programs and interactions with patients around exercise. Whereas exercise and difficulties with adherence are easy for a physical therapist to think about, applying the same principles to changing our own behavior is less familiar.

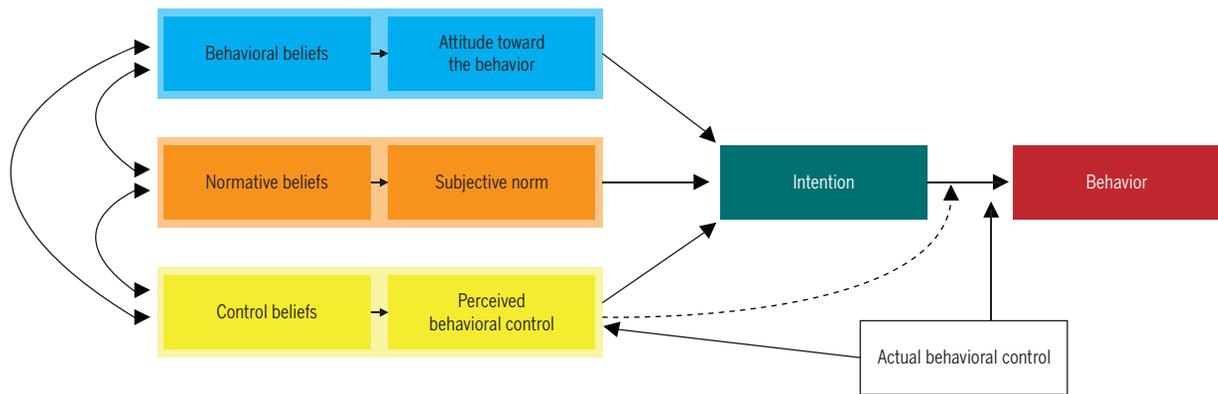


FIGURE 2. The theory of planned behavior. Used with permission. Copyright © 2006 Icek Ajzen, <http://people.umass.edu/ajzen/tpb.diag.html#null-link>.

PROMOTING ACTION ON RESEARCH IMPLEMENTATION IN HEALTH SERVICES FRAMEWORK

A framework for promoting action on research implementation in health services¹⁰ was developed in nursing⁵ and considers implementation to be a function of the relationships among the evidence, context, and facilitation. The framework focuses on the types of evidence required to facilitate change, going beyond research evidence to include clinical experience, patient experiences, and local data/information. In fact, the theory suggests that when acting on only 1 type of evidence, action is compromised. The model focuses on the context, or environment, as a mediator of implementation. Contextual factors that promote successful implementation are categorized under 3 broad themes of culture, leadership, and evaluation. Further, the model provides direction on the importance of facilitation and on what types of facilitation foster change. Briefly summarized, facilitation that empowers or creates capacity is valued, whereas providing resources or information more passively is not.

The scope of knowledge translation interventions is very wide. In knowledge translation, we think about getting the right information to the right people, at the right time, in the right format. Identifying the knowledge user or target audience is a critical component of designing a knowledge translation plan. Then, it is possible to pick from a wide variety of strategies that could be used to effect change. The selection of a knowledge translation strategy should be evidence based. An important source of evidence on the effectiveness of knowledge translation interventions is the Effective Practice and Organisation of Care group of the Cochrane Collaboration (<http://www.epoc.cochrane.org>). The Effective Practice and Organisation of Care group conducts systematic reviews of interventions designed to improve professional practice and the delivery of effective health services. Audit and feedback, active education, and reminders can promote change, and multimodal interventions work better.

Examples of knowledge translation interventions are:

1. Increase awareness of a problem or knowledge gap: social networking, public awareness campaigns.
2. Acquire new knowledge: push out evidence resources, printed materials.
3. Evaluate/synthesize new knowledge: systematic reviews and clinical practice guidelines, or tools to evaluate research quality.
4. Make a decision: patient decision aids, clinical prediction rules.
5. Adaptation of evidence to context: tools to adapt clinical practice guidelines (ADAPTE).
6. Implementation fidelity: electronic tools that implement specific exercises, manuals, audit, and feedback.
7. Facilitate the process of change: opinion leaders, organizational culture interventions.
8. Quality/outcome evaluation/monitoring: professional databases.

When planning knowledge translation, consider the following:

1. What is the specific high-quality research that defines action? Define that best evidence is sufficient.
2. Whose behavior needs to be changed? Define target audience.
3. Is there an indication that best practice is not being followed? Determine the practice pattern.
4. What are the major barriers to knowledge uptake? Define facilitators and barriers that might be manipulated to effect change.
5. What actions are needed to move forward the process of change? Define the change objectives and appropriate knowledge translation intervention.
6. What process changes and outcomes are expected? Define the process, intermediary, and terminal outcomes that would indicate implementation was successful.

In summary, knowledge translation is a process that is required to ensure the benefits of research are achieved and that can only happen through engagement between clinicians

and researchers. There are a variety of effective interventions, but the size of behavior change is usually modest. Knowledge translation requires ongoing relationships and persistent efforts, often with multimodal interventions. For this reason, larger effects may only be achieved over time with considerable effort. However, this is quite variable depending on the nature of the innovation itself. Knowledge translation, like physical therapy, comprises art and science and continues to evolve its evidence base.

REFERENCES

1. Ajzen I. From intentions to actions: a theory of planned behavior. In: Kuhl J, Beckmann J, eds. *Action Control: From Cognition to Behavior*. Berlin, Germany: Springer; 1985:11-39.
2. Ajzen I. The theory of planned behaviour: reactions and reflections. *Psychol Health*. 2011;26:1113-1127. <http://dx.doi.org/10.1080/08870446.2011.613995>
3. Asch SM, McGlynn EA, Hiatt L, et al. Quality of care for hypertension in the United States. *BMC Cardiovasc Disord*. 2005;5:1. <http://dx.doi.org/10.1186/1471-2261-5-1>
4. Blue CL, Wilbur J, Marston-Scott M. Exercise among blue-collar workers: application of the theory of planned behavior. *Res Nurs Health*. 2001;24:481-493. <http://dx.doi.org/10.1002/nur.10008>
5. Colquhoun HL, Letts LJ, Law MC, MacDermid JC, Missiuna CA. A scoping review of the use of theory in studies of knowledge translation. *Can J Occup Ther*. 2010;77:270-279.
6. Conn VS, Tripp-Reimer T, Maas ML. Older women and exercise: theory of planned behavior beliefs. *Public Health Nurs*. 2003;20:153-163.
7. Duncan PW, Horner RD, Reker DM, et al. Adherence to postacute rehabilitation guidelines is associated with functional recovery in stroke. *Stroke*. 2002;33:167-177.
8. Graham ID, Logan J, Harrison MB, et al. Lost in knowledge translation:

time for a map? *J Contin Educ Health Prof*. 2006;26:13-24. <http://dx.doi.org/10.1002/chp.47>

9. Kerner MS, Grossman AH, Kurrant AB. The theory of planned behavior as related to intention to exercise and exercise behavior. *Percept Mot Skills*. 2001;92:721-731.
10. Kitson A, Harvey G, McCormack B. Enabling the implementation of evidence based practice: a conceptual framework. *Qual Health Care*. 1998;7:149-158.
11. Law M, MacDermid J. *Evidence-Based Rehabilitation: A Guide to Practice*. 2nd ed. Thorofare, NJ: SLACK Incorporated; 2008.
12. Lee H. The role of descriptive norm within the theory of planned behavior in predicting Korean Americans' exercise behavior. *Psychol Rep*. 2011;109:208-218.
13. MacDermid JC. An introduction to evidence-based practice for hand therapists. *J Hand Ther*. 2004;17:105-117. <http://dx.doi.org/10.1197/j.jht.2004.02.001>
14. MacDermid JC, Graham ID. Knowledge translation: putting the "practice" in evidence-based practice. *Hand Clin*. 2009;25:125-143. <http://dx.doi.org/10.1016/j.hcl.2008.10.003>
15. Mangione-Smith R, DeCristofaro AH, Setodji CM, et al. The quality of ambulatory care delivered to children in the United States. *N Engl J Med*. 2007;357:1515-1523. <http://dx.doi.org/10.1056/NEJMsa064637>
16. McKibbin KA, Lokker C, Wilczynski NL, et al. A cross-sectional study of the number and frequency of terms used to refer to knowledge translation in a body of health literature in 2006: a Tower of Babel? *Implement Sci*. 2010;5:16. <http://dx.doi.org/10.1186/1748-5908-5-16>
17. Park BH, Lee MS, Hong JY, et al. The stages of physical activity and exercise behavior: an integrated approach to the theory of planned behavior. *Asia Pac J Public Health*. 2009;21:71-83. <http://dx.doi.org/10.1177/1010539508327089>
18. Rogers EM. *Diffusion of Innovations*. 3rd ed. New York, NY: Free Press; 1983.
19. Schuster MA, McGlynn EA, Brook RH. How good is the quality of health care in the United States? *Milbank Q*. 1998;76:517-563.
20. Spink KS, Wilson KS, Bostick JM. Theory of planned behavior and intention to exercise: effects of setting. *Am J Health Behav*. 2012;36:254-264. <http://dx.doi.org/10.5993/AJHB.36.2.10>

THE HIP AS A FACTOR IN LOW BACK PAIN: EVIDENCE WHY RELATIVE FLEXIBILITY IS KEY

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Based on our clinical experience using a standardized examination of patients with low back pain (LBP), we developed a pathokinesiologic model of the human movement system as a basis for our clinical and research studies. We propose that the repeated movements and sustained alignments of daily activities produce tissue adaptations that cause spinal movement to become imprecise. The imprecision is attributed to accessory motion hypermobility of the joint. A key factor in the development and perpetuation of this hypermobility is the imbalance in passive tension (relative stiffness) of muscles affecting a joint, most often those in series about a joint. The relative passive stiffness of the muscles and the intrinsic spinal flexibility combine to produce and/or further the accessory motion hypermobility of the joint. The accessory motion hypermobility is evident in the joint moving more readily than if these imbalances were not present. The extensibility of the supporting structures of the vertebral joints, the loss of disc height, and

“neutral zone”¹¹ motion contribute to intrinsic spinal flexibility. Based on clinical observations, the primary factor determining the readily elicited spinal motion is the underlying spinal hypermobility, which is usually in a specific direction. For example, the right tensor fascia lata may be short and stiffer than the left, as indicated by a greater force required to stretch the right tensor fascia lata than the left. Yet when the patient is prone, passive right knee flexion does not cause lumbopelvic rotation (LPR) but passive left knee flexion does cause LPR. Relative flexibility is the term used to describe the combination of factors contributing to this inappropriate spinal joint motion. The contributing factors are the intrinsic spinal hypermobility and the relative stiffness of the muscles acting about the joint. Hypertrophy resulting from daily activity increases muscle passive stiffness, the change in tension/unit change in length. The passive muscle stiffness, the resistance to passive elongation, is attributed to a large intracellular protein called titin or connectin.^{4,6} There are 6 titin proteins for every myosin filament,⁹ which is consistent with muscle volume being correlated with passive tension.² When a muscle hypertrophies, the addition of myosin is associated with a 6-fold increase in titin. A muscle on one side of a joint can become stiffer than a

muscle on the other side that should be passively restraining the joint. As a joint becomes hypermobile, the variation in the relative stiffness of muscles about the joint can induce motion rather than prevent motion. Consistent with the degenerative process of spinal instability or hypermobility, the progressive increase in the range and frequency of the accessory motion is a source of microtrauma and eventual macrotrauma. The belief is that, though small in range, the presence of early-onset motion of the spine in patients with LBP during motion at other joints, such as the hip, is indicative of factors contributing to degeneration. Importantly, these are not problems of muscle shortness but of relative flexibility, the imbalance in passive muscle stiffness, and the underlying flexibility of the joint relative to the imposed passive tensions.

SPINAL HYPERMOBILITY/INSTABILITY

Spinal hypermobility or instability is described by Zhao et al¹⁸ as associated with back pain that is exacerbated by movement and associated with intersegmental movements that are abnormal or excessive at 1 or more spinal levels. "The 'neutral zone' is the region of the spine with minimal internal resistance to movement,¹¹ can wobble 'freely,'¹ and becomes enlarged in spinal instability. The hypermobility is a predominant component of the degenerative process because the intervertebral discs provide most of the spine's intrinsic resistance to small movements and thus degeneration compromises this function."¹⁸ Increased lumbar motion with passive joint testing has been demonstrated in individuals with LBP.⁹ Treatment for LBP includes the use of braces, spinal stabilization programs, and spinal fusion. Van Dillen and colleagues¹³⁻¹⁷ have measured spinal readiness to move, directional characteristics, contributing factors, and the relationship between lumbar motions and symptoms induced by moving the hip, but not direct measures of accessory motion. We propose that relative stiffness of muscles about a joint further contributes to enlarging the "neutral zone" and increasing the degrees of spinal hypermobility/instability.

STOPPING LUMBAR MOTION DURING LOWER EXTREMITY MOTION DECREASES SYMPTOMS

If motion causes pain, then stopping the spinal motion should reduce the symptoms. Two studies demonstrated the relationships among spinal movement, symptoms induced by extremity motion, and the effect of stopping the spinal motion during the extremity motion.^{14,16} There were 51 subjects, most with subacute and chronic LBP, 37% were male, had a 5/10 mean pain score, and a mean Oswestry Low Back Pain Disability Questionnaire score of 32%. Knee extension in sitting, which caused posterior pelvic tilt and lumbar flexion, increased symptoms in 34% of subjects, hip abduction/lateral rotation from hook-lying in 29%, knee flexion in prone in 26%, hip rotation in prone in 54%, and hip extension in prone in 61%. When the lumbar motion was prevented dur-

ing the lower extremity motions, the majority of subjects had decreased symptoms, with the percentages ranging from 79% with prone hip lateral rotation to 92% with hip extension in prone. Furthermore, in patients with a history of multiple LBP episodes, 67% of the test movements caused pain, whereas in those with their first episode of pain, only 33% of the tests caused symptoms. The difference in the number of tests that were symptomatic in the 2 patient groups is consistent with greater degenerative tissue changes and a greater tendency for movement in the painful direction.

LUMBOPELVIC ROTATION DURING HIP ROTATION

The Van Dillen lab has conducted clinical and quantitative studies of LPR during hip rotation using a 3-D motion analysis system. The analyzed movement variables are the degrees of hip lateral rotation (HLR) and the timing and degrees of LPR that occur during the hip motion. A study³ of gender differences showed that men used 50% of their LPR, whereas women used 36% of their maximum LPR at 60% of HLR. Seventy percent of the men had an increase in symptoms, whereas only 37% of the women had an increase. In summary, (1) compared to women, men performed a larger percentage of their LPR during the earlier part of HLR, (2) a larger percentage of men had symptoms, and (3) gender differences were more pronounced in the subgroup of people with an increase in LBP symptoms during the test. A similar study⁸ of the effect of hip medial rotation (HMR) on LPR found that HMR in women (42°) was significantly different from that in men (30°). The total LPR was less for women (4.5°) than for men (10°). Women used 16° of HMR before the onset of LPR, but men only used 5.4°. As with HLR, more men (60%) had symptoms during the test than women (34%).

LUMBOPELVIC MOTION DURING HLR AND KNEE FLEXION IN PATIENTS WITH LBP AND CONTROLS

In other studies, the onset of LPR during knee flexion and HLR was compared in people with and without LBP.¹² The time difference between onset of HLR and LPR was greater for controls than for patients with LBP. The maximum HLR was not different, nor was the velocity of hip motion for the 2 groups. The maximum degree of LPR was significantly greater in people with LBP than without LBP, but only by about 1.5°. The differences in timing are only in fractions of a second. In summary, these studies demonstrated that LPR is very readily elicited by lower extremity motions. The motion occurs very early during the limb motion and is only a few degrees and a few fractions of a second different in people with LBP compared to those without LBP.

EFFECT OF CLASSIFICATION-SPECIFIC TREATMENT ON LUMBOPELVIC MOVEMENT PATTERNS WITH HIP MOTIONS

The timing between hip rotation and LPR can be modi-

fied with training. In a comparison of classification-specific and nonspecific treatment,⁵ 1 group of subjects with LBP was given exercises that required them to control their pelvis when performing lower extremity motions, whereas the other group was given more general exercises. The subjects were treated 1 time per week for 6 weeks. Those trained in the specific exercises showed a significant change at the end of treatment. The change was from 5° of HLR at onset of LPR to 15° posttreatment. There was no change in the nonspecific exercise group. The pattern was the same for HMR. The specific group had 10° of HMR before LPR pretreatment and 18° posttreatment. There was no change for the nonspecific group. The specific treatment group had a significant decrease in LPR posttreatment during both lateral and medial hip rotation, whereas the nonspecific group had a slight increase.

CLASSIFICATION-SPECIFIC DIFFERENCES IN LPR DURING HLR

Another study examined the differences in the pattern of relative stiffness in different classifications of patients with LBP. The classification is based on an increase in symptoms with movements or alignments in the appropriate directions. A standardized examination with reliable test items¹⁵ and classification validity¹⁷ was used to classify the patients. Two classifications were rotation-extension and rotation. Previous studies⁵ have documented the reliability of the examiners in appropriately classifying the patients. The relative stiffness was assessed by examining the timing difference variable of LPR during HLR for each limb and for each LBP subgroup. If the LPR occurs early, the timing difference values will be small for both groups. If the timing is asymmetric, with the right and left values being different, there is a variation in the relative flexibility of the spine in different directions. The pattern for subjects classified as rotation is symmetric, so that the timing of LPR is highly correlated with movement of both the right and left hip, and the LPR occurs early. In contrast, the pattern for the rotation-extension subjects is asymmetric, without a correlation in the timing of LPR with the left and right hip.¹³ The values are low, so the timing differences are low and the LPR occurs early. These findings support different classifications of patients with LBP, and flexibility of the spine can vary in the directional threshold for movement.

SUMMARY

In summary, the results of our studies support the presence of spinal hypermobility, most likely accessory motion. This hypermobility is most apparent in both clinical examination and laboratory measurements with movements of the hip. Of particular importance is how readily this motion takes place in time and how small in degree. These significant but small differences found in patients with LBP compared to subjects without LBP raise several issues. We hypothesize

that this small but frequent motion is the source of stress on spinal segments and causes microtrauma to become macrotrauma. When considering treatment, these findings emphasize the importance of spinal stabilization, which includes teaching the patient where and how to move the appropriate joints. Last but not least, these findings also support the belief that muscle length is not the cause of movement at adjacent joints; therefore, a focus on stretching muscles is not as effective as a focus on spinal stabilization. Because the imbalance in the relative stiffness of the musculature is a contributing factor, treatment should address this imbalance as well, instructing the patient to restrict motion to the appropriate joint, such as the hip joint, and prevent spinal motion.

REFERENCES

- Adams MA. Biomechanics of the intervertebral disc, vertebra, and ligaments. In: Szpalski M, Gunzburg R, Pope MH, eds. *Lumbar Segmental Instability*. Philadelphia, PA: Lippincott Williams & Wilkins; 1999.
- Chleboun GS, Howell JN, Conatser RR, Giesey JJ. The relationship between elbow flexor volume and angular stiffness at the elbow. *Clin Biomech (Bristol, Avon)*. 1997;12:383-392.
- Gombatto SP, Collins DR, Sahrman SA, Engsborg JR, Van Dillen LR. Gender differences in pattern of hip and lumbopelvic rotation in people with low back pain. *Clin Biomech (Bristol, Avon)*. 2006;21:263-271. <http://dx.doi.org/10.1016/j.clinbiomech.2005.11.002>
- Granzier HL, Labeit S. The giant muscle protein titin is an adjustable molecular spring. *Exerc Sport Sci Rev*. 2006;34:50-53.
- Harris-Hayes M, Van Dillen LR. The inter-tester reliability of physical therapists classifying low back pain problems based on the movement system impairment classification system. *PM R*. 2009;1:117-126.
- Herzog W, Duvall M, Leonard TR. Molecular mechanisms of muscle force regulation: a role for titin? *Exerc Sport Sci Rev*. 2012;40:50-57. <http://dx.doi.org/10.1097/JES.0b013e31823cd75b>
- Hoffman SL, Johnson MB, Zou D, Harris-Hayes M, Van Dillen LR. Effect of classification-specific treatment on lumbopelvic motion during hip rotation in people with low back pain. *Man Ther*. 2011;16:344-350. <http://dx.doi.org/10.1016/j.math.2010.12.00>
- Hoffman SL, Johnson MB, Zou D, Van Dillen LR. Sex differences in lumbopelvic movement patterns during hip medial rotation in people with chronic low back pain. *Arch Phys Med Rehabil*. 2011;92:1053-1059.
- Kulig K, Powers CM, Landel RF, et al. Segmental lumbar mobility in individuals with low back pain: in vivo assessment during manual and self-imposed motion using dynamic MRI. *BMC Musculoskelet Disord*. 2007;8:8. <http://dx.doi.org/10.1186/1471-2474-8-8>
- Nishikawa KC, Monroy JA, Uyeno TE, Yeo SH, Pai DK, Lindstedt SL. Is titin a 'winding filament'? A new twist on muscle contraction. *Proc Biol Sci*. 2012;279:981-990. <http://dx.doi.org/10.1098/rspb.2011.1304>
- Panjabi MM. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *J Spinal Disord*. 1992;5:390-396; discussion 397.
- Scholtes SA, Gombatto SP, Van Dillen LR. Differences in lumbopelvic motion between people with and people without low back pain during two lower limb movement tests. *Clin Biomech (Bristol, Avon)*. 2009;24:7-12.
- Van Dillen LR, Gombatto SP, Collins DR, Engsborg JR, Sahrman SA. Symmetry of timing of hip and lumbopelvic rotation motion in 2 different subgroups of people with low back pain. *Arch Phys Med Rehabil*. 2007;88:351-360.
- Van Dillen LR, Maluf KS, Sahrman SA. Further examination of modifying patient-preferred movement and alignment strategies in patients with low back pain during symptomatic tests. *Man Ther*. 2009;14:52-60.
- Van Dillen LR, Sahrman SA, Norton BJ, et al. Reliability of physical examination items used for classification of patients with low back pain. *Phys*

Ther. 1998;78:979-988.

16. Van Dillen LR, Sahrman SA, Norton BJ, Caldwell CA, McDonnell MK, Bloom N. The effect of modifying patient-preferred spinal movement and alignment during symptom testing in patients with low back pain: a preliminary report. *Arch Phys Med Rehabil.* 2003;84:313-322.

17. Van Dillen LR, Sahrman SA, Norton BJ, Caldwell CA, McDonnell MK, Bloom NJ. Movement system impairment-based categories for low back pain: stage 1 validation. *J Orthop Sports Phys Ther.* 2003;33:126-142.
18. Zhao F, Pollintine P, Hole BD, Dolan P, Adams MA. Discogenic origins of spinal instability. *Spine (Phila Pa 1976).* 2005;30:2621-2630.

ADAPTATION IN PATIENTS WITH LUMBO-PELVIC PAIN, FOR BETTER OR FOR WORSE? CLINICAL REASONING USING BEST AVAILABLE EVIDENCE: A CASE STUDY

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Pregnancy-related lumbopelvic pain (PLPP) is a complex problem. Internationally, the reported prevalence between weeks 34 and 40 of pregnancy is 45% to 89%. Twenty percent of all pregnant women with PLPP seek medical help, but prevalence of those with pain drops significantly to 35% in the first month after delivery and stabilizes after that time.^{3,12,13,53} The assumption is that in patients with PLPP, stability of the pelvic ring is compromised and may influence load transfer.^{29,36,42,50,51} However, instability is hard to define and measure objectively. It is certainly not the same as “loose joints.” Consistent with this remark, only asymmetry in motion of the sacroiliac joints could be defined in these patients.⁸ Actually, the underlying pathogenesis of pelvic girdle pain is still not clear and might differ among patients. By admitting that we do not know the pathogenesis, it seems inappropriate to choose stabilizing exercises as the primary intervention in all patients with PLPP for a necessary stiffening/stabilizing of the pelvic ring. So, when do we choose each intervention? How can we assess and treat these patients with PLPP optimally? The Dutch national⁴ and European guidelines⁴⁸ on PLPP differ extensively in recommendations for best clinical practice for assessment and treatment of this patient group. Logically, because recommendations based on insufficient evidence are based on the authors’ (experts’) opinion (level D), it is likely that this clinical expertise will not be similar. Furthermore, patients with pelvic girdle pain differ from each other, present different problems, and have developed different coping strategies.

In the current lecture, the focus will be placed on differences in presentation of complaints in patients with PLPP and especially why some strategies are adaptive but also may have an adverse effect or be maladaptive. As a basis, the classification by O’Sullivan and Beales³³ will be used. To guide the clinicians on how different strategies can be assessed and how this information can be incorporated in the process of clinical reasoning, we will use a case study: Julia.

This case study is the result of a collaborative consultation

at the Mediferia center in Amersfoort, the Netherlands, of 4 experts: Diane Lee, Marijke Slieker, Britt Stuge, and Annelies Pool. We are proud to present to you this case study, in which an extensive diagnostic assessment took place in a short time. The power of 4 brains working together was a stimulating impulse for all of us to open our minds, to be critical in what we really could assess, and to see through what was really happening with Julia and perhaps in other patients with lumbopelvic pain. Although we are aware of the importance of yellow flags and did take this into account, we will restrict this lecture to the biomedical findings.

The subjective assessment informs us that the complaints of Julia can be defined as PLPP. With PLPP, most problems are reported during prolonged standing, turning in bed, climbing stairs, lifting light loads, and sexual intercourse.^{3,12,48}

The objective assessment starts with inspection and assessment while standing and during transfers. The classification system by O’Sullivan and Beales³³ separates patients into 2 groups based on force closure. Force closure is defined as the attempt to increase transverse forces to the pelvis to secure the joint, while forces will be transferred from the lower extremities to the trunk and vice versa.^{29,30,36,42,50,51} Some patients demonstrate excessive force closure and others a lack of force closure. Signs of excessive force closure can be an increase in global trunk muscle tone of both the extensors and the abdominals (also increasing intra-abdominal pressure [IAP]), no relaxation in spinal muscles after activity, or holding breath.^{5,6,14,27,32,33,35} Signs of lack of force closure can be visible during transfers by lack of tone in the muscles^{6,32} or pushing the belly outward during activities, possibly increasing IAP by stretching the abdominal wall. IAP increase might help to stiffen the spine and possibly the pelvis.¹⁷ Julia showed signs of excessive force closure during the standing stork test (standing on 1 leg) and several transfers. Hu et al²¹ demonstrated that the pelvis of the supporting leg has a tendency to rotate anteriorly because of a forward torque of the pelvis induced from the sustained contraction of the contralateral hip flexor while raising the leg, which is consistent with the suggestions of Hungerford et al.²² Interexaminer reliability (left, $\kappa = 0.67$; right, $\kappa = 0.77$) and the percentage of agreement were high (left, 91.9%; right, 89.9%) when the test was scored positive or negative.²³ We have to be careful when interpreting results of this test as proof for locking or decreased mobility of a sacroiliac joint, because Stuesson et al⁴⁴ demonstrated that during the standing stork test, both sacroiliac joints

only moved 0.2°. Furthermore, Pool-Goudzwaard et al³⁴ demonstrated that during asymmetric movement within the pelvis, the innominate itself was deformed, even more than pubic symphysis mobility. Perhaps this is also the reason for the low kappas on mobility tests, even when using a multiple test regime,⁴⁷ when differences in position of the iliac spines are used as a parameter for sacroiliac joint mobility. In Julia, the posterior pelvic pain test was used for sacroiliac pain provocation, although we have to be aware that validity has only been tested for women during pregnancy.³¹ If PLPP is regarded as a subgroup of nonspecific low back pain, the multiple-tests strategy by Laslett²⁴ or van der Wurff⁴⁵ should be used. Julia scored negative for pain provocation from the sacroiliac joint.

ACTIVE STRAIGHT LEG RAISE (ASLR) AND PELVIC BELT TEST

The ASLR test is advocated as a test for load transfer over the pelvis and is often used to diagnose PLPP.^{29,32} Mens et al²⁸ demonstrated a high sensitivity and specificity at the cutoff point of 1 to classify PLPP; however, this was in pregnant women with PLPP. Not all patients with PLPP have a positive ASLR.³⁵ Julia scored 1 on the left and zero on the right side, again demonstrating an increase in muscle tone and holding her breath. Aberrant motor control patterns have been observed in subjects with PLPP, impacting respiration,^{6,32} control of the pelvic floor, and continence.^{32,35} Patients with PLPP respond differently to resistance against inspiration during the ASLR compared to healthy subjects, with the abdominal wall appearing to attend to lumbopelvic stability instead of respiration.^{6,52} Hu et al^{20,21} demonstrated that during the ASLR (and walking on a treadmill), transverse muscles such as the transversus abdominis (TrA) and the lower portion of the internal oblique are able to create force closure and let the pelvis move as 1 unit in the sagittal plane, with the forward rotation of the innominate on the side of the leg lifted being counteracted by biceps femoris activity on the resting side. In PLPP, the innominate is pulled forward, as inferred with radiographs.³⁰ Instead of less muscle activity, more activity of the internal oblique and iliacus, especially in the ipsilateral muscles, was demonstrated in patients with PLPP.^{6,9,20,21} The fact that transverse and oblique abdominal muscles were less active in conditions with a pelvic belt suggests that the belt provides such force closure, thus confirming Snijders' theory of force closure. The preponderance of ipsilateral over contralateral activity appears to challenge⁶ the old idea of balanced cocontraction in the oblique muscle sling of the internal oblique on one side and the external oblique on the other side.⁴⁹

STABILITY AND MOTOR CONTROL TESTS

Ultrasound imaging is a reliable and valid method to assess contraction of the TrA.¹⁵ Julia was able to show a proper

isolated contraction of her TrA on both sides. There is considerable evidence that the TrA muscle can contribute to stability, defined as increased stiffness of the lumbar spine via: (a) increased tension of the thoracolumbar fascia,^{2,18} (b) increased stiffness of the sacroiliac joint,³⁹ and (c) its effect on IAP.^{18,43} There is also some evidence of delayed activation of the TrA in both clinical and experimental studies of low back pain,^{16,19} although some healthy subjects did not show a feedforward response in experimental settings.¹ A recent systematic review demonstrated that although differences in morphology can be measured using real-time ultrasound imaging, the construct validity, for example, a timing delay, cannot be assessed and it is questionable whether it can be palpated by the clinician. So, what do we test when we let a patient perform a stability test? Julia was able to contract her TrA correctly. Does this mean that Julia is able to give a timely force closure of her pelvis during activities? Perhaps motor control tests such as squats, lunges, and balance tasks tell us more about whether a patient is able to respond with damping and flexibility^{25,37,38,54} separate from robustness. Also, the presence of trigger points can tell us whether a muscle is continuously activated.

PELVIC FLOOR MUSCLES AND DYSFUNCTION

Julia also reported urinary incontinence (UI) during coughing. UI is common, with 45% of women experiencing UI 5 to 7 years postpartum.²⁶ MacLennan et al²⁶ demonstrated that over a 6-year period, 27% of the incontinent women became continent and 31% of continent women became incontinent. The combined prevalence of PLPP and UI has been investigated and a strong relationship noted.⁴¹ A high level of association is present between the ASLR, posterior pelvic pain test, and severity of incontinence.²⁸ Pool-Goudzwaard et al³⁵ reported that 52% of the women surveyed experienced both low back pain as well as pelvic floor dysfunction (voiding dysfunction, UI, sexual dysfunction, and/or constipation), and, of these, 82% stated that their symptoms began with either low back or pelvic girdle pain. Both Pool-Goudzwaard et al³⁵ and O'Sullivan and Beales³² reported pelvic floor dysfunction in patients with low back pain. Pool-Goudzwaard et al³⁵ demonstrated in patients with PLPP a high tone, loss of endurance, a paradoxical push reflex, and a high occurrence of stress UI (odds ratio, 4.1) and sexual complaints (odds ratio, 4.2), especially in the group of women with a negative ASLR. O'Sullivan³² demonstrated low muscle activity in patients with PLPP. So, it is suggested to assess the pelvic floor musculature. If a high tone is present, be aware not to start stabilizing exercises due to cocontraction between the TrA and the pelvic floor muscles.^{7,40} If indeed pelvic floor dysfunction is present in your patient and you are not an expert, refer your patient to the appropriate colleague. Eliasson (2008) demonstrated a 78% prevalence of pelvic floor dysfunction in patients with low back pain. Trauma can also be present

postdelivery. Dietz and Lanzarone¹¹ studied the prevalence of major trauma to the pubovisceral muscles (36%) related to postpartum stress UI. Dietz et al¹⁰ also investigated levator avulsion (23%) and reduction in muscle strength.

It is our collective opinion that Julia sustained a significant trauma to the pelvic floor myofascial structures during the vaginal delivery of her third child. In addition, she sustained a trauma to a portion of the pudendal nerve (S3). The strategies she developed to compensate for this myofascial and neural trauma were nonoptimal for either her musculoskeletal system or her urogynecological system. The neural and myofascial deficit of her pelvic floor was contributing to her inability to remain continent during functional tasks. Neither mobilization nor stabilization would have been helpful in her case. This could easily have been missed if we had only focused on her PLPP complaints. From a physiotherapy point of view, training of the pelvic floor muscles with focus of awareness presurgery can be helpful.

CONCLUSION

- Not all patients with PLPP require stabilization exercises—classify!
- Assess how patients adapt and their different motor strategies.
- Assess pelvic floor dysfunction—if present, refer to a specialist.
- With an increased tone in the pelvic floor musculature, do not start with stabilization exercises.
- Be aware of our own limitations of what we really objectively can measure.

REFERENCES

1. Allison GT, Morris SL. Transversus abdominis and core stability: has the pendulum swung? *Br J Sports Med*. 2008;42:930-931. <http://dx.doi.org/10.1136/bjism.2008.048637>
2. Barker PJ, Guggenheimer KT, Grkovic I, et al. Effects of tensioning the lumbar fasciae on segmental stiffness during flexion and extension: Young Investigator Award winner. *Spine (Phila Pa 1976)*. 2006;31:397-405. <http://dx.doi.org/10.1097/01.brs.0000195869.18844.56>
3. Bastiaenen CH, de Bie RA, Essed GG. Pregnancy-related pelvic girdle pain. *Acta Obstet Gynecol Scand*. 2007;86:1277-1278; author reply 1278-1279. <http://dx.doi.org/10.1080/00016340701659163>
4. Bastiaenen CHG, Hendriks EJM, Pool-Goudzwaard AL, et al. *KNGF-richtlijn Zwangerschapsgelateerde bekkenpijn*. Amersfoort, the Netherlands: Koninklijk Nederlands Genootschap voor Fysiotherapie; 2009.
5. Beales DJ, O'Sullivan PB, Briffa NK. The effects of manual pelvic compression on trunk motor control during an active straight leg raise in chronic pelvic girdle pain subjects. *Man Ther*. 2010;15:190-199. <http://dx.doi.org/10.1016/j.math.2009.10.008>
6. Beales DJ, O'Sullivan PB, Briffa NK. Motor control patterns during an active straight leg raise in chronic pelvic girdle pain subjects. *Spine (Phila Pa 1976)*. 2009;34:861-870. <http://dx.doi.org/10.1097/BRS.0b013e318198d212>
7. Bø K, Sherburn M, Allen T. Transabdominal ultrasound measurement of pelvic floor muscle activity when activated directly or via a transversus abdominis muscle contraction. *NeuroUrol Urodyn*. 2003;22:582-588. <http://dx.doi.org/10.1002/nau.10139>
8. Damen L, Buyruk HM, Guler-Uysal F, Lotgering FK, Snijders CJ, Stam HJ.

Pelvic pain during pregnancy is associated with asymmetric laxity of the sacroiliac joints. *Acta Obstet Gynecol Scand*. 2001;80:1019-1024.

9. de Groot M, Pool-Goudzwaard AL, Spoor CW, Snijders CJ. The active straight leg raising test (ASLR) in pregnant women: differences in muscle activity and force between patients and healthy subjects. *Man Ther*. 2008;13:68-74. <http://dx.doi.org/10.1016/j.math.2006.08.006>
10. Dietz HP, Chantarasorn V, Shek KL. Levator avulsion is a risk factor for cystocele recurrence. *Ultrasound Obstet Gynecol*. 2010;36:76-80. <http://dx.doi.org/10.1002/uog.7678>
11. Dietz HP, Lanzarone V. Levator trauma after vaginal delivery. *Obstet Gynecol*. 2005;106:707-712. <http://dx.doi.org/10.1097/01.AOG.0000178779.62181.01>
12. Gutke A, Kjellby-Wendt G, Öberg B. The inter-rater reliability of a standardised classification system for pregnancy-related lumbopelvic pain. *Man Ther*. 2010;15:13-18. <http://dx.doi.org/10.1016/j.math.2009.05.005>
13. Gutke A, Östgaard HC, Öberg B. Pelvic girdle pain and lumbar pain in pregnancy: a cohort study of the consequences in terms of health and functioning. *Spine (Phila Pa 1976)*. 2006;31:E149-E155. <http://dx.doi.org/10.1097/01.brs.0000201259.63363.e1>
14. Healey EL, Fowler NE, Burden AM, McEwan IM. The influence of different unloading positions upon stature recovery and paraspinal muscle activity. *Clin Biomech (Bristol, Avon)*. 2005;20:365-371. <http://dx.doi.org/10.1016/j.clinbiomech.2004.11.003>
15. Hebert JJ, Koppenhaver SL, Parent EC, Fritz JM. A systematic review of the reliability of rehabilitative ultrasound imaging for the quantitative assessment of the abdominal and lumbar trunk muscles. *Spine (Phila Pa 1976)*. 2009;34:E848-E856. <http://dx.doi.org/10.1097/BRS.0b013e3181ae625c>
16. Hodges PW. Is there a role for transversus abdominis in lumbo-pelvic stability? *Man Ther*. 1999;4:74-86. <http://dx.doi.org/10.1054/math.1999.0169>
17. Hodges PW, Eriksson AE, Shirley D, Gandevia SC. Intra-abdominal pressure increases stiffness of the lumbar spine. *J Biomech*. 2005;38:1873-1880. <http://dx.doi.org/10.1016/j.jbiomech.2004.08.016>
18. Hodges PW, Moseley GL. Pain and motor control of the lumbopelvic region: effect and possible mechanisms. *J Electromyogr Kinesiol*. 2003;13:361-370.
19. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. *Spine (Phila Pa 1976)*. 1996;21:2640-2650.
20. Hu H, Meijer OG, Hodges PW, et al. Understanding the Active Straight Leg Raise (ASLR): an electromyographic study in healthy subjects. *Man Ther*. In press. <http://dx.doi.org/10.1016/j.math.2012.05.010>
21. Hu H, Meijer OG, van Dieën JH, et al. Muscle activity during the active straight leg raise (ASLR), and the effects of a pelvic belt on the ASLR and on treadmill walking. *J Biomech*. 2010;43:532-539. <http://dx.doi.org/10.1016/j.jbiomech.2009.09.035>
22. Hungerford B, Gilleard W, Hodges P. Evidence of altered lumbopelvic muscle recruitment in the presence of sacroiliac joint pain. *Spine (Phila Pa 1976)*. 2003;28:1593-1600.
23. Hungerford BA, Gilleard W, Moran M, Emmerson C. Evaluation of the ability of physical therapists to palpate intrapelvic motion with the Stork Test on the support side. *Phys Ther*. 2007;87:879-887. <http://dx.doi.org/10.2522/ptj.20060014>
24. Laslett M. Evidence-based diagnosis and treatment of the painful sacroiliac joint. *J Man Manip Ther*. 2008;16:142-152.
25. Lee AS, Cholewicki J, Reeves NP, Zazulak BT, Mysliwiec LW. Comparison of trunk proprioception between patients with low back pain and healthy controls. *Arch Phys Med Rehabil*. 2010;91:1327-1331. <http://dx.doi.org/10.1016/j.apmr.2010.06.004>
26. MacLennan AH, Taylor AW, Wilson DH, Wilson D. The prevalence of pelvic floor disorders and their relationship to gender, age, parity and mode of delivery. *BJOG*. 2000;107:1460-1470.
27. Mens JM, Damen L, Snijders CJ, Stam HJ. The mechanical effect of a pelvic belt in patients with pregnancy-related pelvic pain. *Clin Biomech (Bristol, Avon)*. 2006;21:122-127. <http://dx.doi.org/10.1016/j.clinbiomech.2005.08.016>

28. Mens JM, Huis in 't Veld YH, Pool-Goudzwaard A. The Active Straight Leg Raise test in lumbopelvic pain during pregnancy. *Man Ther.* 2012;17:364-368. <http://dx.doi.org/10.1016/j.math.2012.01.007>
29. Mens JM, Vleeming A, Snijders CJ, Koes BW, Stam HJ. Reliability and validity of the active straight leg raise test in posterior pelvic pain since pregnancy. *Spine (Phila Pa 1976).* 2001;26:1167-1171.
30. Mens JM, Vleeming A, Snijders CJ, Stam HJ, Ginai AZ. The active straight leg raising test and mobility of the pelvic joints. *Eur Spine J.* 1999;8:468-473.
31. Östgaard HC, Zetherström G, Roos-Hansson E. The posterior pelvic pain provocation test in pregnant women. *Eur Spine J.* 1994;3:258-260.
32. O'Sullivan PB, Beales DJ. Changes in pelvic floor and diaphragm kinematics and respiratory patterns in subjects with sacroiliac joint pain following a motor learning intervention: a case series. *Man Ther.* 2007;12:209-218. <http://dx.doi.org/10.1016/j.math.2006.06.006>
33. O'Sullivan PB, Beales DJ. Diagnosis and classification of pelvic girdle pain disorders—part I: a mechanism based approach within a biopsychosocial framework. *Man Ther.* 2007;12:86-97. <http://dx.doi.org/10.1016/j.math.2007.02.001>
34. Pool-Goudzwaard A, Gnat R, Spoor K. Deformation of the innominate bone and mobility of the pubic symphysis during asymmetric moment application to the pelvis. *Man Ther.* 2012;17:66-70. <http://dx.doi.org/10.1016/j.math.2011.09.002>
35. Pool-Goudzwaard AL, Slieker ten Hove MC, Vierhout ME, et al. Relations between pregnancy-related low back pain, pelvic floor activity and pelvic floor dysfunction. *Int Urogynecol J Pelvic Floor Dysfunct.* 2005;16:468-474. <http://dx.doi.org/10.1007/s00192-005-1292-7>
36. Pool-Goudzwaard AL, Vleeming A, Stoeckart R, Snijders CJ, Mens JM. Insufficient lumbopelvic stability: a clinical, anatomical and biomechanical approach to 'a-specific' low back pain. *Man Ther.* 1998;3:12-20. <http://dx.doi.org/10.1054/math.1998.0311>
37. Reeves NP, Narendra KS, Cholewicki J. Spine stability: lessons from balancing a stick. *Clin Biomech (Bristol, Avon).* 2011;26:325-330. <http://dx.doi.org/10.1016/j.clinbiomech.2010.11.010>
38. Reeves NP, Narendra KS, Cholewicki J. Spine stability: the six blind men and the elephant. *Clin Biomech (Bristol, Avon).* 2007;22:266-274. <http://dx.doi.org/10.1016/j.clinbiomech.2006.11.011>
39. Richardson CA, Snijders CJ, Hides JA, Damen L, Pas MS, Storm J. The relation between the transversus abdominis muscles, sacroiliac joint mechanics, and low back pain. *Spine (Phila Pa 1976).* 2002;27:399-405.
40. Sapsford RR, Hodges PW, Richardson CA, Cooper DH, Markwell SJ, Jull GA. Co-activation of the abdominal and pelvic floor muscles during voluntary exercises. *Neurourology.* 2001;20:31-42. [http://dx.doi.org/10.1002/1520-6777\(2001\)20:1<31::AID-NAU5>3.0.CO;2-P](http://dx.doi.org/10.1002/1520-6777(2001)20:1<31::AID-NAU5>3.0.CO;2-P)
41. Smith MD, Russell A, Hodges PW. Is there a relationship between parity, pregnancy, back pain and incontinence? *Int Urogynecol J Pelvic Floor Dysfunct.* 2008;19:205-211. <http://dx.doi.org/10.1007/s00192-007-0421-x>
42. Snijders CJ, Ribbers MT, de Bakker HV, Stoeckart R, Stam HJ. EMG recordings of abdominal and back muscles in various standing postures: validation of a biomechanical model on sacroiliac joint stability. *J Electromyogr Kinesiol.* 1998;8:205-214.
43. Stokes IA, Gardner-Morse MG, Henry SM. Abdominal muscle activation increases lumbar spinal stability: analysis of contributions of different muscle groups. *Clin Biomech (Bristol, Avon).* 2011;26:797-803. <http://dx.doi.org/10.1016/j.clinbiomech.2011.04.006>
44. Sturesson B, Uden A, Vleeming A. A radiostereometric analysis of movements of the sacroiliac joints during the standing hip flexion test. *Spine (Phila Pa 1976).* 2000;25:364-368.
45. van der Wurff P. Clinical diagnostic tests for the sacroiliac joint: motion and palpation tests. *Aust J Physiother.* 2006;52:308.
46. van Dieën JH, Selen LP, Cholewicki J. Trunk muscle activation in low-back pain patients, an analysis of the literature. *J Electromyogr Kinesiol.* 2003;13:333-351.
47. van Kessel-Cobelens AM, Verhagen AP, Mens JM, Snijders CJ, Koes BW. Pregnancy-related pelvic girdle pain: intertester reliability of 3 tests to determine asymmetric mobility of the sacroiliac joints. *J Manipulative Physiol Ther.* 2008;31:130-136. <http://dx.doi.org/10.1016/j.jmpt.2007.12.003>
48. Vleeming A, Albert HB, Östgaard HC, Sturesson B, Stuge B. European guidelines for the diagnosis and treatment of pelvic girdle pain. *Eur Spine J.* 2008;17:794-819. <http://dx.doi.org/10.1007/s00586-008-0602-4>
49. Vleeming A, Pool-Goudzwaard AL, Stoeckart R, van Wingerden JP, Snijders CJ. The posterior layer of the thoracolumbar fascia. Its function in load transfer from spine to legs. *Spine (Phila Pa 1976).* 1995;20:753-758.
50. Vleeming A, Stoeckart R, Volkers AC, Snijders CJ. Relation between form and function in the sacroiliac joint. Part I: clinical anatomical aspects. *Spine (Phila Pa 1976).* 1990;15:130-132.
51. Vleeming A, Volkers AC, Snijders CJ, Stoeckart R. Relation between form and function in the sacroiliac joint. Part II: biomechanical aspects. *Spine (Phila Pa 1976).* 1990;15:133-136.
52. Wang S, McGill SM. Links between the mechanics of ventilation and spine stability. *J Appl Biomech.* 2008;24:166-174.
53. Wu WH, Meijer OG, Uegaki K, et al. Pregnancy-related pelvic girdle pain (PPP), I: terminology, clinical presentation, and prevalence. *Eur Spine J.* 2004;13:575-589. <http://dx.doi.org/10.1007/s00586-003-0615-y>
54. Xu Y, Choi J, Reeves NP, Cholewicki J. Optimal control of the spine system. *J Biomech Eng.* 2010;132:051004. <http://dx.doi.org/10.1115/1.4000955>

A CLASSIFICATION-BASED COGNITIVE FUNCTIONAL APPROACH FOR THE MANAGEMENT OF BACK PAIN

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THE FAILURE OF CURRENT PRACTICE

Hi, I am almost 25 years old and up until June 2007 I was very active and played a lot of sport. My back problems began in late 2004. The physical therapist gave me core strength exercises. I was determined not to reinjure my back and did a lot of core stability/strength work prior to the June 2007 injury. In June 2007, I felt some restriction and pain on the lower right side of my back. It is still the same today and I am nowhere near the once active lifestyle I had a few years ago.

I have seen a number of specialists, including physical

therapists, chiropractors, osteopaths, an orthopaedic surgeon, neurosurgeon, sports physician, golf physical therapist, and pain doctor, and have tried orthotics to try and get rid of my leg length discrepancy.

My MRI shows a damaged L5-S1 disc and damaged L4-5 disc. Up until a few months ago, I didn't really know what was causing my pain, until I had a discogram done. I could only describe it as the worst pain I've ever had when they put a needle in my L5-S1 lumbar disc. This proved that the majority of the pain and problems are coming from this area. A neurosurgeon says he can perform a fusion on my lower back but I think this may be very risky.

I am disappointed that I can never play basketball, golf, and go for a run ever again. Does my back problem sound like something that you may be able to help me with? Is surgery the right thing for a 25-year-old? My pain is very restricting,

which is why I am considering surgery. I am even considering getting an ozone disc injection, which was recommended to me by a prolotherapist a few weeks ago.

Is this the kind of problem you can help? I would like to get a professional opinion on my back problem...

–E-mail, July 2010

This true story highlights the enormous personal, social, and economic burden of persistent back pain (PBP) disorders, and the failure of current therapies to effectively manage them. The biomedical approaches to manage PBP over the past 15 years have led to an exponential increase in rehabilitation therapies that have largely focused on enhancing the core stability of the spine, magnetic resonance imaging (MRI), spinal injections, surgical interventions, and pharmacological treatments, with a massive increase in healthcare costs. Ironically, this has been associated with a concurrent increase in disability related to PBP.⁷

THE MULTIDIMENSIONAL NATURE OF PBP

There is growing evidence that PBP disorders are associated with a complex combination of physical, lifestyle, cognitive, psychological, social, neurophysiological, and genetic factors that can coexist to maintain a vicious cycle of pain and disability.^{10,23}

Pathoanatomical Factors

- A definitive pathoanatomical diagnosis cannot be made for the majority of low back pain (LBP) disorders.²⁶
- There is a high prevalence of abnormal findings on MRI in pain-free populations (disc degeneration [91%], disc bulges [56%], disc protrusion [32%], annular tears [38%]).¹⁹
- Prospective research shows that depression is more predictive of future LBP than MRI findings.¹⁵
- Early MRI for minor back strains results in poorer prognosis, more sick leave, and a greater risk of surgery.²⁸
- Healthcare practitioners (HCPs) play a critical role in communicating radiology findings to the patient.

Physical Factors

- People with PBP demonstrate increased trunk muscle co-activation and an inability to relax the back muscles,^{5,11} as well as a tendency for earlier onset of activation of the transverse abdominal wall muscles,¹² challenging the basis of core stability practice prevalent in the world.
- Growing evidence suggests that people with PBP adopt maladaptive movement behaviors that become provocative of their disorder.^{5,22} This is like a limp that persists past natural tissue healing time. These behaviors are not stereotypical^{5,22} and can be characterized and identified by trained therapists.^{6,9}
- High levels of back muscle electromyography correlate with pain intensity, disability levels, and a range of psychological factors, supporting the close mind-body relationship in people with PBP.¹⁶

relationship in people with PBP.¹⁶

- There is evidence that altered movement behaviors are associated with central nervous system changes reflecting altered body schema.^{18,27}

LIFESTYLE FACTORS

- Lifestyle factors such as smoking, sedentary behaviors, activity levels, obesity, sleep deficits, and chronic stress are all known to be risk factors for LBP.^{2,20}
- Cognitive and psychosocial factors.
- Cognitive factors such as negative LBP beliefs and fear of movement and activity are more predictive of disability than pain intensity levels.³ HCPs provide a critical role in transferring back pain beliefs to their patients. Language such as “your back is unstable” may be interpreted as “my back is damaged and it is dangerous to move.” A “lack of core stability” may mean to the patient that “my back is weak and vulnerable and I need to be vigilant to protect it when I move.”
- Emotional factors such as fear, stress, anxiety and depression, catastrophizing, and vigilance act to reinforce maladaptive behaviors, further enhancing the pain experience and disability levels.¹⁰ They also influence pain processing via dysregulation of the hypothalamic-pituitary-adrenal axis and altered immune and neuroendocrine function.⁴

Social Factors

- Factors such as work and family stress, poor family functioning, low job satisfaction, low socioeconomic level, and cultural factors have an influence on pain beliefs, coping, and vulnerability.^{10,23}

Neurophysiological Factors

- PBP has been associated with a loss of gray matter, increased resting state of the brain, changes in the sensorimotor cortex/body schema, and loss of endogenous pain inhibition.²⁷ These factors contribute to widespread sensory changes as well as altered motor and movement disturbances.^{21,27}
- LBP may manifest as any one or a combination of pain states (nociceptive, inflammatory, functional, and neuropathic), with different associated sensory profiles, supporting the need for targeted management.²⁹

Individual Considerations

- The presence of health and pain comorbidities; perceived general health; and the patient’s goals, values, health literacy, levels of acceptance, expectation, and readiness for change are known to be important considerations in the assessment, management, and prognosis of people with LBP.^{3,10,23,25}

Genetic Factors

- There is growing evidence to support that genetic-environmental factors contribute to the development and progression of PBP.

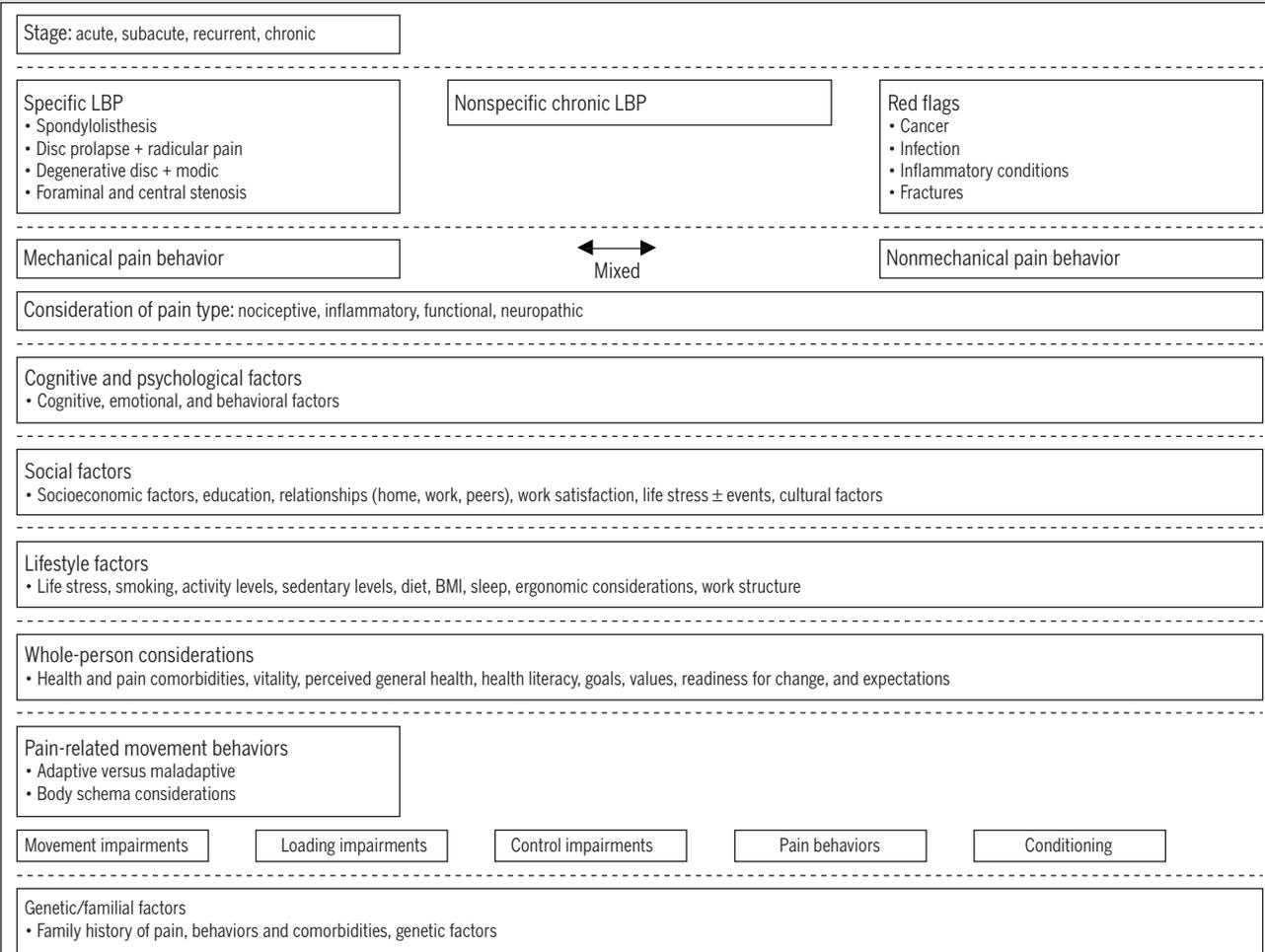


FIGURE. Multidimensional classification for low back pain.

ronmental interactions have a potential influence on pain vulnerability in specific populations.^{10,24}

- There is a clear need for a consensus in the diagnosis and classification of LBP disorders. A multidimensional model (**FIGURE**) is proposed, directed by a clinical reasoning process based on the patient’s “story,” screening questionnaires,^{13,17} and clinical examination. During this process, consideration is made to determine the relative weighting, dominance, and relevance of the different factors to the person’s disorder.

COGNITIVE FUNCTIONAL APPROACH TO MANAGE PBP DISORDERS

There is growing evidence to support that, for many patients with PBP, targeting the beliefs and behaviors that drive pain and disability is more effective than simply treating the symptom of pain.^{1,8,14}

An integrated person-centered and goal-orientated management approach for PBP called cognitive functional therapy (CFT) is proposed. The focus of this process is directed by the findings on the multidimensional examination (**FIGURE**)

as to the primary contributing factors (across the different domains) linked to the person’s disorder.

The key components of the CFT approach involve the following:

- Addressing negative beliefs and fear regarding pain and MRI findings.
- Providing effective patient-centered education regarding the multidimensional mechanisms that drive the vicious cycle of pain and disability.
- Promoting active coping strategies for pain and instilling confidence and hope for change.
- Facilitating goal-orientated behavioral change regarding stress management, sleep hygiene, physical activity, pacing, and diet.
- Utilizing motivational interviewing techniques.
- Training mindfulness of body and movement (body schema retraining).
- Feedback is critical to this process and involves:
 - Mindfulness of the body-mind responses to pain, movement, and its perceived threat.
 - Visual feedback with the use of mirrors, video, and

written instruction.

- Maladaptive movement and pain behaviors are identified and provocative movement patterns are broken down into component parts and retrained in a mindful/relaxed manner.
- The “new” movement behaviors are gradually targeted toward the activities and movements that provoke pain and/or are avoided by the patient to reduce the threat value of the task and normalize it.
- These new behaviors are then integrated into activities of daily life to ensure carryover to activities of daily living.
- Targeted strengthening and conditioning are incorporated as required by the functional goals of the patient.

In situations where central pain mechanisms and/or psychological comorbidities dominate, CFT may need to be integrated with medical and/or psychological management. Manual therapy is only used as a window of opportunity to change behaviors where movement impairments are present.

A recent randomized controlled trial has demonstrated that CFT resulted in superior outcomes (reduced pain intensity and episodes, disability, fear, improved mood, less need for ongoing care, and reduced sick leave) when compared to manual therapy and stabilizing exercises.⁸ Further trials are under way.

It is proposed that this model of assessment and management applies to musculoskeletal pain disorders in general.

WHAT HAPPENED TO THE YOUNG MAN?

The young man in the story had a belief that his back was damaged and no active coping strategies to manage it. He was hypervigilant to his pain, fearful, anxious, and avoidant of movement and activity. He had a predominant mechanical behavior to his pain linked to movement and loading. This was reinforced by maladaptive movement behaviors related to avoiding loading his right leg and abnormal bracing strategies through his back and abdominal wall muscles, due to fear of pain. He was highly deconditioned, was in a depressed state, and had low levels of self-efficacy. He adopted unhealthy lifestyle habits such as sedentary behaviors, slept poorly, and adopted unhealthy dietary habits. He had little hope for change. Many of his beliefs and behaviors were reinforced by well-meaning HCPs.

He was provided with a CFT intervention based on these findings. This involved education that his MRI findings were common in active people without pain, and that pain did not equal harm. It was explained that his pain state represented sensitization of his nervous system, fed by a vicious cycle of fear, anxiety, negative beliefs, vigilance, protective muscle guarding, and avoidance of movement and activity. He was educated that the spine is strong and robust and about the importance of adopting relaxed, normal patterns of movement.

In conjunction with this, he underwent a graduated func-

tional rehabilitation program that focused on training him to relax his back and abdominal wall muscles with diaphragm breathing and adopting relaxed postures and movements. He was given a graduated program of loading his right leg with visual mirror feedback to reinforce a normal body schema. Once he realized that loading his leg and moving in a relaxed manner did not provoke his back pain, his fear of movement reduced. This was progressed in a gym setting, where his functional capacity was gradually developed around his goals to run and play golf and basketball again. Whole-body functional movements specific to his sport were used to reinforce his confidence in this process.

These are his words after completing this program:

Just an update on my lower back problem. It has been just over 6 months since I began my rehab program and I have improved in lots of areas. My fitness has gotten better and I am doing things that I believed I would never do again. A previous PT told me I could never run again. I ran 5 km the other day, played basketball, and then played volleyball in the evening. I am doing these things with a bit of pain, but it decreases when I'm active and not thinking about it. On a good day I almost feel perfectly normal and just want to go out and be active. I would like to thank you for getting me back on the right track.

–E-mail, December 2010

This young man is now (2 years later) traveling around the world with no need for ongoing healthcare, has confidence in his back, and has full functional capacity and hope for the future. This outcome is not the case for all people with PBP, and, sadly, many never get the opportunity to take this journey.

It is our challenge as HCPs to help our patients on this journey!

(E-mails published with permission.)

REFERENCES

1. Åsenlöf P, Denison E, Lindberg P. Long-term follow-up of tailored behavioural treatment and exercise based physical therapy in persistent musculoskeletal pain: a randomized controlled trial in primary care. *Eur J Pain*. 2009;13:1080-1088. <http://dx.doi.org/10.1016/j.ejpain.2009.01.010>
2. Björck-van Dijken C, Fjellman-Wiklund A, Hildingsson C. Low back pain, lifestyle factors and physical activity: a population-based study. *J Rehabil Med*. 2008;40:864-869. <http://dx.doi.org/10.2340/16501977-0273>
3. Briggs AM, Jordan JE, Buchbinder R, et al. Health literacy and beliefs among a community cohort with and without chronic low back pain. *Pain*. 2010;150:275-283. <http://dx.doi.org/10.1016/j.pain.2010.04.031>
4. Campbell CM, Edwards RR. Mind-body interactions in pain: the neurophysiology of anxious and catastrophic pain-related thoughts. *Transl Res*. 2009;153:97-101. <http://dx.doi.org/10.1016/j.trsl.2008.12.002>
5. Dankaerts W, O'Sullivan P, Burnett A, Straker L, Davey P, Gupta R. Discriminating healthy controls and two clinical subgroups of nonspecific chronic low back pain patients using trunk muscle activation and lumbosacral kinematics of postures and movements: a statistical classification model. *Spine (Phila Pa 1976)*. 2009;34:1610-1618. <http://dx.doi.org/10.1097/BRS.Ob013e3181aa6175>
6. Dankaerts W, O'Sullivan PB, Straker LM, Burnett AF, Skouen JS. The inter-

examiner reliability of a classification method for non-specific chronic low back pain patients with motor control impairment. *Man Ther.* 2006;11:28-39. <http://dx.doi.org/10.1016/j.math.2005.02.001>

7. Deyo RA, Mirza SK, Turner JA, Martin BI. Overtreating chronic back pain: time to back off? *J Am Board Fam Med.* 2009;22:62-68. <http://dx.doi.org/10.3122/jabfm.2009.01.080102>
8. Fersum KV, O'Sullivan P, Kvåle A, Smith A, Skouen J. Classification based cognitive functional therapy for the management of non-specific low back pain (NSLBP) – a randomized control trial. *Melbourne International Forum XI: Primary Care Research on Low Back Pain*; March 15-18, 2011; Melbourne, Australia.
9. Fersum KV, O'Sullivan PB, Kvåle A, Skouen JS. Inter-examiner reliability of a classification system for patients with non-specific low back pain. *Man Ther.* 2009;14:555-561. <http://dx.doi.org/10.1016/j.math.2008.08.003>
10. Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC. The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychol Bull.* 2007;133:581-624. <http://dx.doi.org/10.1037/0033-2909.133.4.581>
11. Geisser ME, Haig AJ, Wallbom AS, Wiggert EA. Pain-related fear, lumbar flexion, and dynamic EMG among persons with chronic musculoskeletal low back pain. *Clin J Pain.* 2004;20:61-69.
12. Gubler D, Mannion AF, Schenk P, et al. Ultrasound tissue Doppler imaging reveals no delay in abdominal muscle feed-forward activity during rapid arm movements in patients with chronic low back pain. *Spine (Phila Pa 1976).* 2010;35:1506-1513. <http://dx.doi.org/10.1097/BRS.0b013e3181c3ed41>
13. Hill JC, Vohora K, Dunn KM, Main CJ, Hay EM. Comparing the STarT back screening tool's subgroup allocation of individual patients with that of independent clinical experts. *Clin J Pain.* 2010;26:783-787. <http://dx.doi.org/10.1097/AJP.0b013e3181f18aac>
14. Hill JC, Whitehurst DG, Lewis M, et al. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. *Lancet.* 2011;378:1560-1571. [http://dx.doi.org/10.1016/S0140-6736\(11\)60937-9](http://dx.doi.org/10.1016/S0140-6736(11)60937-9)
15. Jarvik JG, Hollingworth W, Heagerty PJ, Haynor DR, Boyko EJ, Deyo RA. Three-year incidence of low back pain in an initially asymptomatic cohort: clinical and imaging risk factors. *Spine (Phila Pa 1976).* 2005;30:1541-1548; discussion 1549.
16. Lewis S, Holmes P, Woby S, Hindle J, Fowler N. The relationships between measures of stature recovery, muscle activity and psychological factors in patients with chronic low back pain. *Man Ther.* 2012;17:27-33. <http://dx.doi.org/10.1016/j.math.2011.08.001>
17. Linton SJ, Boersma K. Early identification of patients at risk of developing a

persistent back problem: the predictive validity of the Örebro Musculoskeletal Pain Questionnaire. *Clin J Pain.* 2003;19:80-86.

18. Luomajoki H, Moseley GL. Tactile acuity and lumbopelvic motor control in patients with back pain and healthy controls. *Br J Sports Med.* 2011;45:437-440. <http://dx.doi.org/10.1136/bjsm.2009.060731>
19. McCullough BJ, Johnson GR, Martin BI, Jarvik JG. Lumbar MR imaging and reporting epidemiology: do epidemiologic data in reports affect clinical management? *Radiology.* 2012;262:941-946. <http://dx.doi.org/10.1148/radiol.11110618>
20. Mitchell T, O'Sullivan PB, Burnett A, et al. Identification of modifiable personal factors that predict new-onset low back pain: a prospective study of female nursing students. *Clin J Pain.* 2010;26:275-283. <http://dx.doi.org/10.1097/AJP.0b013e3181cd16e1>
21. Moseley GL. Pain, brain imaging and physiotherapy—opportunity is knocking. *Man Ther.* 2008;13:475-477. <http://dx.doi.org/10.1016/j.math.2008.10.001>
22. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Man Ther.* 2005;10:242-255. <http://dx.doi.org/10.1016/j.math.2005.07.001>
23. O'Sullivan P. It's time for change with the management of non-specific chronic low back pain. *Br J Sports Med.* 2012;46:224-227. <http://dx.doi.org/10.1136/bjsm.2010.081638>
24. Skouen JS, Smith AJ, Warrington NM, et al. Genetic variation in the beta-2 adrenergic receptor is associated with chronic musculoskeletal complaints in adolescents. *Eur J Pain.* 2012;16:1232-1242. <http://dx.doi.org/10.1002/j.1532-2149.2012.00131.x>
25. Tschudi-Madsen H, Kjeldsberg M, Natvig B, et al. A strong association between non-musculoskeletal symptoms and musculoskeletal pain symptoms: results from a population study. *BMC Musculoskelet Disord.* 2011;12:285. <http://dx.doi.org/10.1186/1471-2474-12-285>
26. Waddell G. *The Back Pain Revolution.* 2nd ed. New York, NY: Churchill Livingstone; 2004.
27. Wand BM, Parkitny L, O'Connell NE, et al. Cortical changes in chronic low back pain: current state of the art and implications for clinical practice. *Man Ther.* 2011;16:15-20. <http://dx.doi.org/10.1016/j.math.2010.06.008>
28. Webster BS, Cifuentes M. Relationship of early magnetic resonance imaging for work-related acute low back pain with disability and medical utilization outcomes. *J Occup Environ Med.* 2010;52:900-907. <http://dx.doi.org/10.1097/JOM.0b013e3181ef7e53>
29. Woolf CJ. What is this thing called pain? *J Clin Invest.* 2010;120:3742-3744. <http://dx.doi.org/10.1172/JCI45178>

WHAT IS OUR BASELINE FOR MOVEMENT? THE CLINICAL NEED FOR MOVEMENT SCREENING AND ASSESSMENT

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The musculoskeletal system is unique among the systems of the human body. However, unlike other systems of the body, we professionals wait for symptoms before we consider the meaningful signs of dysfunction and disease. Screening for and proactive early detection of dysfunction have been an evolutionary hallmark among many other health and medical practices, such as optometry, dentistry, and cardiology, for example. We currently benefit from the use of meaningful biomarkers of elevated risk and dysfunction for other organ systems in the body, but we have not used this example or

taken the challenge to employ the same logic into orthopaedic practice. Orthopaedic practice lags behind other medical specialties in the field of risk prediction and postrehabilitation prognosis. Most other specialty practices routinely investigate clinical signs with established biomarkers to practice in a proactive manner, and acting whenever possible before symptoms are present. Conservative orthopaedic practice does not currently support a standard operating procedure (SOP) for movement-related biomarkers for prognosis and future risk prediction. An effort to establish movement-related biomarkers would support both clinical practice as well as the clinical efficacy of yearly preventative screens in the active asymptomatic population.

As orthopaedic physical therapists, if we were given access to the general public for a yearly movement-based checkup, what would we do? How would we handle this responsibility?

ity? Would we employ our standard orthopaedic exam designed for symptomatic clinical situations? Would we act based on the current best evidence for injury risk prediction? Hopefully, we would realize the significant difference between screening for meaningful biomarkers and assessing an individual with clinical signs and symptoms to establish a functional diagnosis. Movement-based screening, testing, and assessment are different tools with a common purpose. They are designed to connect movement impairments with movement behaviors in a systematic way. The systematic approach to movement-pattern appraisal is also designed to assist the clinician with the most complementary exercise choices that reinforce appropriate manual therapies. Historically, manual therapists have followed an anatomical and kinesiological approach to exercise. The new paradigm requires the consideration of developmental movement patterns and reacquisition of motor control. Patients with the same orthopaedic presentation may have unique and individual movement profiles, leading to compensation in different ways. Because of these differences, the ideal exercise approach will vary, even though the manual and modality treatments might be identical.

PAIN AND MOTOR CONTROL

It is well established in the scientific literature, as well as clinical practice, that musculoskeletal pain alters motor control. A better understanding of the underlying mechanisms related to these changes will help provide further rationale supporting the need for individual movement-oriented screening, testing, and assessment, regardless of the regional approach employed by the clinician.

Originally, pain was thought to affect motor control simply through reflex-driven muscle spasm or splinting. Observation and measurement of diminished motor control in the presence of pain led to the development of the pain adaptation theory that suggested that pain-related changes were likely due to the role of the muscle as an agonist or antagonist.¹⁶ A better understanding of the complexity of the motor system and pain has led to what Hodges and Tucker¹¹ describe as a “new theory” of how pain affects motor control. This theory describes 5 tenets of the effect of pain on motor control. The theory describes how the role of a given muscle can change under the influence of pain in a somewhat unpredictable manner. In some circumstances, pain causes an increase in a given muscle’s activation level, whereas in other circumstances pain causes a decrease in activation to a given muscle.¹⁴ This so-called “redistribution” of responsibility occurs between and within muscles. The response is thought to be, in part, task dependent, leading to variability among individuals. Some individuals will revert to their normal motor control strategies when the painful condition has resolved, whereas others will retain the painful motor strategy, even after the painful episode subsides. The theory goes on to state

that pain-driven changes occur at multiple levels in the motor control system, which include planning regions in the cortex, helping to explain the altered movement patterns observed clinically. Ultimately, the theory concludes that “people move differently in pain,” highlighting the importance of clinically distinguishing painful movement patterns from nonpainful movement patterns.

It is difficult to predict the long-term effects of pain-mediated motor control changes on musculoskeletal health. There is 1 compelling risk factor from the sports medicine literature that may help us understand the effect that altered motor control has on injury. Multiple prospective studies have indicated that the strongest predictor of future injury is previous injury.⁹ This statistic implies that rehabilitation might be less successful for long-term outcomes even when short-term success is appreciated through symptom management and return to previous level of activity. There are now several studies that have identified a link between dysfunctional movement patterns (limited or asymmetrical) and subsequent injury. We must embrace the concept that symptom resolution and functional restoration should have independent measurement tools and be used together to demonstrate resolution of movement-related pain and dysfunction. Regardless of rehabilitation approach or program, a standardized movement-oriented screen is needed to identify and document motor control dysfunction that may not be directly related to the painful region but is likely to contribute to subsequent injury in the future.

CLINICAL APPLICATION

It is thought that pain-related changes in motor strategy may have profound effects on future injury and in part help explain why previous injury is such a strong predictor of future injury. This has been shown even when standard clinical measures, such as strength and range of motion, are normalized at discharge.¹ Thus, healthcare professionals need a systematic method to clinically screen and assess movement patterns and to demonstrate a direct connection between impairment measurements and movement-pattern dysfunction. This systematic process would serve to refine the initial evaluation and discharge criteria by identifying dysfunction not necessarily linked to symptoms. Systematization of movement-pattern dysfunction identification would also allow the clinician to train and refine corrective exercise and direct efforts toward restoration of movement patterns during the rehabilitation process. This approach would create corrective exercise options that capture both local segment dysfunction, as well as dysfunctions in other regions that might otherwise be overlooked in a regional approach.

FUNCTIONAL MOVEMENT SYSTEMS

The functional movement systems are a group of move-

ment-based appraisals that focus on biomarkers of movement quality. Collectively, our consistent use of standards is far more developed with measurement and categorization of movement quantities than movement qualities. These systems have been set forth to establish biomarkers within human movement patterns. The screening system is designed to provide SOPs for identifying movement-pattern asymmetries and motor control limitations, in practice, categorizing risk and providing suggested corrective strategies. The system also offers higher levels of testing when asymmetry and motor control are considered problematic with basic screening. Last, a movement-pattern assessment model helps the clinician to separate asymptomatic dysfunctional movement patterns from movement patterns that produce symptoms and may or may not be dysfunctional. To accomplish this, the functional movement systems provide a basic screening SOP, a measurement and testing SOP, and a diagnostic assessment SOP.

The Functional Movement Screen—The Categorization and Predictive System

The Functional Movement Screen (FMS) is a reliable^{7,17,22,23} screening system created to rank movement patterns that are fundamental to normal function. By screening these patterns, movement limitations and asymmetries are readily identified and measured. Basic movement-pattern limitation and asymmetry are thought to reduce the effects of functional training and physical conditioning, and recent data suggest that these factors may be related to injury.^{2,4,13,19} One goal of the FMS is to identify active individuals and athletes with movement-pattern limitations so individualized corrective exercise can be prescribed to normalize movement prior to an increase in physical stress, physical training, or a competitive sports season. Researchers have demonstrated that a standardized individual program, based in corrective exercise, does improve dysfunctional movement and asymmetry as measured by the FMS.¹² The system is equally effective in tactical populations and the active general population because the basic screen only considers fundamental movement patterns that support more specialized skills and conditioning. The FMS is simply a screen and is therefore designed for those individuals who do not have a known musculoskeletal injury or patients who are asymptomatic and are nearing discharge to active, athletic, or tactical situations.

The Y-Balance Tests—The Measurement System

The Y-balance tests are clinically reliable^{8,20,26} and serve as tools for both clinical measurement and predictive testing for risk.^{6,21} They functionally represent the upper and lower quarters of the body, and researchers have demonstrated that normative values on Y-balance test performance vary based on gender, age, and sport played. The tests require moderate to advanced motor control abilities and should be used in

asymptomatic situations to accurately measure motor control abilities. They provide systematic feedback about the effectiveness of manual therapy and corrective exercise on motor control and movement-pattern symmetry. They can be used throughout the rehabilitation process and are recommended as part of a standard return-to-activity testing protocol.

The Selective Functional Movement Assessment—The Diagnostic System

The Selective Functional Movement Assessment (SFMA) is specifically designed for clinical situations in which movement is complicated by symptoms. The SFMA is a series of 7 full-body movement tests designed to assess fundamental patterns of movement such as bending, twisting, and squatting in those with known musculoskeletal pain.⁵ The SFMA is a tool within the complete evaluation that complements the standard musculoskeletal exam in 2 distinct ways. First, when the clinical assessment is initiated from the perspective of the movement pattern, the clinician has the opportunity to identify meaningful impairments that may be seemingly unrelated to the main musculoskeletal complaint but contribute to the associated disability. This concept, known as regional interdependence,²⁵ is a hallmark of the SFMA that guides the clinician to the most dysfunctional nonpainful movement pattern, which is then assessed in detail. Second, the SFMA is specifically designed to assist the clinician in the most effective therapeutic exercise choices targeting movement-pattern restoration. Manual therapy is highly effective at managing the impairment level of motor control; however, the orthopaedic clinician must also utilize the most successful strategies to restore motor control through developmental movement patterns and facilitation techniques. Following the logic in the SFMA, each pattern is assigned to 1 of 4 categories: functional and nonpainful, functional and painful, dysfunctional and nonpainful, and dysfunctional and painful. Next, following a systematic approach, the dysfunctional patterns are broken down to identify the root cause of the dysfunction as primarily a mobility deficit or a stability/motor control deficit. The system accounts for managing multiple dysfunctional patterns simultaneously, and, with this knowledge, a precise intervention can be prescribed to normalize the dysfunctional patterns from a motor control perspective.

CONCLUSION

There is a need within musculoskeletal medicine to transition to a proactive preventative model. Because it is known that injury and pain adversely affect movement^{10,11} and that functional asymmetry^{15,18,21,24} and dynamic neuromuscular control^{3,21,27} are also predictors of injury, a systematic method is needed to screen, test, and assess patients and clients from a motor control perspective. Movement-oriented assessment should be utilized throughout the rehabilitation process, regardless of the approach employed. Movement-based test-

ing should be used to document changes in motor control throughout the rehabilitation process and in screening for injury risk at or near discharge. These tests, carried out by the orthopaedic clinician, should be used to ensure that evidence-based movement-oriented risk factors have been resolved. Evidence suggests that this same screen should be used in asymptomatic individuals prior to a planned increase in physical activity. Additionally, the screen should also be used in concert with the yearly medical exam to document musculoskeletal risk factors prior to the onset of symptoms, allowing the opportunity for preventative intervention.

Mr Cook is owner of Functional Movement Systems Inc (Functional Movement Screen) and co-owner of SFMA LLC (Selective Functional Movement Assessment).

REFERENCES

1. Ardern CL, Taylor NF, Feller JA, Webster KE. Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *Am J Sports Med.* 2012;40:41-48. <http://dx.doi.org/10.1177/0363546511422999>
2. Butler RJ, Contreras M, Burton L, Plisky PJ, Kiesel KB. Modifiable risk factors predict injuries in firefighters during training academies. *Work.* In press.
3. Cholewicki J, Silfies SP, Shah RA, et al. Delayed trunk muscle reflex responses increase the risk of low back injuries. *Spine (Phila Pa 1976).* 2005;30:2614-2620.
4. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *N Am J Sports Phys Ther.* 2010;5:47-54.
5. Cook G, Burton L, Kiesel K, Rose G, Bryant MF. *Movement: Functional Movement Systems: Screening—Assessment—Corrective Strategies.* Aptos, CA: On Target Publications; 2010.
6. de Noronha M, França LC, Haupenthal A, Nunes GS. Intrinsic predictive factors for ankle sprain in active university students: a prospective study. *Scand J Med Sci Sports.* In press. <http://dx.doi.org/10.1111/j.1600-0838.2011.01434.x>
7. Frohm A, Heijne A, Kowalski J, Svensson P, Myklebust G. A nine-test screening battery for athletes: a reliability study. *Scand J Med Sci Sports.* 2012;22:306-315. <http://dx.doi.org/10.1111/j.1600-0838.2010.01267.x>
8. Gorman PP, Butler RJ, Plisky PJ, Kiesel KB. Upper quarter Y balance test: reliability and performance comparison between gender in active adults. *J Strength Cond Res.* In press. <http://dx.doi.org/10.1519/JSC.0b013e3182472fdb>
9. Hagglund M, Walden M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med.* 2006;40:767-772. <http://dx.doi.org/10.1136/bjsm.2006.026609>
10. Hodges PW. Pain and motor control: from the laboratory to rehabilitation. *J Electromyogr Kinesiol.* 2011;21:220-228. <http://dx.doi.org/10.1016/j.jelekin.2011.01.002>
11. Hodges PW, Tucker K. Moving differently in pain: a new theory to explain the adaptation to pain. *Pain.* 2011;152:S90-S98. <http://dx.doi.org/10.1016/j.pain.2010.10.020>

12. Kiesel K, Plisky P, Butler R. Functional movement test scores improve following a standardized off-season intervention program in professional football players. *Scand J Med Sci Sports.* 2011;21:287-292. <http://dx.doi.org/10.1111/j.1600-0838.2009.01038.x>
13. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason Functional Movement Screen? *N Am J Sports Phys Ther.* 2007;2:147-158.
14. Kiesel KB, Butler RJ, Duckworth A, et al. Experimentally induced pain alters the EMG activity of the lumbar multifidus in asymptomatic subjects. *Man Ther.* 2012;17:236-240. <http://dx.doi.org/10.1016/j.math.2012.01.008>
15. Knapik JJ, Bauman CL, Jones BH, Harris JM, Vaughan L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med.* 1991;19:76-81.
16. Lund JP, Donga R, Widmer CG, Stohler CS. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. *Can J Physiol Pharmacol.* 1991;69:683-694.
17. Minick KI, Kiesel KB, Burton L, Taylor A, Plisky P, Butler RJ. Interrater reliability of the Functional Movement Screen. *J Strength Cond Res.* 2010;24:479-486. <http://dx.doi.org/10.1519/JSC.0b013e3181c09c04>
18. Nadler SF, Malanga GA, Feinberg JH, Prybcien M, Stitik TP, DePrince M. Relationship between hip muscle imbalance and occurrence of low back pain in collegiate athletes: a prospective study. *Am J Phys Med Rehabil.* 2001;80:572-577.
19. O'Connor FG, Deuster PA, Davis J, Pappas CG, Knapik JJ. Functional movement screening: predicting injuries in officer candidates. *Med Sci Sports Exerc.* 2011;43:2224-2230. <http://dx.doi.org/10.1249/MSS.0b013e318223522d>
20. Plisky PJ, Gorman PP, Butler RJ, Kiesel KB, Underwood FB, Elkins B. The reliability of an instrumented device for measuring components of the Star Excursion Balance Test. *N Am J Sports Phys Ther.* 2009;4:92-99.
21. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *J Orthop Sports Phys Ther.* 2006;36:911-919. <http://dx.doi.org/10.2519/jospt.2006.2244>
22. Schneiders AG, Davidsson A, Hörman E, Sullivan SJ. Functional Movement Screen normative values in a young, active population. *Int J Sports Phys Ther.* 2011;6:75-82.
23. Teyhen DS, Shaffer SW, Lorenson CL, et al. The Functional Movement Screen: a reliability study. *J Orthop Sports Phys Ther.* 2012;42:530-540. <http://dx.doi.org/10.2519/jospt.2012.3838>
24. Tyler TF, McHugh MP, Mirabella MR, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school football players: the role of previous ankle sprains and body mass index. *Am J Sports Med.* 2006;34:471-475. <http://dx.doi.org/10.1177/0363546505280429>
25. Wainner RS, Whitman JM, Cleland JA, Flynn TW. Regional interdependence: a musculoskeletal examination model whose time has come. *J Orthop Sports Phys Ther.* 2007;37:658-660. <http://dx.doi.org/10.2519/jospt.2007.0110>
26. Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the Y-balance test for assessment of upper quarter closed kinetic chain performance. *Int J Sports Phys Ther.* 2012;7:139-147.
27. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J. Deficits in neuromuscular control of the trunk predict knee injury risk: a prospective biomechanical-epidemiologic study. *Am J Sports Med.* 2007;35:1123-1130. <http://dx.doi.org/10.1177/0363546507301585>

MANUAL THERAPY IN A NEUROPLASTIC WORLD

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THE NEUROPLASTICITY PARADIGM

In a Kuhnian sense,¹² a paradigm is an overarching way of thinking, a framework under which we think about, research, and manage clients and, in fact, live. Biomechanics and gate control theory are examples. But paradigms shift

in their importance, and we are now aware of a massive and recent increase in the understanding of brain function and, in particular, its changeability. It is appropriate to ascribe paradigm status to neuroplasticity. We didn't have such a paradigm when many of us started in manual therapy. The notion that the C2-3 joint that we were mobilizing was also plastically represented in the brain was quite foreign.

Basically, this paradigm suggests that the human brain is extremely changeable throughout the lifespan, that functions do not necessarily reside in a particular area, that it can change from within, and that the essential learning and memory changes usually happen to the benefit of the species.

We are well into the neuroplasticity paradigm—25 years at least, if you date it from pioneering work such as that by Merzenich, Taub, Pascual-Leone, Bach-y-Rita, Ramachandran, and Flor, among others. Thirty-five thousand books on the brain are now available to the public, of which *The Brain That Changes Itself*⁶ has been rated the best.⁷

Neuroplasticity is strongly linked with information domains such as neuroimmunology, central sensitization, genetics, and learning theory, among others. It also facilitates a neurophilosophy allowing clinical frameworks for brain engagement, such as neuromatrix and neurosignatures.^{15,17}

GIFTS FROM THE NEUROPLASTICITY PARADIGM

The world of science bears gifts—like an apple tree—and the professionals who take science to therapeutic destinations can select and pluck apples of knowledge and philosophy, road test them, and potentially enrich the profession. The neuroplasticity paradigm is particularly generous with its offerings. Here is my view on 4 selected gifts (among many) that encourage a fresh perspective for manual therapy:

- Manual therapist as biopsychosocialist
- Manual therapist as brain reinhibitor and sculptor
- Manual therapist as immunotherapist
- Manual therapist as linguist

MANUAL THERAPIST AS BIOPSYCHOSOCIALIST

Clinical trials, meta-analyses, expert opinion, numerous textbooks, and bodies such as the World Health Organization support a biopsychosocial framework as the way to go for managing spinal pain. However, the so-called opposing view, biomedicalism (“find it and fix it”), has served us well, and many of us may be alive and healthy today because of it, thus creating a barrier to change. An additional problem occurs, as therapists are known to hold both mental frameworks when managing pain.^{5,11,21}

Biopsychosocialism, if you'll excuse the Marxist language, has been around for at least 35 years, but a “new” biopsychosocialism, refreshed particularly by the neuroimmune sciences, has emerged.¹⁰ A unity of the 3 components of *bio*, *psycho*, and *social* is occurring. For example, the biological substrates of cognitions and emotions are becoming clearer and there is

an awareness that the problems our patients have (eg, limited health literacy) are problems in society as a whole.

Biomedicalism does not work for chronic disease states or anywhere a problem has multiple causes and depends on what a person thinks and does about it. Manual therapists are asked to reflect on their mental framework for management and on the suggestion that the one overwhelming but generous and inclusive framework of biopsychosocialism will be most effective. Biomedicalism fits into biopsychosocialism, but the reverse is not possible. Biopsychosocialism welcomes and embraces biomedical thinking and enriches it by the addition of interactions between brain and body, preventative medicine, interdisciplinary medicine, and psychosocial predictors of chronic problems.

Simply said, you can manipulate a joint in a biopsychosocial framework. It may be as simple as asking the question, “Why did this person end up as a patient?”

MANUAL THERAPIST AS BRAIN REINHIBITOR AND SCULPTOR

The “hibitions”—inhibition, disinhibition, and reinhibition—have confused generations of therapists. Reinhibition may well be our most potent therapeutic avenue and most valuable gift from the paradigm.

To have useful patterns of activity (neurosignatures), say, of an index finger sensory representation in the brain, the neurones that are needed to represent the finger at a particular time are turned on, and neurones that don't usually appear in the finger representation are inhibited. We are aware, from brain mapping research, that in certain situations columns of neurones around the finger can become disinhibited (excited) and join into the representation of the index finger. The index finger representation may broaden and move a little in the brain. Spread of pain, weaker 2-point discrimination skills, and difficulty moving the fingers independently may result. Many reviews exist.^{9,18,22} The term *smudging* has emerged to describe these plasticity changes. Clear thoughts and cloudy thoughts would have similar mechanisms, and the paradigm allows the notion that neighboring relational cells drawn into the index finger could represent other fingers, the elbow, the other side, or even a thought or a memory.

Manual therapists have been reinhibiting and brain sculpting all along, and, although there is evidence of reversal of these changes,¹⁴ it is logical that brain changes must reverse for better health. Early restoration of movement, reduction of fear to facilitate movement, empowering education, limiting lingering unhelpful metaphors, mobilization of a part, meaningful movement, and even getting to like the body part and reintegrate it are all potential reinhibitory brain resculpting techniques.

The neuroplasticity paradigm also facilitates techniques that preempt actual movement and target the brain representation itself. These include sensory retraining, left-right

discrimination, explicit motor imagery, and mirror therapy. These are components of graded motor imagery strategies sometimes necessary to get behind the protective radar of pain for effective therapy.¹⁸

MANUAL THERAPIST AS IMMUNOTHERAPIST

Not long after the neuroplasticity paradigm became obvious, it was evident that the immune system is intricately involved in modulating memory, learning, and sensitivity. The nervous system is a neuroimmune organ with far more glial cells, such as astrocytes, microglia, and Schwann cells, than neurones.^{4,23} The brain remapping that has brought the neuroplasticity paradigm to the public is orchestrated by the immune system, as groups of glial cells have the ability to draw columns of neurones into different representations.³

While the immune system is clearly involved in pain (we ache with the flu) and as views of pain as an interaction between neurones, glial cells, their products (such as cytokines and chemokines), and feedback loops with the endocrine and autonomic system become more commonplace, it demands that at least basic immunology should be a core subject for manual therapy. The immune system is a homeostatic system, and its responses range from the learning and memory activities of the “resting” immune systems to the “cytokine storms” and immune takeover of severe injury and disease. The notion of immune balance is realistic, and an out-of-kilter proinflammatory and anti-inflammatory cytokine balance seems to be a likely part of chronic pain. Higher proinflammatory cytokine levels have been shown to be a part of some chronic pain states.¹

The immune response defies segmentalism and unhelpful dualisms like the central/peripheral and the emotional/physical divide. A peripheral nerve injury will have an immune response at the injury site, the contralateral limb, spinal cord, and the brain, with immune cells activated at least 3 months after the injury. The immune system itself permits a pervious blood-brain barrier, allowing a rapid total nervous system response.² Immune cell activation in the brain is also in the limbic and prefrontal area, suggesting a role in mood as well as nociception.

Manual therapy strategies, including education and movement, could be considered antigenic²⁰ and the immune system an inevitable influence on our therapy. The development of glial-modifying agents is enticing to pharmacology but should be to manual therapy as well. Well-known “immune-healthy behaviors,” such as knowledge, meaning in life, appropriate exercise, availability of coping strategies, diet, and even laughter, are also known chronic pain management strategies and are often included in manual therapy sessions.

New knowledge of the immune system offers an explanatory, guiding, and often therapeutic narrative. For example, why pain can worsen at certain times, thoughts can activate immune processes, and some immune-culpable pains, such

as mirror pains,¹⁶ are not necessarily related to damage but to a master protective system. Immune cells can remain “experienced” after activation. From an evolutionary perspective, why would people forget a nasty back pain experience and how sensible it would be, like a fire drill, to test systems, to “play the pain again” at a time when glial cells are activated, perhaps at a time of stress or flu? It raises the notion that many “reinjuries” may not be reinjured tissues and suggests that therapists who revert to acute management again may worsen the situation.

MANUAL THERAPIST AS LINGUIST

A neuroplasticity paradigm embraces central sensitization and multiple and linked brain outputs. These outputs (for example, motor, sympathetic, sleep, cognitions, emotions, endocrine, creativity, and language) all help us cope. However, if a stressor persists and these systems are called upon inappropriately, they may become perturbed in their own right, as in altered motor patterns or hypocortisolism. An excess of perturbed outputs is expensive to the organism (little time or energy for much else in life), and they become inputs (eg, nociceptive input from cortisol-based inflammation) and a feedback loop.

Manual therapists should not be limited to the more traditional areas of pain and movement. In a neuroplasticity sense, a limp output is not much different to a language output (“it’s bone on bone at L4”). Both are repeated innumerable; both exist in widely distributed neurosignatures with probable overlap. A limp would be a therapeutic target, and alteration of the limp circuitry could decrease pain. An alteration of language output may be as clinically potent. We all aim for full expression of motor outputs, but many patients are left with a limited linguistic expression of the therapeutic journey, for example, neurosignatures such as “I have a disc.” It’s like leaving someone with an uncorrected limp.

With the arrival of evidence-based therapeutic neuroscience education^{6,13,19} comes the notion of therapist as linguist. High-quality clinical rhetorical skills require neuroscience knowledge in both narrative and metaphorical forms, and it is metaphor in particular that dominates both our educational and a patient’s descriptive language.

A variety of metaphors exist, from simple equalizing metaphors (“he is as strong as an ox”) to invasive metaphors (“like a knife in there,” “my head is in a vice”) that have potentially unhealthy immunological ramifications and need softening. Ontological metaphors, as patients try to verbalize abstract notions such as pain and emotions (“I feel as though I am going to pieces”), are likely to need grounding, and, for example, an explanation of central sensitization or neurosignatures may be appropriate. Some metaphors are orientational (“my back is out,” “it goes up to my head”), some static (“something is wedged in there”), and some mobile (“it moves from the back and goes into my groin”). Yet others suggest a separa-

tion of body and mind, or ownership, as the problem gets labeled “it” or “my back is killing me,” suggesting a separation of “back” and “me.” An analysis of “why are they saying this” may give diagnostic help and the metaphor may become a therapy target. In addition, this suggests potential for a novel research field in manual therapy.

Neuroplasticity has exposed dated metaphors that need challenging (“It’s just old age,” “I know what you are going through”) and has also provided language and knowledge to contextually enrich useful metaphors, such as “Motion is lotion.” For example, a brief description of the body and mind benefits of movement or adding neuroplasticity stories to more philosophical metaphors (“You are not your thoughts”) goes well with a brief “majesty of the brain” discussion. “Ships are safest in the harbor, but that is not what they are designed for,” provides a framework for a narrative on graded movement and re-entry to life. Further contextualization could come from the use of multimedia, even simple drawings, links to “hands-on,” humor, and emotional valence. With the correct rhetorical skills, “If your back was on your face, you would take better care of it,” could be a clinical winner.

CONCLUSION

Perhaps it comes to professional declarative knowledge—the knowledge that makes a profession what it is—easy to define in some professions, dentistry, for example, but much harder in the movement therapies. To take on the paradigm requires considerable resource distribution, new subjects, conceptual shifts, and, for many, an admission that we were not quite right in the past and could do it all better.

Perhaps we need a name change? The term *manual therapist* downplays our skills and declarative knowledge. You’ll certainly need a different breed of plenary speakers at forthcoming talks. But ultimately, direction must come from those in trouble, especially the 25% of the population in ongoing pain. Neuroplasticity has already lifted expectations of outcome—we can now say “pain treatment” instead of the cop-out “pain management,” we can engage patients where we had little to offer in the past—plexus tears, phantom pains, central sensitization, for example—and we can add new apples of knowledge and philosophy to the profession. These are exciting times for the profession as the brain unfolds, but critically it has to be made exciting for those in trouble as well.

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Many thanks to IFOMPT for the invitation, especially as I am more an educationalist and a clinician and just dabble in research. My interest is in widening the scope of play in manual therapy to embrace the brain and the astonishing neuroplasticity revolution. Integration of knowledge into undergraduate and postgraduate curricula in clinical pain and performance sciences is a particular interest of mine.

REFERENCES

1. Austin PJ, Moalem-Taylor G. The neuro-immune balance in neuropathic pain: involvement of inflammatory immune cells, immune-like glial cells and cytokines. *J Neuroimmunol*. 2010;229:26-50. <http://dx.doi.org/10.1016/j.jneuroim.2010.08.013>
2. Beggs S, Liu XJ, Kwan C, Salter MW. Peripheral nerve injury and TRPV1-expressing primary afferent C-fibers cause opening of the blood-brain barrier. *Mol Pain*. 2010;6:74. <http://dx.doi.org/10.1186/1744-8069-6-74>
3. Ben Achour S, Pascual O. Glia: the many ways to modulate synaptic plasticity. *Neurochem Int*. 2010;57:440-445. <http://dx.doi.org/10.1016/j.neuint.2010.02.013>
4. Besedovsky HO, del Rey A. Central and peripheral cytokines mediate immune-brain connectivity. *Neurochem Res*. 2011;36:1-6. <http://dx.doi.org/10.1007/s11064-010-0252-x>
5. Butler DS. *South Australian Physiotherapy Students' and Graduates' Knowledge and Beliefs About Chronic Musculoskeletal Pain* [thesis]. Adelaide, Australia: Flinders University; 2010.
6. Butler DS, Moseley GL. *Explain Pain*. Adelaide, Australia: Noigroup Publications; 2003.
7. The Dana Foundation. Homepage. Available at: <http://www.dana.org/>. Accessed August 24, 2012.
8. Doidge N. *The Brain That Changes Itself: Stories of Personal Triumph From the Frontiers of Brain Science*. New York, NY: Viking Penguin; 2007.
9. Flor H, Devor M, Jensen TS. Phantom limb pain: causes and cures. In: Dostrovsky JO, Carr DB, Koltzenburg M, eds. *Proceedings of the 10th World Congress on Pain*. Seattle, WA: IASP Press; 2003.
10. Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC. The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychol Bull*. 2007;133:581-624. <http://dx.doi.org/10.1037/0033-2909.133.4.581>
11. Houben RM, Ostelo RW, Vlaeyen JW, Wolters PM, Peters M, Stomp-van den Berg SG. Health care providers' orientations towards common low back pain predict perceived harmfulness of physical activities and recommendations regarding return to normal activity. *Eur J Pain*. 2005;9:173-183. <http://dx.doi.org/10.1016/j.ejpain.2004.05.002>
12. Kuhn TS. *The Structure of Scientific Revolutions*. 2nd ed. Chicago, IL: University of Chicago Press; 1970.
13. Louw A, Diener I, Butler DS, Puentedura EJ. The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. *Arch Phys Med Rehabil*. 2011;92:2041-2056. <http://dx.doi.org/10.1016/j.apmr.2011.07.198>
14. Maihofner C, Handwerker HO, Neundorfer B, Birklein F. Cortical reorganization during recovery from complex regional pain syndrome. *Neurology*. 2004;63:693-701.
15. Melzack R. Pain and the neuromatrix in the brain. *J Dent Educ*. 2001;65:1378-1382.
16. Milligan ED, Twining C, Chacur M, et al. Spinal glia and proinflammatory cytokines mediate mirror-image neuropathic pain in rats. *J Neurosci*. 2003;23:1026-1040.
17. Moseley GL. A pain neuromatrix approach to patients with chronic pain. *Man Ther*. 2003;8:130-140.
18. Moseley GL, Butler DS, Beames TB, Giles TJ. *The Graded Motor Imagery Handbook*. Adelaide, Australia: Noigroup Publications; 2012.
19. Moseley GL, Nicholas MK, Hodges PW. A randomized controlled trial of intensive neurophysiology education in chronic low back pain. *Clin J Pain*. 2004;20:324-330.
20. NOI Group Publications. NOI notes on movement as antigen. Available at: <http://noinotes.blogspot.com.au/2009/10/noi-notes-on-movement-as-antigen.html>. Accessed January 1, 2010.
21. Pincus T, Morley S. Cognitive-processing bias in chronic pain: a review and integration. *Psychol Bull*. 2001;127:599-617.
22. Wand BM, Parkitny L, O'Connell NE, et al. Cortical changes in chronic low back pain: current state of the art and implications for clinical practice. *Man Ther*. 2011;16:15-20. <http://dx.doi.org/10.1016/j.math.2010.06.008>
23. Yirmiya R, Goshen I. Immune modulation of learning, memory, neural plasticity and neurogenesis. *Brain Behav Immun*. 2011;25:181-213. <http://dx.doi.org/10.1016/j.bbi.2010.10.015>

THE PHYSIOTHERAPIST'S/PHYSICAL THERAPIST'S ROLE IN EXERCISE PRESCRIPTION AND EXERCISE IS MEDICINE

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I am a patient of physiotherapists, a friend of physiotherapists, a fan of the physiotherapy profession, and a colleague of terrific physiotherapist researchers and faculty. I appreciate the privilege of being part of IFOMPT 2012 in Quebec City. The purpose of this keynote is to focus on 4 elements of the public health issue of physical inactivity. I strongly support the position that physiotherapists have a key role to play in the war against physical inactivity (if you will forgive me the military metaphor). I want to make some practical suggestions that individuals and the profession may like to consider. To provide a brief outline of today's journey, the 4 elements are (1) emphasizing the burden of physical inactivity in an emotional, "sticky" way, (2) a success story, the 23.5-hour video, (3) the 7 investments that have been proven effective for mitigating physical inactivity through a physiotherapy lens, and (4) a simple framework for behavior change that can be used in the clinical setting, as well as in the policy domain.

THE BURDEN OF PHYSICAL INACTIVITY—A PHYSIOTHERAPY PERSPECTIVE

The Chartered Society of Physiotherapy (UK) identifies public health as a clear focus for physiotherapy. It defines public health as "the science and art of preventing disease, prolonging life, and promoting health through organized efforts of society."² It defines health improvement as 1 domain of public health, and the website concludes by saying that "Physiotherapists, as allied health professionals are key members of the wider public health workforce."² I respectfully suggest that the word *key* be bolded, underlined, and zapf-dingbatted, as (1) physiotherapists are ideally placed, should they choose, to be advocating against the noncommunicable disease (NCD) of physical inactivity, and (2) "membership" does not preclude "leadership," but I believe that physiotherapists are also ideally placed to be leaders in this public health issue and that this should be made more explicit. Respectful suggestions from a fan. Let me briefly outline my favorite points when I need to pitch the burden of physical inactivity while walking alongside someone up a flight of stairs.

First, physical inactivity kills more Americans than smoking, diabetes, and obesity combined. Yes, it does! Physical inactivity puts folks in the lowest quintile of cardiorespiratory fitness, and Professor Steven Blair¹ has shown elegantly that in a population—in this case, the Aerobics Centre Longitudinal Study—baseline low fitness (bottom quintile) was associated with around 16% of subsequent deaths in an approximate 20-year follow-up period. Smoking was associated with about 8% of deaths in that cohort, obesity 4%, and dia-

betes 2%. In sum, low fitness killed more people than what we might call "smokadiabesity."

Another approach to emphasize the scourge of physical inactivity is to offer someone who has been inactive for a day 3 cigarettes. Too busy to do any activity today? Had to drive to work, sit all day, drive home, then rest on a couch/chair? No problem, that happens. And here are the 3 cigarettes you may as well have smoked. Not a big deal—just 3 smokes. Won't kill you, will it? You have had a week of physical inactivity? So, here is your packet of Marlboro. Those data come from a "back of the envelope" comparison of the annual costs of smoking and the annual costs of physical inactivity.⁵ However, just 3 months ago, the prestigious *Lancet* reported that physical inactivity produced the same global burden as smoking.⁷

SUCCESS STORIES—LET'S SHOW THE WAY!

Physiotherapists are very good at encouraging patients to perform exercises. How can physiotherapists promote physical activity solutions? Given our love of evidence, we should follow the guidelines designed by psychologists and marketers—they are the experts at behavior change. We'll follow up on that a bit more below, but one resource I have found to be particularly helpful has been the Heath brothers' book *Made to Stick*.⁴ Chip Heath and Dan Heath have backgrounds in business and education. They beautifully captured the science behind those "sticky" advertisements you can't get out of your head—think of many Apple ads. The acronym for the 6 elements makes up the word SUCCESS, and 3 I will focus on right now are the "U" for unexpected, the "E" for emotion, and the "S" for story. I'm going to share the first few minutes of a YouTube video that is nudging 3 million downloads. Let's watch the video (<http://www.youtube.com/watch?v=aUaInS6HIGo>) and then discuss how physiotherapists can make use of lessons from Dr Mike Evans,³ who created this engaging video.

ANOTHER SUCCESS—"7 INVESTMENTS" IS A PRACTICAL ROAD MAP

I can hear you saying you agree with Steven Blair¹ that physical inactivity is the world's greatest public health challenge—so the question is, "How can physiotherapists individually and collectively contribute?" I draw your attention to what I call the "World Health Organization" "7 investments" document, and I put both elements in separate quotation marks because the World Health Organization was influenced by this document—it did not create it. I hope to convince you that this document is a critical operational plan for physical activity promotion. Join me on a journey through these 7 worlds, where the evidence is very strong.

1. The "whole of school" environment: physiotherapists' role equals advocates to parents, teachers, and school board connections you have.
2. Transport policies and systems that prioritize walking, cy-

- cling, and public transport. This links quite closely with:
3. Urban design regulations and infrastructure that provide for equitable and safe access for recreational physical activity, and recreational and transport-related walking and cycling across the life course. Physiotherapists can contribute by using transit and encouraging others to use it. In many cases, these decisions are made at the local council level, where you vote.
 4. Physical activity and NCD prevention integrated into primary healthcare systems. This is an obvious, but I hope you agree not the only, home for physiotherapists. The document states explicitly that physiotherapists are among the “important influencers of patient behavior and key initiators of NCD (noncommunicable disease) prevention actions within the health care system.” As the authors point out, the collective effort among health professionals means we can influence large proportions of the population. The authors underscore that “health care systems should include physical activity as an explicit element of regular behavioral risk factor screening for NCD prevention, patient education and referral.” Physiotherapists have tremendous advantages over all other health professionals in this domain because of their understanding of exercise prescription for special populations—the people who might think they “cannot” exercise. Importantly, the more frail a patient is, in most cases, the more benefits will accrue with exercise therapy.
 5. Public education, including mass media to raise awareness and change social norms on physical activity. Clearly, physiotherapists can and do contribute to these opportunities. I contend that the magnitude of the problem is that we should all be grasping these public education opportunities. Are universities encouraging and rewarding faculty to take advantage of linking physical activity stories to global events such as “physical activity days”?
 6. Community-wide programs involving multiple settings and sectors and that mobilize and integrate community engagement and resources.
 7. Sports systems and programs that promote “sport for all” and encourage participation across the lifespan.⁶

I won't labor these opportunities, as you will see how you could potentially fit into various categories—and you can influence other folks to engage as well. So effectively, we could all do better and “switch” our behavior to a more physically active one.

THE CRITICAL ACT—CHANGING BEHAVIOR (FOR PHYSICAL ACTIVITY PROMOTION OR ANYTHING ELSE!)

The Heath brothers' other book concerns behavior change: *Switch: How to Change Things When Change Is Hard*. The very useful lessons here are 3-fold. First, to motivate people, we need to engage their emotion. This seems paradoxical for

post-1996 clinicians—born post-Cochrane database! Isn't the future about evidence, graphs, and sophisticated keynote or Prezzi demonstrations?

This is where we need to differentiate decision making from advocating for behavior change. The difference between “steak” and “sizzle.” Our clinical decisions need to be grounded in data and the patient's opinion, but when we are looking to change behavior that will come via emotional buy-in. Bottom line—convince patients with stories and true emotion—few are convinced by data!

The second key message from the Heath brothers, and this applies equally well in the clinical setting, is to give clear messages as to what needs to be done. “Walk until your pedometer clicks over 10,000 steps every day of the week.” “Use the stairs.” These are great examples of what is referred to as “direct the rider” (think of an elephant rider needing to focus and unable to attend to a myriad of messages).

And just as the 7 investments attend to infrastructure such as transit and the urban environment, the Heath brothers make the point that simple facilitators of behavior can make a massive difference. You have a bus pass, so you don't need to find change. There are showers and bike lockers at work (not to mention a divided cycle lane). Everyone at work runs, so it is the easy thing to do—there is a leader, so I don't have to think! This third category of behavior influencers are referred to as things that “shape the path,” make it easier to complete the behavior. A literal example of this in industry is “drive-through” (fast food, McDonald's, it matters not) or, in this century, Amazon's “one-click” to make it easy to purchase. Automatic banking payments or Skype refills from your credit card all shape the path.

SUMMARY

The World Health Organization supports the argument that physical inactivity is a very major public health problem—it ranks from first to fourth depending on how you calculate the burden of disease. Physiotherapists are ideally placed to make a difference because physiotherapists understand psychology, compliance, and patient communication. These clinical skills can be successfully applied at hospital and policy levels. What needs to be advocated for? Think of the 7 investments. Is there a science of how to change behavior? There is—and if we make stubborn or “poor behavior” choices our target, the solution will usually need 1 or a combination of (a) motivate the person to change using emotion (including stories), (b) direct the rider: provide clear, specific instructions, and/or (c) shape the path. Make it easier for folks. Good luck in whatever domain of physical therapy or policy you work in, and for those of you who want to join the Global Advocacy for Physical Activity group, there is a straightforward website and it costs \$125 to join. Thanks a lot for listening.

REFERENCES

1. Blair SN. Physical inactivity: the biggest public health problem of the 21st century. *Br J Sports Med.* 2009;43:1-2.
2. The Chartered Society of Physiotherapy. Public health. Available at: <http://www.csp.org.uk/topics/public-health>. Accessed September 6, 2012.
3. Evans MF. '23 and 1/2 h' goes viral: top 10 learnings about making a health message that people give to one another. *Br J Sports Med.* 2012;46:461-462. <http://dx.doi.org/10.1136/bjsports-2012-091113>
4. Heath C, Heath D. *Made to Stick: Why Some Ideas Survive and Others Die.* New York, NY: Random House; 2007.

5. Khan KM, Davis JC. A week of physical inactivity has similar health costs to smoking a packet of cigarettes. *Br J Sports Med.* 2010;44:395. <http://dx.doi.org/10.1136/bjsm.2010.074047>
6. Khan KM, Thompson AM, Blair SN, et al. Sport and exercise as contributors to the health of nations. *Lancet.* 2012;380:59-64. [http://dx.doi.org/10.1016/S0140-6736\(12\)60865-4](http://dx.doi.org/10.1016/S0140-6736(12)60865-4)
7. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet.* 2012;380:219-229. [http://dx.doi.org/10.1016/S0140-6736\(12\)61031-9](http://dx.doi.org/10.1016/S0140-6736(12)61031-9)

KNOWLEDGE TRANSFER IN THE AGE OF TECHNOLOGY

DR STUART GOWLAND

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What if ... I was not actually here today, but a new-generation hologram, in natural color, in 3 dimensions, and with natural motion and clear resolution?

What if ... I was giving this presentation from New Zealand that was the same as me being here?

What if ... we called it teleporting, and with the use of remote camera control we could visit places in the world for entertainment as well as for professional reasons? We could teleport to London or New York. We could purchase items at Bloomingdale's on 65th Street, or pass through Times Square on our way down Fifth Avenue to 42nd Street to watch a prebooked show?

What if ... we could contract for work at a remote venue, perhaps seeing patients, reviewing radiographs, attending local management meetings?

What if ... at these meetings we could see all our associates, we could look around, respond to a greeting with resolution and motion and sound so natural that it would be as good as being there?

What if ... with this technology, where we lived physically didn't matter nearly as much because we would be so well connected?

What if ... the audience of today of a thousand or so was added to by perhaps a hundred thousand virtual attendees from all over the world, who could ask questions, make suggestions via the Chair, and visit the associated exhibition with motorized cameras?

What if ... they could speak to the salespeople and download their sales brochures?

What if ... we could visit colleagues' clinics, almost anywhere in the world, where they were managing clinical issues we were seeking to learn from?

Is this sort of thing simple naive dreaming? Is this knowledge transfer of the future?

MOBILE SURGICAL SERVICES

We are a private organization, supported partly by the

New Zealand Government, since 2002, to implement 2 ideas we had suggested would be beneficial to the health system of the country. The benefits have been targeted at both rural and urban New Zealand because in many ways the country is relatively isolated and the issues are similar.

The 2 ideas at the time were:

- If you need facilities and equipment that are not used every day, share them—but share them “mobile,” so everyone can have local access to them.
- Use video communication and other technologies to regularly share knowledge on a wider geographic level than had been thought of previously.

We are very small and have 2 mobile units, 1 that shares a device that fragments kidney stones with sound waves called a Lithotripter. We also provide a mobile operating room traveling around rural New Zealand providing day surgery at 22 small hospitals, moving between them every day. It doesn't travel with a team of specialist nurses and doctors, but uses the visited small towns' retrained local nurses and the regional specialists. The idea of “share mobile” has been well established in the northern hemisphere.

Many smaller diagnostic technology items are also able to be shared; in this case, the devices can be combined in small vehicles. The plan for these vehicles is to have satellite communication capability to stream edited information generated from the tests, for example, echocardiography and ultrasound, to city-based specialists for reporting.

KNOWLEDGE TRANSFER TOOLS

We are going to look at some, but not all, of the modern technologies available. The extended toolkit of technologies that are now progressively part of knowledge transfer includes:

- Video communication (quality collaboration with expert colleagues now possible over distance, national or international)
- Internet options (collaboration of learning is very well utilized now via the internet and our computer terminals)
- Smartphones and information management (assuming the role of computers but especially useful because of their access almost anywhere and any time)
- Television (wide span and easy knowledge transfer at work

or home, with text questions allowing discussion with presenters)

- Simulation (allowing local expertise to develop and to be measured for competency)
- Augmented and virtual reality (use in a range of areas, especially with skills development and also with virtual meetings)

Video collaboration we use, in a series of iterations that are significantly expanded over conventional video conferencing. Back in time, knowledge transfer always started with face-to-face collaborations. Trust was gained between the participants, based only partly on the words spoken but much more predominantly on the gestures, facial movements, and voice intonation. The interpretation of these was used to gauge the level of trust we would put in our colleague. The challenge for modern technology is to bring “virtual” collaborators together from different places in a way that is close to being physically together.

It is worth taking time to understand some of the technology needed behind the concept.

Following looking at how we get pictures and where they can go wrong, we will look at what uses they can be put to for us and address some of the applications we use from a “technology toolbox.”

VIDEO COMMUNICATION 101

The Video Stream and Requirements

Bandwidth in megabits per second is the size of the network pathway required to deliver the required information. Video streams are much larger than the usual stream connecting us on the internet or getting simple patient data from a database. One hundred kilobits per second will easily handle simple data, but broadcast-quality pictures, such as television, will take at least a stream of 4 megabits per second. This data stream, with video, can't get away with missing odd bits of data (packets) or the picture is significantly affected. Normally, network connections will recognize that a bit of data has been missed and simply resend it, probably without being noticed by the viewer. Video, being more demanding, cannot handle the delay in this resend, and that is what leads to bad pictures.

Image Compression and Codecs

High-quality moving pictures out of a broadcast camera can generate several hundred megabits of information per second, and this would rapidly overflow networks. Increasingly sophisticated compression technology is evolving to convert the 300 megabits per second to 4 megabits per second by simply only sending the things that change between the individual pictures in the stream. This minimal change is reflected in the reduced bandwidth required, being as low as 1% of the raw signal. The quality and amount of compression will influence the picture, and the compression technology

used in a given link is called the video codec.

Picture Quality and How It Goes Wrong

Assessment by Motion, Resolution, and Audio Latency
Bandwidth, while being the metric to describe the capability of the network, is dependent on how much was purchased. It is the measure of the size of the information stream needed to transmit the pictures. If the requirement exceeds the network capability, the pictures experience severe disruption, with resolution, naturalness of motion, and audio latency all suffering. If pictures are generated by the video terminals at a higher bandwidth than the network can cope with, the trade-off will be lower resolution, jerky motion, and significant audio delay. Delay is fine for movies, where it will not be important, as they only stream 1 way, but it is critically important in 2-way interactive sessions such as in video collaboration.

An example of latency we've all seen is the international news report, often done with satellite links, showing a gap between the station presenter saying he is crossing live for a report and the journalist reporting, standing there, looking and waiting and not answering for a second or sometimes longer.

WIDE AREA NETWORKS (WANS), LOCAL AREA NETWORKS (LANS), AND EVER MORE ACRONYMS!

Television was the first to regularly transmit pictures, and it used private physical networks of microwave, copper wire, and then fiber optics that were reserved for it alone. This was extremely expensive and, although available to corporate broadcasters, was way beyond the reach of individuals. Modern networks are by definition the internet, which we all use.

WANS traverse towns, countries, and continents using a combination of fiber optics, microwaves, satellites, and copper wire.

LANS exist within buildings and use building wiring in combination with fiber optics. They terminate in our offices in sockets (called ethernet sockets) and are controlled in institutions by information technology departments that usually employ specialist network engineers to manage them. Much energy is spent on the subject of security of these networks, and this extends from the simple use of passwords to the much more complex protectors called firewalls. The latter are tricky for video streams to negotiate.

The common networks we use are for our computers (internet and database access), and our phone systems are progressively being used for the more demanding video stream. The video streams run across WANS using a selection of layers that have multiplied and sometimes superseded each other with time.

The plethora of acronyms is, as usual, confusing, but the fashionable acronyms in layers that we have are ATM (asynchronous transfer mode), MPLS (multiprotocol label

switching), and IP (internet protocol). The IP assigns telephone-type numbers to electronic devices, such as a video terminal, and is partly responsible for safely transferring video streams to other terminals simply by using a set of traffic directions. Access can be as simple as reaching for the telephone and pressing a labeled speed-dial button.

CONTESTABILITY—WHAT YOU PAY FOR IS OFTEN NOT WHAT YOU GET

The public internet allows the sharing of the information “pipe.” To provide security of transmission quality while traversing the pipe, all sorts of technologies have been developed to keep the information streams from interfering with each other (contestability). Instead of the historical private physical networks of the broadcasters, virtual private networks (VPNs) are set up to give security of quality by blocking access to that stream from nonauthorized terminals. The ability to share space (at a price!) without contestability is still cheaper than the broadcasters’ private network, but still not cheap.

Large increases in the numbers of people using an expanded public internet make up the major factor in the gradual reduction of network costs. The trade-off is that the public internet is relatively unprotected, and, as we have all found, it is important to know that this paid-for access, without VPN privileges, is contestable and a fight for space. This contestability is a major factor in significantly slowing our internet access, especially at certain times of the day.

Skype users have the tremendous advantage of easy access at minimal cost to video communication, but suffer the disadvantages of public internet contestability and relatively slow processors, especially on their iPads or smartphones.

KNOWLEDGE TRANSFER APPLICATIONS

Video Applications

Below are the video applications that go beyond the usual “talking heads” of conventional video conferencing. Like the phone, the terminals need to be predominantly on our desks and belts to be useful. In these cases, only occasionally is the video conferencing suite used.

Remote Clinical Consultations

This is usually an elective link discussing difficult patient problems with an expert. A physiotherapist in a small town may consult an expert in a larger town, with the patient present, and seek advice. A fee structure has been developed for this type of thing in some countries. A consultation in the medical arena, which we have demonstrated, may be an acute requirement for a video consultation—in 1 case, a woman who had fallen on a glass door had a large shard buried in her abdomen, probably in the liver. Consultation was short, with the emergency department at the regional hospital being the fastest method of transport. It was clear that this patient was going to be admitted. In a second example, a small robotic

camera was designed that could accompany ambulances and stream pictures back to the regional controllers. An ambulance officer was shown being supported through the emergency use of chest drainage in a case of tension pneumothorax—something that could otherwise lead to a patient dying on the way to hospital.

Continuing Professional Development Programs

These can be either seminar-style lectures with specialists on requested topics or the use of the multidisciplinary meeting concept to review cases including groups of colleagues in the region. The group also would have the ability to have an expert chosen by colleagues teleported in to mentor the session.

This so-called “MDM” is often a request of the appropriate professional organizations. We run these sessions in New Zealand between some 20 rural communities and include in this 2 in Australia.

Remote Meeting Attendance

This is not designed to replace the physical attendance at meetings, but to enable attendance at a wider range of offerings. Examples we have developed show visitors as virtual attendees joining meetings and asking questions of the speaker via text to the Chair. The speaker usually has a monitor, watching scrolling questions that could be answered at their discretion. Experience has taught us that to make this look professional, these remote meeting attendance sessions need to be properly produced, with at least 3 cameras with operators, a floor manager, and a vision mixer/producer. These live presentations, done with adequate bandwidth, are a major improvement on the single webcam monitoring a meeting speaker and streaming out images on the public internet. Being interactive is a highly significant advantage over the rather simple webcam system and is also superior to simply looking at a DVD distributed after the meeting.

Remote Viewing or Supervision of Specialist Procedures

Either a clinician joins an expert colleague to see and discuss a special procedure being performed, or a colleague can collaborate with the expert, monitoring them as a new entrant learning the procedure. We have examples of this level of collaboration to show.

Smartphones, iPads, etc

We show demonstrations of these devices being involved in regular automated monitoring of treatments and results, and also the use of profiled information made available relating to a series of things that are of interest, including meetings that fit the profile coming up in the world, likewise, with seminars and articles appearing in the literature. The device’s strength is that it can be accessed during those pockets of spare time we have, for example, on a plane flight or other

natural gaps for us in a day. Smartphones could be used to have patients record and return automatically measurable results of an instituted therapy. This would add to the physiotherapy assessment at the routine follow-up visit by giving a better trend analysis on the basis that the recording is now happening every day.

Virtual Reality

This is potentially a very big field. Examples are given of group meetings around a virtual table with each person from a different country. Full audiovisual resources are available and a drag-and-drop technology is demonstrated to show realistic exchange of documents, much as might happen in a normal meeting between the participants.

A virtual world is used in various rehabilitation programs and may reduce recovery times in, say, stroke.

SUMMARY

Technology improving knowledge transfer is a rapidly

expanding field. More information is available than ever before, but weighting the apparent evidence is difficult and probably still best done in discussion with trusted colleagues.

Most of the technologies discussed are about enhancing the possibility to be involved with a much wider range of respected colleagues in those discussions.

As with most discussions between healthcare professionals, the knowledge transfer is rarely only 1 way.

Dr Gowland is the managing director of Mobile Surgical Services, a public-private partnership with the New Zealand Government now in its 12th year. The contract with the Government is to provide a regular day surgical operating theater (mobile) to a number of small communities and to provide a rural health development program to rural healthcare professionals, including certification and general professional development. The organization is still given a free hand as to what technologies are used or are being developed to deliver these outputs.

Schedule

The following abstracts are available online only at www.jospt.org.

OCTOBER 1, 2012

10:30 AM

Manual Therapy Directed at the Knee or Lumbopelvic Region Does Not Influence Quadriceps Motoneuron Pool Excitability
Grindstaff T

The Effect of Joint Mobilization on Diffuse Noxious Inhibitory Control in Individuals With Osteoarthritis of the Knee
Courtney C

The Frequency of Hamstring Stretches Required to Maintain Knee Extension Range of Motion Following an Initial 6-Week Stretching Program
Reid D

Rate of Cartilage Loss in Medial Knee Osteoarthritis Is Faster in Patients With Increased Duration of Cocontraction of Medial Knee Muscles
Hodges P

Validation of a Set of Clinical Identifiers for the Early Stage of Primary/Idiopathic Adhesive Capsulitis: Preliminary Results
Walmsley S

Mathematical Modeling of the Convex Rule at the Glenohumeral Joint and Its Application to Validate the Convex Rule Through the Analysis of Kinematical Evidence of the Glenohumeral Joint
Viloria PT

Muscle Recruitment Patterns During Abduction in Different Planes and at Different Loads
Reed D

Effectiveness of Translational Manipulation Under Interscalene Block for the Treatment of Adhesive Capsulitis of the Shoulder
Rendeiro D

11:45 AM

The Cervical Flexor Muscles Investigated With Ultrasound: A Comparison Between Patients With Whiplash Injury and Controls
Peterson G

Detailed Myofascial Dissection of the Longus Capitis and Longus Colli Muscles
Kennedy C

Mechanical Neck Muscle Activation During 120° Arm Flexion Registered With Ultrasound: A Comparison of Patients and Healthy Controls
Peolsson A

Interpretation of Cervical Passive Accessory Intervertebral Movements: From Thumbs to Outcomes
Tuttle N

A Pilot Study Comparing Cervical Spine Stiffness in Patients With Chronic Nonspecific Neck Pain and Asymptomatic Individuals
Ingram L

Lack of Uniform Diagnostic Criteria for Cervical Radiculopathy in Conservative Intervention Studies: A Systematic Review
Thoomes E

2:45 PM

A Comparison of General Seated and Targeted Supine Thoracic Spine Thrusts and Their Effect on Cervical Pain and Range of Motion
Karas S

Short-Term Combined Effects of Thoracic Manipulation With Cervical Mobilization in Patients With Mechanical Neck Pain: An RCT
Masaracchio M

The Side, Duration, and Number of Cavitation Sounds During Upper Cervical Thrust Manipulation
Dunning J

Upper Cervical and Upper Thoracic Thrust Manipulation Versus Nonthrust Mobilization in Patients With Mechanical Neck Pain: A Multicenter Randomized Clinical Trial
Dunning J

The Treatment of Plantar Fasciitis in the New Millennium: The Effects of Extracorporeal Shockwave Therapy (ECSWT), Joint Mobilizations, and Exercise on the Visual Analog Scale (VAS) and Lower Extremity Functional Scale (LEFS)
Sanzo P

The Effect of a Loss of Ankle Dorsiflexion Range on Frontal and Transverse Plane Lower-Limb Alignment
Bell-Jenje T

Injured Tendons Continue to Attempt to Heal, Even After Prolonged Damage
Fearon A

IFOMPT SUPPLEMENT: SCHEDULE

Effect of Glenohumeral Forward Flexion on Upper-Limb Myoelectric Activity During Simulated Mills Manipulation: Relations to Peripheral Nerve Biomechanics and Specificity of Mills Manipulation

Rade M

Can Elbow Manipulation and Exercise Change the Classic Poorer Long-Term Recovery Trajectory of Chronic Lateral Epicondylalgia Following Corticosteroid Injections?

Vicenzino B

Manual Therapy and Exercises in Patients With Shoulder Impingement Syndrome: A Randomized Controlled Trial

Kromer TO

The Combined Effect of Utilizing Manual Therapy and Motor Control Training for 2 Recreational Throwers With Chronic Shoulder Pain

Lockwood M

The Effectiveness of a Manual Physical Therapy Approach Versus Corticosteroid Injection for the Treatment of Shoulder Impingement Syndrome: Short-Term Results From a Randomized Controlled Trial

Rhon D

The Effectiveness of Manual Therapy and Eccentric Exercise in the Management of Bicipital Tendinopathy: A Case Series

Phillips HJ

Repeatability of Vibration Thresholds and Pressure Pain Thresholds in Individuals With Spinally Referred Leg Pain

Ridehalgh C

Are Face Recognition and Emotional Expression of Chronic Face-Pain Patients Different From a Sample of Healthy Controls?

von Piekartz H

Neuromodulatory Cortical Priming: The Effect of Time

Andrews R

The Effect of Neuroscience Education on Pain, Disability, Anxiety, and Stress in Chronic Musculoskeletal Pain

Puentedura E

OCTOBER 2, 2012

10:30 AM

The Influence of a Moderate Specific-Exercise Program on Portuguese Elderly Executive Function

Melo C

Functional Impairments in Patients With Joint Hypermobility Syndrome and Developmental Coordination Disorder

Clark C

Development and Validation of the Functional Difficulties Questionnaire for Assessing Developmental Coordination Disorder in Adults

Clark C

Manual Therapy for Chronic Obstructive Pulmonary Disease: A Systematic Review of Current Evidence

Heneghan N

Correlation Between Functional Variables and Symptoms in Patients With Hip Osteoarthritis

Hidalgo C

Do Symptoms or Radiographic Findings Best Predict Function in Those With and Without Patellofemoral Joint Osteoarthritis 7 to 12 Years After Anterior Cruciate Ligament Reconstruction?

Culvenor A

The Relationship Between Lumbopelvic Muscle Size/Motor Control and Lower-Limb Muscle Injuries Among Elite Australian Football League Players

Hides J

Efficacy of Common Peroneal Neurodynamic Mobilization as an Adjunct to Standard Physical Therapy in Treatment of People With Painful Diabetic Distal Symmetric Polyneuropathy: A Randomized Clinical Trial

Kumar SP

11:45 AM

Blood Pressure and Heart Rate Response to Unilateral Posterior Glide of the Cervical Spine in Normal Volunteers: A Pilot Case Series

Yung E

Differential Diagnosis of a Patient Referred to Physical Therapy With Neck Pain: An Atypical Presentation of Angina

Mathers J

The Validity of Red Flags to Diagnose Spinal Neoplasms in Spinal Triage

Finucane L

The Effectiveness of Noninvasive Interactive Neurostimulation in Patients With Chronic Neck Pain: A Pilot Randomized Controlled Trial

Chipchase L

Dose Optimization for Spinal Treatment Effectiveness (the DOSE Study): Higher Applied Mobilization Force Associated With Reduced Pain and Spinal Stiffness in Patients With Chronic Neck Pain

Snodgrass S

2:45 PM

Sensorimotor Incongruence Exacerbates Symptoms in Patients With Chronic Whiplash-Associated Disorders: An Experimental Study

Daenen L

Radiofrequency Neurotomy Results in Immediate Improvements in Physical Impairments in Individuals With Chronic Whiplash Symptoms

Smith A

OCTOBER 3, 2012

Physiotherapy for Acute Whiplash Injuries:
A Randomized Controlled Trial

Williamson E

Curricula Modifications in the Postgraduate
Musculoskeletal Program From Association
Based to Academic Master Level

Luomajoki H

Different Knowledge Forms in Performing
Knowledge Translation

Lillehagen I

Investigating the Use of Research Evidence
Among Manual and Manipulative
Physiotherapists in Canada

Yeung E

2:45 PM

Short-Term Results of a Randomized
Controlled Trial on Specific Physiotherapy
Versus Advice for Subacute Low Back
Disorders

Ford J

Pain Location Is Associated With Pain and
Disability in Patients With Nonspecific Low
Back Pain

Parent E

Targeted Behavioral Approach for the
Management of NSCLBP: A Randomized
Controlled Trial

Vibe Fersum K

Patients' Perceptions of a Physiotherapy
Functional Restoration Treatment Protocol
for People With Discogenic Low Back
Pain With or Without Radiculopathy:
A Qualitative Study

Chan A

Preliminary Evidence for the Validity of
Features of Nonreducible Discogenic Low
Back Pain: Survey of an International
Physiotherapy Expert Panel With the
Delphi Technique

Chan A

Clinical Guidelines for Low Back Pain,
Recommendations for Patients With
Neurologic Involvement in Primary Care

Haswell K

Classification Accuracy of Motor Control
Tests of the Lumbar Spine for Subgroups
of Mechanical Low Back Pain

Sandlund J

Interrater Agreement of Clinical Tests/
Signs Used to Identify Patients With
Lumbar Functional Instability

Demoulin C

4:15 PM

Predictors of Response to Exercise and
Manual Therapy in Hip Osteoarthritis

French H

What Does the Language We Use About
Arthritis Mean to a Patient?

Barker K

Evaluation of Patient Acceptable Symptom
State Estimates Among Self-Report and
Physical Performance Outcome Measures
in Patients With Hip Osteoarthritis

Emerson Kavchak A

Predictors of Response to Physical Therapy
Intervention in Patients With Primary Hip
Osteoarthritis: A Comparison of Predictive
Modeling Based on Varying Response
Criteria

Wright A

Rehabilitation Following Hip Resurfacing
Arthroplasty: Are Outcomes Improved
Using a Tailored Physiotherapy Protocol?

Barker K

9:00 AM

Identifying the Sequence of Sciatic Nerve
Excursion During Different Neural
Mobilization Exercises: An In Vivo Study
Utilizing Ultrasound Imaging

Ellis R

Comparison of Different Neural
Mobilization Exercises Upon Longitudinal
Sciatic Nerve Movement: An In Vivo Study
Utilizing Ultrasound Imaging

Ellis R

Repeatability and Normative Values of
Measuring Sciatic Nerve Excursion During
the Straight Leg Raise With B-Mode
Ultrasound

Ridehalgh C

Sonography Assessment of the Median
Nerve During Cervical Lateral Glide and
Lateral Flexion: Is There a Difference in
Neurodynamics?

Brochwic P

Improving the Mechanical Validity of
Radial and Ulnar Nerve Neurodynamic
Testing: An Observation of Strain During
Upper-Limb Positioning

Snodgrass S

Can Patients With Severe Tennis Elbow
Be Differentiated on the Basis of Cervical
Spine Palpation and Neurodynamic Tests?

Bisset L

A Comparison of 3-Point Bending and
Displacement Methods of Stiffness
Measurements in the Lumbar Spine

Hebron C

Measuring Total Lumbar Spine Range
of Motion Through 2 Variables: A Pilot
Reliability Study

Al Zoubi F

Interpreting the Rotation Stress Test for the Alar Ligaments: What Should Be Considered Normal Range?

Osmotherly P

The Anterior Shear and Distraction Tests for Craniocervical Ligament Instability: An Assessment of Construct Validity

Osmotherly P

Risk Factors and Clinical Features of Craniocervical Arterial Dissection: Preliminary Results of a Prospective Study

Thomas L

The Effect of Selected Manual Therapy Interventions for Mechanical Neck Pain on Vertebral and Internal Carotid Arterial Blood Flow and Total Cerebral Perfusion

Thomas L

Dynamic Stability of the Lumbar Spine During the Sit-to-Stand Movement Task

Preuss R

Responses to Active Straight Leg Raise Test in Pregnancy Are Associated With Serum Levels of Relaxin in Pregnancy

Vøllestad N

Trunk Muscle Activity in Low Back Pain Subgroups

Karayannis N

Effects of Various Proprioceptive Disturbances on the Repositioning Sense of the Lower Spine During Active Trunk Forward Bending

Hidalgo B

Movement Control of the Back Is Impaired in Patients With Pain in Other Body Regions

Luomajoki H

Electromyographic Fatigue Characteristics and Muscle Recruitment Patterns During Trunk Endurance Tests in Healthy Subjects

Stevens V

9:30 AM

Reliability of Movement Control Tests in the Cervical Spine

Patroncini M

Trunk-Head Coordination in Neck Pain Subjects

Treleaven J

Interobserver Reliability of Head and Eye Movement Control Tests

Della Casa E

Multimodal Physiotherapy in the Treatment of Individuals With Persistent Symptoms Following a Sport-Related Concussion: A Randomized Controlled Trial

Schneider K

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Characteristics of Visual Disturbances Reported by Subjects With Neck Pain

Treleaven J

Using the CROM to Assess Head Repositioning Accuracy in Individuals With Cervical Disc Disease in Comparison to Reference Values in Neck-Healthy Individuals

Wibault J

The Influence of Neck Pain on Sensorimotor Function in the Elderly

Uthaiakhp S

Computer-Based Assessment and Treatment of Cervicocephalic Kinesthetic Sensibility

Kristjansson E

Pragmatic Application of Logic and the Scientific Method to Clinical Reasoning Exposes Some Avoidable Traps for Young and Old Players

Tuttle N

Correlations Between Changes in Pathoanatomical MRI Findings and Changes in Pain With a Bout of Flexion Exercises in Persons With Low Back Pain

Parent E

Manual Therapy for Low Back Pain: The Patient's Perspective

Slater S

The Effect of Emotional Distress on Persistent Pelvic Girdle Pain After Delivery: A Longitudinal Population Study

Bjelland EK

Back Pain Beliefs Are Related to the Impact of Low Back Pain in 17-Year-Olds: A Cross-Sectional Study From the Raine Cohort

Beales D

Comorbidities, Health-Related Quality of Life, and Specific Low Back Pain-Related Impacts at 17: Cross-Sectional Study From the Raine Cohort

Beales D

Healthcare Utilization by People With Chronic Back Disorders: A Population-Based Analysis of the 2008 Canadian Community Health Survey

Bath B

The Back Pain Beliefs of Physiotherapists Are More Positive After Brief Biopsychosocially Orientated Workshops

O'Sullivan K

Electromyography and Sonography Assessment of Abdominal Muscle Function in Individuals With and Without Lumbopelvic Pain

Whittaker J

Evidence of Altered Loading of the Abdominal Wall? A Sonographic Study Comparing People With and Without Lumbopelvic Pain

Whittaker J

The Effect of Low Back Pain on Lumbar Multifidus Muscle Size and Activity Using Rehabilitative Ultrasound Imaging and Their Correlation With Functional Outcomes

Ryan A

Transperineal Ultrasound Imaging of Pelvic Floor Muscle Activation in Men for Assessment and Treatment of Low Back and Pelvic Pain

Hodges P

11:45 AM

The Treatment of Cervicogenic Dizziness With Manual Therapy: Preliminary Results of a Randomized Controlled Trial

Reid S

Musculoskeletal Function of the Upper Cervical Spine in Children With and Without Cervicogenic Headache: A Cross-Sectional Study

Budermann K

Treatment to Address Temporomandibular Dysfunction in Addition to Usual Care Improves Cervicogenic Headache and Cervical Mobility

von Piekartz H

Association Between Movement Control Dysfunction of the Pelvis, Positive Scoring in ASLR, and Tenderness in the Dorsal SI Ligament

Lahtinen-Suopanki T

Pelvic Girdle Pain and Disability After Delivery: Do Some Groups of Women Have Potential Unfavorable Development?

Robinson HS

Symmetry of Trunk and Femoropelvic Motion During Single-Leg Loading Tests

Ippert P

Development of a Clinical Prediction Rule to Identify Patients With Neck Pain Likely to Benefit From Cervical Spine Manipulation

Puentedura E

Is Behavioral Graded Activity More Effective in Comparison With Manual Therapy in Patients With Subacute Neck Pain?

Pool J

The Effectiveness of Conservative Treatment for Patients With Cervical Radiculopathy: A Systematic Review

Thoomes E

The Effect of Different Durations of Lumbar Spine Posteroanterior Mobilizations on Pressure Pain Thresholds

Pentelka L

Interrater Reliability of the 2-Point Discrimination Test on the Lumbar Spine

Haller S

More Than Understanding Reliability: The Accuracy of Spinal Palpation in Students and Clinicians

Kawchuk G

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Does Advanced Certification Influence How Physical Therapists Manage Patients With Whiplash-Associated Disorder?

Corkery M

Improving Access: A Spinal Triage Program Delivered by Physiotherapists in Collaboration With Orthopaedic Surgeons

Bath B

Development and Implementation of a Dedicated Advanced-Practice Education Program for Musculoskeletal Physiotherapists Within Queensland Health

Kelly PS

The Benefits of Physiotherapists in Advanced-Practice Roles to Manage Patients With Musculoskeletal Disorders: A Systematic Review of the Literature

Desmeules F

Patient-Held Beliefs About Injury and Recovery Following a Whiplash Injury: An Exploratory Interview Study

Williamson E

Two Different Courses of Impaired Cervical Kinesthesia Following a Whiplash Injury. A 1-Year Prospective Study

Oddsottir GL

Online Education Is Effective in Improving General Practitioners' Knowledge of Clinical Guidelines for Whiplash

Rebbeck T

Evidence for Central Sensitization in Chronic Whiplash: A Systematic Literature Review

Meeus M

Low- Versus High-Load Motor Control Exercise to Reduce Disability in Patients With Persistent Peripherally Mediated Mechanical Low Back Pain

Aasa B

The Effectiveness of Subgroup-Specific Manual Therapy for Low Back Pain: A Systematic Review

Slater S

The Neurophysiological Effects of Spinal Manipulative Therapy on Patients With Acute and Subacute LBP

Perry J

Early Use of Thrust Manipulation Versus Nonthrust Manipulation: A Randomized Clinical Trial

Learman K

What Factors Are Associated With a Successful Outcome in Patients With Low Back Pain Who Receive a Manual Therapy Approach?

Learman K

IFOMPT SUPPLEMENT: SCHEDULE

<p>11:45 AM</p> <p>Constraint-Induced Therapy and Motor Control Retraining in the Treatment of Musicians' Focal Hand Dystonia: Long-Term Follow-up <i>Berque P</i></p> <p>Sensory Hypersensitivity and Not Sensory Hypoesthesia Is Characteristic of Nonspecific Arm Pain <i>Moloney N</i></p> <p>Somatosensory Profiles in Nonspecific Arm Pain and Matched Healthy Controls <i>Moloney N</i></p> <p>2:00 PM</p> <p>Velocity of Isokinetic Trunk Exercises Influences Back Muscle Recruitment Patterns in Healthy Subjects <i>Van Damme B</i></p> <p>Effects of Low- and High-Load Motor Control Exercises on Lumbar Curvature During Stance in Patients With Low Back Pain <i>Aasa U</i></p>	<p>The Efficacy of Directional Preference Management for Low Back Pain: A Systematic Review <i>Ford J</i></p> <p>Reliability and Validity of a Kinematic Spine Model During Active Trunk Movements in Healthy Subjects and Nonspecific LBP <i>Hidalgo B</i></p> <p>Radiological and Clinical Analysis of Thoracic Spine Extension Motion Associated With Bilateral Arm Elevation <i>Ippersiel P</i></p> <p>What Do Physiotherapists Consider to Be the Best Sitting Spinal Posture? <i>O'Sullivan K</i></p> <p>The Slump Test: A Screening Tool for Neuropathic Pain <i>Urban L</i></p> <p>3:00 PM</p> <p>Are Child-Bearing Hips a Risk Factor for Greater Trochanteric Pain Syndrome? A Case-Control Study <i>Fearon A</i></p>	<p>Gluteus Minimius Activation Is Earlier in Subjects With Hip Pain: A Noninvasive Study by M-Mode Ultrasound Imaging <i>Dieterich A</i></p> <p>The Effect of Manual Therapy Applied to Patients With Meniscus Tear: A Case Series With a Minimum of 6 Months of Follow-up <i>Yung E</i></p> <p>Predictors of Groin and Lower-Limb Injury Across 4 Codes of Football <i>Nicholson L</i></p> <p>3:15 PM</p> <p>Classification of Sagittal Standing Alignment and Its Relationship to Spinal Pain: A Study Among Pre-Peak Height Velocity Subjects <i>Dolphens M</i></p> <p>Effect of Different Cognitive Dual Tasks on Postural Sway and Trunk Stiffness in Chronic Low Back Pain Patients Compared to Healthy Controls <i>Van Daele U</i></p> <p>Phase Analysis of Multisegmental Spine Kinematics at 2 Gait Speeds <i>Pakzad M</i></p>
<p><i>The IFOMPT 2012 abstracts can be found online on the JOSPT website (www.jospt.org).</i></p>		

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Abstracts

The Journal of Orthopaedic & Sports Physical Therapy is pleased to publish abstracts of the IFOMPT 2012 meeting, which took place in Quebec City, Canada, September 30 to October 5, 2012. This collection of abstracts provides a brief summary of the research presented at that meeting. These abstracts were selected by the meeting research committee but did not undergo peer review by the editorial board of the Journal. Each abstract represents a short summary of a project, often presenting only preliminary data. These summaries do not permit a full evaluation of the scientific rigor with which the work was conducted, but they provide an idea of the type of clinical questions being researched by individuals participating in that meeting.

MANUAL THERAPY DIRECTED AT THE KNEE OR LUMBOPELVIC REGION DOES NOT INFLUENCE QUADRICEPS MOTONEURON POOL EXCITABILITY

Terry Grindstaff, Brian Pietrosimone, D. Casey Kerrigan, James Patrie, Jay Hertel, Christopher Ingersoll

Creighton University, Omaha, NE; University of Toledo, Toledo, OH; JKM Technologies LLC, Charlottesville, VA; University of Virginia, Charlottesville, VA; Central Michigan University, Mt Pleasant, MI

PURPOSE: To determine the effect of local and distant mobilization/manipulation interventions on quadriceps motoneuron pool excitability.

RELEVANCE: Quadriceps inhibition is a common impairment associated with knee joint injury. Manual therapies directed at the knee joint and lumbopelvic region have been shown to improve quadriceps muscle activation and decrease pain in individuals with knee joint pathology. The extent and duration of changes in quadriceps motoneuron pool excitability are unknown.

METHODS: Seventy-five individuals with a history of knee joint injury and current quadriceps inhibition (mean \pm SD age, 21.4 \pm 3.1 years; height, 169.4 \pm 10.5 cm; mass, 71.4 \pm 11.6 kg; quadriceps activation, 75.3 \pm 12.6) volunteered for this IRB-approved study. Subjects were randomized to 1 of 5 intervention groups: lumbopelvic manipulation (grade V), lumbopelvic manipulation positioning only (no thrust), grade IV patellar mobilization, grade I patellar mobilization, and control (no treatment). Changes in motoneuron excitability were quantified by assessing the H-reflex before and after therapeutic intervention. A repeated-measures ANCOVA, with preintervention values utilized as a covariate, was performed to compare changes in the ratio of the maximum H-reflex and maximum M-wave measurements (H/M ratio) of the quadriceps between groups over time (pre and after 0, 30, 60, 90 minutes).

RESULTS: There were no significant differences in the quadriceps H/M ratio ($F_{12,70} = 0.89, P = .56$) between the 5 intervention groups or across time intervals (time main effect) ($F_{3,70} = 0.22, P = .88$) when groups were pooled.

CONCLUSIONS: Manual therapies directed at the knee and lumbopelvic region did not acutely change quadriceps motoneuron pool excitability. Although manual therapies may improve impairments and functional outcomes, the underlying mechanism does not appear to be related to changes in motoneuron pool excitability.

IMPLICATIONS: Although changes in quadriceps motoneuron pool excitability did not occur due to manual therapy intervention, future studies should continue to investigate the underlying mechanism of effectiveness in order to further optimize interventions for joint pathology.

THE EFFECT OF JOINT MOBILIZATION ON DIFFUSE NOXIOUS INHIBITORY CONTROL IN INDIVIDUALS WITH OSTEOARTHRITIS OF THE KNEE

Carol A. Courtney, César Fernández-de-las-Peñas

University of Illinois at Chicago, Department of Physical Therapy, Chicago,

IL; Universidad Rey Juan Carlos, Madrid, Spain

PURPOSE: To examine the effect of oscillatory accessory mobilization on baseline diffuse noxious inhibitory control (DNIC) responses in individuals with chronic knee osteoarthritis (OA).

RELEVANCE: Central sensitization and impaired nociceptive inhibitory mechanisms both contribute to heightened pain in chronic knee OA. DNIC (counterirritation) has been found deficient in the chronic OA population, and normalization of this mechanism has been reported following total joint arthroplasty (ie, extinction of noxious input). Modulation of hyperexcitable nociceptive pathways through joint mobilization has been demonstrated in both animal-model and human studies, but its effect on defective DNIC mechanisms has not been studied.

METHODS: Twenty-one individuals (mean \pm SD age, 61 \pm 8 years; 8 male) with grade II or greater Kellgren and Lawrence radiographic evidence of knee OA were recruited, with average Knee Outcome Survey scores of 45% \pm 17% and average resting pain of 3.5 \pm 2.2. Baseline DNIC responses were established through application of a tourniquet test (arm), which induces ischemic pain. Modulation of knee OA pain was measured by pressure pain threshold (PPT) at knee medial joint line bilaterally, and at contralateral web space between the first and second metacarpophalangeal joints. Vibration detection thresholds (VDT) were measured.

RESULTS: Resting pain and PPT were unchanged in 15 of 21 subjects following the tourniquet test, indicating aberrant DNIC response. In this subgroup, a grade III oscillatory accessory mobilization technique (PA, 6 minutes) resulted in decreased resting pain and significant increase in PPT at the medial joint line ($P < .05$), but not at the contralateral hand. Follow-up application of the tourniquet test revealed further increases in PPT at all 3 sites.

CONCLUSIONS: This preliminary evidence suggests that application of a nonthrust manual therapy technique may have some effect on faulty descending inhibition in subjects with knee OA.

IMPLICATIONS: Understanding the neurophysiologic mechanisms underlying pain relief and improved function following manual therapy interventions allows for targeted application of these therapeutic techniques.

THE FREQUENCY OF HAMSTRING STRETCHES REQUIRED TO MAINTAIN KNEE EXTENSION RANGE OF MOTION FOLLOWING AN INITIAL 6-WEEK STRETCHING PROGRAM

Duncan Reid, Joshua Kim

School of Rehabilitation and Occupation Studies, AUT University, Auckland, New Zealand

PURPOSE: The purpose of this study was to compare 2 different hamstring stretching frequencies after an initial stretching period of 6 weeks.

RELEVANCE: Previous research has demonstrated that stretching the hamstring muscle group once per day, 5 days a week for a 6-week period improves knee extension range of motion (ROM). There is little research to demonstrate the frequency of stretching required to maintain that range once the initial improvements have been gained.

METHODS: A randomized control trial design was used. Sixty-three males (mean \pm SD age, 22.9 \pm 5 years) were recruited for the study. Participants were randomly assigned to 1 of 3 groups, 2 groups that stretched and 1 group that acted as a control and did not stretch. The 2 stretching groups both stretched initially 3 times for 30 seconds, once per day, 5 days a week, for 6 weeks. Group 1 then continued stretching with the same stretching routine once a day, 3 days per week, and group 2 once a day, 1 day per week, for a further 6 weeks. Statistical analysis was undertaken

via a 3-factor, repeated-measures ANOVA. The alpha level was set at .05. **RESULTS:** The results of the study indicate that the groups that stretched over the first 6 weeks increased their knee extension ROM significantly ($P < .05$). Over the second 6 weeks of stretching, those participants who stretched 3 days a week maintained their ROM, whereas those who stretched 1 day per week did not. This difference was significant ($P < .05$). Participants in the control group did not change their ROM at any time point ($P > .05$).

CONCLUSION AND IMPLICATIONS: To maintain improvements in knee extension ROM after an initial stretching program, stretching 3 times per week is required.

RATE OF CARTILAGE LOSS IN MEDIAL KNEE OSTEOARTHRITIS IS FASTER IN PATIENTS WITH INCREASED DURATION OF COCONTRACTION OF MEDIAL KNEE MUSCLES

Paul Hodges, Wolbert van den Hoorn, Kim Bennell, Tim Wrigley

The University of Queensland, Brisbane, Australia; The University of Melbourne, Melbourne, Australia

PURPOSE: As knee osteoarthritis (OA) cannot be cured, treatments that slow disease progression (ie, rate of cartilage loss) are a priority. Knee muscle activation has a potential role. Although 1 theory postulates benefit from enhanced knee muscle cocontraction to augment joint stability, this may speed structural progression by increased joint load. We studied, prospectively, the relationship between cartilage loss and cocontraction timing of medial/lateral knee muscles in knee OA with varus deformity.

RELEVANCE: Identification of mechanisms underpinning progression of knee OA will aid treatment design to slow this process.

METHODS: Medial (vastus medialis [VM], semimembranosus [SM]) and lateral (vastus lateralis [VL], biceps femoris [BF]) knee muscle electromyography (EMG) was recorded in 36 people with knee OA during walking at a naturally selected speed at baseline. Medial and lateral tibial cartilage volume was measured from MRI at baseline and 12 months. Relationship between onset, offset, and duration of cocontraction of medial and lateral muscles at baseline and loss of medial and lateral cartilage volume were evaluated with the Pearson correlation.

RESULTS: Duration and offset of medial muscle (VM-SM) cocontraction were significantly correlated with loss of medial cartilage volume (both, $P = .02$; 1% greater cartilage loss for 8.5% increase in cocontraction duration). Timing of VM-SM cocontraction was not correlated with loss of lateral cartilage volume. Onset of lateral muscle (VL-BF) cocontraction was correlated with lateral tibial cartilage loss ($P = .01$; 1% greater cartilage loss for 1.7% delay in cocontraction onset).

CONCLUSIONS: The relationship between knee joint cartilage loss and duration/offset of cocontraction of medial and onset of lateral knee muscle cocontraction supports the hypothesis that augmented knee muscle cocontraction may underpin faster progression of knee OA with varus deformity.

IMPLICATIONS: Exercise interventions that change knee muscle activation patterns should be considered as possible methods to slow progression of knee joint OA.

VALIDATION OF A SET OF CLINICAL IDENTIFIERS FOR THE EARLY STAGE OF PRIMARY/IDIOPATHIC ADHESIVE CAPSULITIS: PRELIMINARY RESULTS

Sarah Walmsley, Darren Rivett, Peter Osmotherly

School of Health Sciences, The University of Newcastle, Newcastle, Australia

PURPOSE: The purpose of this study was to validate a set of 8 clinical identifiers of early-stage primary/idiopathic adhesive capsulitis (AC) established in an earlier Delphi study. These identifiers comprised both patient-reported and physical examination findings.

RELEVANCE: AC often poses a diagnostic dilemma in its early stage and may be confused with other commonly presenting shoulder disorders.

METHODS: Forty-three patients diagnosed with early-stage AC by a physiotherapist or medical practitioner were included in the study. Active and

passive shoulder ranges of movements and visual analog scale (VAS) pain scores for each movement were recorded, prior to and immediately following a radiologically guided intra-articular injection of corticosteroid and local anesthetic as part of normal clinical management. Using the local anesthetic as the reference standard, pain relief of $\geq 70\%$ for passive external rotation in neutral abduction following the injection was determined a positive anesthetic response (PAR). The 8 criteria were analyzed against anesthetic response using backward stepwise logistic regression.

RESULTS: Ten patients demonstrated a PAR. Univariate analysis identified that global loss of active and passive ranges of motion ($OR = 0.148$, $P = .015$) and pain at the end of passive range in all directions ($OR = 8.00$, $P = .017$) were significantly associated with a PAR. Following stepwise removal of variables in a multivariate model, pain at the end of range in all directions was the only statistically significant predictor of PAR.

CONCLUSIONS: Preliminary results suggest that of the 8 clinical identifiers developed in the previous Delphi study, pain at the end of passive movement in all directions during physical examination may be the only independent predictor of early-stage AC.

IMPLICATIONS: While a defined subset of clinical identifiers of early AC remains to be determined, pain at the end of range of passive movement in all directions should be considered the strongest indicator.

MATHEMATICAL MODELING OF THE CONVEX RULE AT THE GLENOHUMERAL JOINT AND ITS APPLICATION TO VALIDATE THE CONVEX RULE THROUGH THE ANALYSIS OF KINEMATICAL EVIDENCE OF THE GLENOHUMERAL JOINT

Philippe Tudger Viloria

OMT Venezuela, Caracas, Venezuela

RELEVANCE: The convex rule is an important clinical rule to evaluate and treat joint dysfunctions, because it can predict the normal relationship between the arthrokinematics and osteokinematics. The suggested model will help to solve the lack of consensus on the bibliography concerning the validity of the glenohumeral convex rule.

DESCRIPTION: The qualitative modeling of the glenohumeral convex rule consisted of: the simplification of the surfaces of the joints and the restriction in 2 degrees of freedom. The quantitative modeling was deduced from the condition of pure rolling motion over the translation of a circle's center (θ multiplied by r , or $\theta \times r$) with a radius (r) that rolls in an angle (θ) over a plane. The rule's validation was made by checking that the translation of the geometric center of the humeral head (TGCHH) was lower than the predicted range by the mathematical model in each study. The analyzed studies belong to peer-reviewed journals (1976-2010) that describe glenohumeral kinematics based on the TGCHH.

EVALUATION: Given a bone rotation range (θ) and a radius of the humeral head (r), the suggested model of the convex rule predicts that TGCHH has to be lower than $\theta \times r$. The convex rule was met in all of the analyzed studies.

CONCLUSION: The glenohumeral convex rule model demonstrates that the convex rule is accomplished if and only if: the maximum TGCHH is lower than $\theta \times r$; moreover, the convex rule was validated through the analysis of kinematical evidence in the glenohumeral joint.

IMPLICATIONS: The suggested model will establish a better communication between biomechanists and physiotherapists with the establishment of an equivalence between most frequently used kinematic variables of each guild.

MUSCLE RECRUITMENT PATTERNS DURING ABDUCTION IN DIFFERENT PLANES AND AT DIFFERENT LOADS

Mark Halaki, Darren Reed, Ian Cathers, Karen Ginn

Exercise and Sport Science, Faculty of Health Sciences, The University of Sydney, Sydney, Australia; Biomedical Science, Sydney Medical School, The University of Sydney, Sydney, Australia

PURPOSE: To determine the effects of performing shoulder abduction in different planes with increasing load on muscle activation levels.

RELEVANCE: Knowledge of normal muscle function is crucial in prescribing exercises.

METHODS: Fourteen asymptomatic subjects with no history of shoulder pain volunteered. Dynamic abduction was performed in the coronal, scapular, and midway between the scapular and sagittal planes (scap-sag) and at 25%, 50%, and 75% maximum load. Electromyographic signals were recorded from supraspinatus, infraspinatus, subscapularis, upper and lower trapezius, serratus anterior, pectoralis major, and middle deltoid. A 3-factor repeated-measures ANOVA (7 muscles, 3 planes, 3 loads) with Tukey post hoc analyses was performed to compare average muscle activation levels.

RESULTS: Different muscles were activated at different levels ($F_{6,78} = 2.2$, $P < .05$). The activity in all muscles increased as load increased ($F_{2,26} = 65.2$, $P < .01$). The only significant interaction was between muscles and plane ($F_{12,156} = 4.3$, $P < .01$). Among the muscles, only middle deltoid was significantly less active in the scap-sag plane compared to the coronal plane ($P < .05$). In the coronal plane, infraspinatus was activated higher than subscapularis ($P < .05$) but both were similar to supraspinatus ($P \geq .23$). Upper trapezius was activated higher than lower trapezius ($P < .05$) and both were similar to serratus anterior ($P \geq .67$). In both scapular and scap-sag planes, infraspinatus was activated higher than supraspinatus ($P < .05$) and both were activated higher than subscapularis ($P < .05$). Both upper trapezius and serratus anterior had similar levels ($P \geq .99$) and were higher than lower trapezius ($P < .05$).

CONCLUSION: Abduction performed in any of the 3 abduction planes activates all muscles tested at similar levels, except middle deltoid. The relative contribution of individual rotator cuff muscles and axio-shoulder muscles changes between planes. Increasing load systematically increases the activation of all muscles.

IMPLICATIONS: When prescribing abduction, the relative contribution of the rotator cuff and axio-shoulder muscles in each plane should be considered.

EFFECTIVENESS OF TRANSLATIONAL MANIPULATION UNDER INTERSCALENE BLOCK FOR THE TREATMENT OF ADHESIVE CAPSULITIS OF THE SHOULDER

Daniel Rendeiro, Guy Majkowski, Norman Gill, Ian Lee, Dale Jensen, Gail Deyle, Robert Wainner, Stephen Allison

Army-Baylor University Postprofessional Doctoral Fellowship in OMPT, San Antonio, TX; 31st Medical Operations Squadron, US Air Force, Aviano, Italy; Defense Health Information Management System, Falls Church, VA; Naval Medical Center, Portsmouth, VA; Texas State University, San Marcos, TX; Rocky Mountain University of Health Professions, Provo, UT

PURPOSE: To determine whether translational manipulation (TM) under regional block adds to the benefit of mobilization and exercise for improving pain and functional status among patients with adhesive capsulitis (AC) of the shoulder.

RELEVANCE: TM under regional block has been shown to improve pain and dysfunction in patients with AC who are unresponsive to traditional physical therapy. This intervention has not been directly compared to physical therapy treatment without TM in a prospective trial.

METHODS: Sixteen consecutive patients with a primary diagnosis of AC were divided into 2 groups. Patients in the first (TM) group received a session of TM under interscalene block, followed by 6 sessions of mobilization and exercise. Patients in the second (comparison) group received 7 sessions of mobilization and exercise. Outcome measures taken at baseline and 3, 6, and 12 months and 4 years included Shoulder Pain and Disability Index (SPADI) scores. Four-year outcomes included percent of normal ratings, medication use, and activity limitations.

RESULTS: Both interventions led to excellent long-term outcomes, as indicated by nonexistent or low levels of disability, activity limitations, and medication use. Both groups showed improved SPADI scores across all follow-up times compared to baseline. The TM group showed a greater improvement in SPADI scores than the comparison group at 3 weeks, but no subsequent between-group differences were significant. At 4 years,

percent of normal ratings were similar in both groups; 5 of 8 subjects in the comparison group had activity limitations, versus 1 of 8 subjects in the TM group.

CONCLUSIONS: TM under regional block may be a useful adjunct to joint mobilization and exercise for patients with AC.

IMPLICATIONS: Larger controlled trials are needed to determine whether TM under regional block offers additional benefit beyond joint manipulation and exercise for patients with AC.

THE CERVICAL FLEXOR MUSCLES INVESTIGATED WITH ULTRASOUND: A COMPARISON BETWEEN PATIENTS WITH WHIPLASH INJURY AND CONTROLS

Gunnel Peterson, Michael Peolsson, Anneli Peolsson

Paramedicine Mälarsjukhuset, Eskilstuna, Sweden; Computational Life Science Cluster and Department of Chemistry, Umeå University, Umeå, Sweden; Department of Medical and Health Sciences, Division of Physiotherapy, Linköping, Sweden

BACKGROUND: Neck muscles act in a complex activation pattern and dysfunction in the motor control system is a feature of persistent whiplash-associated disorder (WAD). Ultrasound with speckle-tracking software allows noninvasive investigation of superficial and deep ventral neck muscle activation.

PURPOSE: The aim of this study was to compare the mechanical activation pattern of the ventral neck muscles sternocleidomastoid (SCM), longus capitis (Lcap), and longus colli (Lcoll) during unilateral arm elevation, between persons suffering from WAD and healthy controls.

RELEVANCE: There have been very few studies investigating the deep ventral neck muscles.

METHODS: Thirty patients (mean \pm SD age, 38 ± 11.2 years) with persistent neck pain (6 months to 3 years) after WAD and 30 healthy sex- and age-matched controls participated in the study. Ultrasound images of the ventral neck muscles were investigated at C4 level during the 10th repetition of loaded (men, 2 kg; women, 1 kg) arm flexion to 90°. Speckle-tracking algorithms were used to analyze degree of deformation (%) (muscle contraction or elongation) and deformation rate (1/s).

RESULTS: Muscle deformation pattern within each group showed a significant difference ($P < .04$) between patients and controls. Patients had highest contraction of SCM, followed by Lcap and an elongation of Lcoll. Controls had highest contraction of Lcoll, followed by SCM and an elongation of Lcap. In contrast to the WAD group ($P = .95$), controls had higher deformation rate of the Lcap and Lcoll than of SCM ($P < .001$) and higher deformation rate of the Lcoll than Lcap ($P < .002$).

CONCLUSION: Individuals with WAD showed a different muscle deformation pattern and deformation rate compared to healthy controls. The results suggest an altered pattern of motor control after WAD.

IMPLICATIONS: Ultrasound with speckle-tracking analysis of the neck muscles might improve WAD diagnosis and allow development of specific exercise programs for better rehabilitation.

DETAILED MYOFASCIAL DISSECTION OF THE LONGUS CAPITIS AND LONGUS COLLI MUSCLES

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PURPOSE: To provide a detailed anatomical description of the deep cervical flexors (DCF), longus capitis (Lca), and longus colli (LCo).

RELEVANCE: Clinical research has proceeded without a current detailed anatomical description of the DCF, which could assist with understanding the function of this muscle group.

METHODS: The morphological structure of Lca and LCo was studied by gross dissection and microdissection of 8 embalmed adult human cadavers. Details of fibrous attachment, orientation, and distribution were

recorded through journal documentation.

RESULTS: LCa originates from 2 bony fossae anterior to the foramen magnum and attaches to the anterior tubercles of C3-C6. LCo presents as 1 continuous muscle with slight variation of fascicle orientation from superior to middle to inferior regions. The superior region originates from the anterior arch of C1 and anterior vertebral body of C2, with fascicles oriented in an inferior-lateral direction attaching to the anterior tubercles of C2-C4. Fascicles in the middle region, C3-C6, are housed within gutters formed between the lateral vertebral bodies and the anterior tubercles, are vertically oriented, and distinguished by a superficial aponeurosis. In the inferior region, deep and superficial layers of fascicles continue in an inferior-medial direction, to insert at the anterior-lateral aspect of T3 or T4 vertebral bodies. Throughout its length, a continuous distinct fascial connection with the anterior longitudinal ligament was demonstrated.

CONCLUSIONS: LCa and LCo appear anatomically suited for their proposed primary function as stabilizers of the cervical spine. LCa is the principal flexor of the head on the neck and has a reasonable mechanical advantage for this action. LCo lacks the mechanical advantage to act much other than a stabilizer.

IMPLICATIONS: The results of this study can be used to enhance the understanding of the anatomy and guide further research on the function of this muscle group.

MECHANICAL NECK MUSCLE ACTIVATION DURING 120° ARM FLEXION REGISTERED WITH ULTRASOUND: A COMPARISON OF PATIENTS AND HEALTHY CONTROLS

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PURPOSE: To compare the mechanical activity of the ventral and dorsal neck muscles in individuals with persistent longstanding disability after surgery for cervical disc disease to that of healthy controls, during a loaded arm elevation task.

RELEVANCE: There are limited studies investigating the long-term effect on cervical motor function associated with surgery for cervical disc disease.

METHODS: Ten individuals (mean \pm SD age, 60 ± 7.1 years) who underwent anterior cervical decompression and fusion (10-13 years ago) for cervical disc disease and 10 healthy age- and sex-matched controls participated in the study. Ultrasonography and postprocess speckle-tracking analysis were used to investigate the degree of deformation (%) and deformation rate (m/s) of ventral and dorsal neck muscles at the C4 segmental level during 1 repetition of loaded arm flexion to 120° (barbell, 2 kg for men and 1 kg for women).

RESULTS: There were significant group effects for ventral muscle deformation and deformation rate (elevated in patients, $P < .04$), but no group-by-muscle interactions ($P > .12$). Compared to controls, tests of simple effects revealed that in patients, deformation was significantly elevated for the longus capitis muscle ($P < .03$) only, and deformation rate for the longus capitis and sternocleidomastoid muscles ($P < .04$) only. For the dorsal neck muscles, no group ($P > .87$) or group-by-muscle interactions ($P > .33$) were observed for either the deformation or deformation rate measures.

CONCLUSIONS: Greater muscle deformation and deformation rates were observed in the ventral neck muscles of patients with longstanding neck disability compared to controls. These differences may be indicative of an altered motor strategy in this patient group when performing the upper-limb task.

IMPLICATIONS: These findings are of potential clinical relevance, particularly for those patients who complain of aggravation of neck symptoms during activities of the upper limb.

INTERPRETATION OF CERVICAL PASSIVE ACCESSORY INTERVERTEBRAL MOVEMENTS: FROM THUMBS TO OUTCOMES

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PURPOSE: To describe the specific characteristics of passive accessory intervertebral movements (PAIVMs) to the cervical spine that relate to patient symptoms and segmental mobility.

RELEVANCE: PAIVMs are common manual therapy techniques. The interpretation of PAIVM findings is often described using force-displacement curves contained in movement diagrams, but it has not been clear what aspects of the force-displacement curves are related to patient symptoms or to intervertebral mobility.

DESCRIPTION: Contrary to the initial concepts of PAIVMs, the intervertebral movements produced are neither accessory nor localized, but rather physiological and involve the entire cervical region. Nonetheless, specific, measurable characteristics of PAIVMs have been shown to be related to patient outcomes and to local tenderness. This paper will discuss how these specific characteristics compare to simulations using computer-based modeling.

EVALUATION: Experimentally determined changes in PAIVMs at symptomatic locations that occur with symptom improvement are similar to differences between tender and less tender locations. The relevant differences are easier to visualize using stiffness-displacement curves than the force-displacement curves that are typically used in movement diagrams and become apparent at levels of force starting at less than those required to click a retractable pen (4-5 N). Computer-based modeling indicates that similar differences in PAIVM stiffness to those found in the clinical studies would be expected to occur with a reduced lax zone of the underlying motion segment.

CONCLUSIONS: The behaviors of PAIVM stiffness related to patient symptoms (1) are more clearly visualized with stiffness curves than force-displacement curves, (2) occur from low levels of force, and (3) are consistent with a smaller lax zone at the underlying intervertebral motion segment.

IMPLICATIONS: The early parts of PAIVM movements contain clinically important information. Simple linear approximations of force-displacement curves of PAIVMs may not be sufficient to detect the specific characteristics that are related to patient symptoms.

A PILOT STUDY COMPARING CERVICAL SPINE STIFFNESS IN PATIENTS WITH CHRONIC NONSPECIFIC NECK PAIN AND ASYMPTOMATIC INDIVIDUALS

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PURPOSE: To determine if spinal joint stiffness is greater in patients with nonspecific neck pain, and whether the magnitude of stiffness is associated with self-reported pain and disability.

RELEVANCE: Musculoskeletal practitioners commonly evaluate spinal joint stiffness as part of their clinical examination in patients presenting with nonspecific neck pain. However, a relationship between cervical spine stiffness and nonspecific neck pain has not yet been demonstrated.

METHODS: Participants with chronic nonspecific neck pain whose symptomatic level was identified at C7 were matched with pain-free controls. A cervical spine stiffness assessment device quantified segmental stiffness by applying 5 cycles of standardized mechanical posteroanterior force to the C7 spinous process while measuring concurrent displacement and resistance to movement. Stiffness was defined as the slope of the linear region of the force-displacement curve and compared between groups using a paired *t* test. Clinical measures of self-reported pain (visual analog scale) and disability (Neck Disability Index) were obtained from those with neck pain to determine whether the magnitude of stiffness was associated with pain intensity (Spearman rho) or the level of disability (Pearson r).

RESULTS: Participants with neck pain ($n = 12$) demonstrated greater spi-

nal joint stiffness compared with pain-free individuals ($n = 12$) ($P = .014$). However, the magnitude of stiffness was not associated with pain intensity or the level of disability in participants with neck pain.

CONCLUSION: These preliminary results support the hypothesis that cervical spine stiffness is greater in the presence of nonspecific neck pain. Further judgments regarding the intensity of pain and the level of disability cannot be inferred from examinations of spinal joint stiffness.

IMPLICATIONS: These findings provide preliminary support for the clinical utility of the examination of cervical spine stiffness as a screening tool to identify and differentiate those patients presenting with chronic nonspecific neck pain from asymptomatic individuals.

LACK OF UNIFORM DIAGNOSTIC CRITERIA FOR CERVICAL RADICULOPATHY IN CONSERVATIVE INTERVENTION STUDIES: A SYSTEMATIC REVIEW

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PURPOSE: Cervical radiculopathy (CR) is a common diagnosis. It is unclear if intervention studies use uniform definitions and criteria for patient selection. Our objective was to assess the uniformity of diagnostic criteria and definitions used in intervention studies to select patients with CR.

METHODS: We electronically searched the Cochrane Controlled Trials Register, MEDLINE, Embase, and CINAHL. Studies were included when evaluating conservative interventions in randomized clinical trials (RCTs) in patients with CR. Selection criteria and definitions for patients with CR were extracted and evaluated on their uniformity.

RESULTS: Thirteen RCTs were included. Pain was used as an inclusion criterion in 11 studies. Inclusion based on the duration and location of pain varied between studies. Five studies used sensory symptoms in the arm as an inclusion criterion. Four studies used cervical range of motion and motor disturbances as inclusion criteria, and reflex changes were used in 2 studies. Three studies included patients with a positive Spurling test, and 2 studies used it within a cluster of provocation tests.

CONCLUSIONS: Criteria used to select patients with CR vary widely between different intervention studies. Selection criteria and test methods used are poorly described. There is consensus on the presence of pain, but not on the exact location of pain.

A COMPARISON OF GENERAL SEATED AND TARGETED SUPINE THORACIC SPINE THRUSTS AND THEIR EFFECT ON CERVICAL PAIN AND RANGE OF MOTION

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PURPOSE: A randomized control trial to determine the effectiveness of a general seated thoracic manipulation versus a targeted supine thoracic manipulation on cervical spine pain and range of motion.

RELEVANCE: Thoracic spine manipulation is a treatment option for patients presenting with neck pain. Comparing methods of thoracic spine manipulation and their effectiveness on neck pain and range of motion will provide optimal relief for patients and may result in more frequent utilization of effective techniques.

METHODS: Twenty-eight patients who presented with neck pain and no contraindications for manipulation volunteered for this study and were treated by 3 manual physical therapists. A pretreatment education program was undertaken so the therapists used the same manipulation techniques. Patients were then randomly assigned to 1 of 2 thoracic spine manipulation groups: a general seated or a targeted supine group. The general seated group received a general distraction manipulation. The targeted supine group received supine thrust manipulation to segments

(a maximum of 2) that were identified as hypomobile. Hypomobility was determined by the PA after assessing posterior/anterior mobility. Cervical range of motion and end-range pain were assessed pretreatment and posttreatment.

RESULTS: There was a significant difference in posttreatment pain relief in those subjects receiving the specific supine thrust ($P < .05$). Although not significant, there was a trend to greater range of motion with the specific supine group.

CONCLUSIONS: The result of this study concludes that a specific supine thoracic thrust may be more effective in reducing neck pain and improving cervical range of motion than a general seated thoracic thrust.

IMPLICATIONS: Manual physical therapists should consider a specific treatment technique of the thoracic spine when treating patients with cervical spine pain. Future studies should include a variety of patients and therapists to validate our findings.

SHORT-TERM COMBINED EFFECTS OF THORACIC MANIPULATION WITH CERVICAL MOBILIZATION IN PATIENTS WITH MECHANICAL NECK PAIN: AN RCT

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PURPOSE: The purpose of this randomized clinical trial was to investigate the short-term effects of thoracic spine thrust manipulation combined with cervical spine nonthrust manipulation (TS+CS group) versus cervical spine nonthrust manipulation alone (CS-only group) in patients with mechanical neck pain.

RELEVANCE: Recent research demonstrated that the use of thrust manipulation directed at the thoracic spine is an effective short-term intervention in decreasing pain and disability in patients with neck pain. However, previous studies have not determined if thoracic spine thrust manipulation would increase benefits beyond that provided by cervical nonthrust manipulation alone.

METHODS: Sixty-four participants with mechanical neck pain were randomized into 2 groups (TS+CS and CS group). Both groups received cervical spine nonthrust manipulation and a general active-range-of-motion program, whereas only the TS+CS group received additional thoracic spine thrust manipulations. Outcome measures were collected at baseline and at a 1-week follow-up and included the numeric pain rating scale (NPRS), the Neck Disability Index (NDI), and the global rating of change (GROC).

RESULTS: There was a statistically significant interaction in favor of the TS+CS group ($P < .001$) for both the NPRS and NDI at the 1-week follow-up. In addition, 31 of 33 (94%) of participants in the experimental group demonstrated a follow-up GROC score of +4 or higher at the 1-week follow-up. The number needed to treat was 1.7 at the 1-week follow-up.

CONCLUSIONS: This study demonstrated that participants in the TS+CS group demonstrated greater improvements in pain reduction and function compared to participants in the CS-only group.

IMPLICATIONS: The results of this study suggest that the addition of thoracic spine thrust manipulation adds substantial clinical benefit in the short-term management of individuals with mechanical neck pain.

THE SIDE, DIRECTION, AND NUMBER OF CAVITATION SOUNDS DURING UPPER CERVICAL THRUST MANIPULATION

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PURPOSE: The primary purpose was to determine which side of the spine cavitates during C1-2 thrust manipulation. Secondary purposes were to calculate the average number of pops, the duration of upper cervical thrust manipulation, and the duration of a single cavitation.

RELEVANCE: The popping produced during joint manipulation is a common sound; however, to date, only 1 study has previously investigated the location of cavitation sounds during thrust manipulation of the cervical spine, and no study has investigated the side, duration, or number of popping sounds when targeting the C1-2 articulation.

METHODS: Nineteen asymptomatic participants received 2 upper cervical thrust manipulations targeting the right and left C1-2 articulation, respectively. Skin-mounted microphones were secured bilaterally over the transverse process of C1. Sound-wave signals were recorded. Identification of the side, duration, and number of popping sounds was determined by simultaneous analysis of spectrograms with audio feedback using custom software developed in MATLAB.

RESULTS: Bilateral popping sounds were detected in 34 (91.9%) of 37 manipulations, whereas unilateral popping sounds were detected in just 3 (8.1%) manipulations. Of the 132 total cavitations, 72 occurred ipsilateral and 60 occurred contralateral to the targeted C1-2 articulation; that is, cavitation was no more likely to occur on the ipsilateral than the contralateral side ($P = .294$). The mean number of pops per manipulation was 3.57. The mean duration of a single manipulation was 96.95 milliseconds, and the mean duration of a single pop was 5.66 milliseconds.

CONCLUSIONS: Most subjects produced 3 to 4 pops during a single C1-2 thrust manipulation. The cavitation sounds during upper cervical thrust manipulation are 11 times more likely to occur bilaterally than just unilaterally.

IMPLICATIONS: Clinicians should expect multiple popping sounds when performing upper cervical thrust manipulation; hence, the traditional approach of targeting a single ipsilateral or contralateral facet joint may not be realistic.

UPPER CERVICAL AND UPPER THORACIC THRUST MANIPULATION VERSUS NONTHRUST MOBILIZATION IN PATIENTS WITH MECHANICAL NECK PAIN: A MULTICENTER RANDOMIZED CLINICAL TRIAL

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PURPOSE: To compare the short-term effects of upper cervical and upper thoracic high-velocity, low-amplitude (HVLA) thrust manipulation to nonthrust mobilization in patients with neck pain.

RELEVANCE: Although commonly utilized interventions for the management of neck pain, no studies have directly compared the effects of both upper cervical and upper thoracic HVLA thrust manipulation to nonthrust mobilization in this population.

METHODS: Patients completed the Neck Disability Index, the numeric pain rating scale, the flexion-rotation test for measurement of C1-2 rotation ROM, and the craniocervical flexion test for measurement of deep cervical flexor motor performance. Following baseline evaluation, patients were randomized to receive HVLA thrust manipulation or nonthrust mobilization to the upper cervical (C1-2) and upper thoracic (T1-2) spines. Patients were re-examined 48 hours after the initial examination.

RESULTS: One hundred seven patients were randomized into HVLA thrust manipulation ($n = 56$) and nonthrust mobilization ($n = 51$) groups. The 2-by-2 ANOVA demonstrated that patients with mechanical neck pain who received both upper cervical and upper thoracic HVLA thrust manipulation experienced significantly ($P < .001$) greater reductions in disability (50.5%) and pain (58.5%) than the nonthrust mobilization group (12.8% and 12.6%, respectively). The HVLA thrust manipulation group showed significantly ($P < .001$) greater improvement in C1-2 ROM and motor performance of the deep cervical flexor muscles than the nonthrust mobilization group. The number needed to treat to avoid an unsuccessful outcome was 1.8 and 2.3 using the global rating of change and NDI cut scores, respectively.

CONCLUSIONS: Patients who received HVLA thrust manipulation to both the upper cervical and upper thoracic articulations had greater improvements in disability, pain, ROM, and motor performance than patients who received nonthrust mobilization.

IMPLICATIONS: The combination of upper cervical and upper thoracic HVLA thrust manipulation is appreciably more effective in the short term than nonthrust mobilization in patients with mechanical neck pain.

THE TREATMENT OF PLANTAR FASCIITIS IN THE NEW MILLENNIUM: THE EFFECTS OF EXTRACORPOREAL SHOCKWAVE THERAPY (ECSWT), JOINT MOBILIZATIONS, AND EXERCISE ON THE VISUAL ANALOG SCALE (VAS) AND LOWER EXTREMITY FUNCTIONAL SCALE (LEFS)

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PURPOSE: To assess the effects of ECSWT, joint mobilizations, and exercise on heel pain in patients with plantar fasciitis, as measured via the VAS and LEFS.

RELEVANCE: Plantar fasciitis is the most common cause of heel pain today. Two million people are treated for plantar fasciitis yearly, accounting for 11% to 15% of visits to medical professionals. It's estimated that 10% of the population will develop plantar fasciitis during their lifetime. Treatment for plantar fasciitis may include a variety of interventions, including the use of ECSWT, manual therapy, and exercises.

METHODS: Subjects ($n = 75$) were randomly assigned into 3 groups: ECSWT (group 1); ECSWT and joint mobilizations to the talocrural, subtalar, and first MTP joint (group 2); or ECSWT and stretching the gastrocnemius, soleus, and plantar fascia and strengthening for the ankle (group 3). A VAS for pain and LEFS was measured pretreatment and 3 months posttreatment.

RESULTS: A significant difference was found posttreatment among the groups for VAS and LEFS. There was a significant main effect from pretreatment to posttreatment in the LEFS score ($F = -65.73$, $df = 1.72$, $P = .0001$), in VAS for pain at rest ($F = 34.61$, $df = 1.72$, $P = .0001$), in the VAS for pain following activity ($F = 215.27$, $df = 1.72$, $P = .0001$), and in the overall improvement in heel pain ($F = 325.35$, $df = 1.72$, $P = .0001$).

CONCLUSIONS: ECSWT alone or in combination with joint mobilizations or exercise was shown to be an effective treatment for the relief of heel pain in patients with plantar fasciitis.

IMPLICATIONS: ECSWT in combination with joint mobilizations and exercises offers an exciting and relatively new intervention for the treatment of plantar fasciitis. In the future, we may see this combination of treatment utilized in more clinical facilities earlier in treatment and may limit the progression of the disorder and minimize the long-term healthcare costs associated with plantar fasciitis.

THE EFFECT OF A LOSS OF ANKLE DORSIFLEXION RANGE ON FRONTAL AND TRANSVERSE PLANE LOWER-LIMB ALIGNMENT

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PURPOSE: The aim of this study was to investigate whether limited ankle dorsiflexion range of motion is associated with increased hip adduction/internal rotation during a functional loading test.

RELEVANCE: A pattern of excessive hip adduction and internal rotation with medial deviation of the knee has been associated with numerous musculoskeletal conditions. To date, most research has focused on deviant hip biomechanics, and not the role that ankle dorsiflexion range of motion may play in this medial collapse of the lower limb.

METHODS: Thirty healthy females (aged 18-30) participated. Ranges of motion were measured kinematically using an 8-camera Optitrack motion-analysis system. Light-reflective markers were attached to 21 predefined

anatomical sites. The participants were instructed to step down from a height of 25 cm at a standard rate of 2 seconds. Ankle dorsiflexion and hip adduction and internal rotation were measured for the supporting leg at a point just prior to toe touch by the leading leg. The step-down was repeated with the supporting heel placed on a 35-mm platform, which prevented the ankle from requiring dorsiflexion range during the step-down. **RESULTS:** Decreased ankle dorsiflexion of the supporting leg during the step-down was associated with increased medial collapse (Pearson; $P = .06$). Participants who achieved less than 16° of dorsiflexion during the step-down showed improved lower-limb alignment (indicated by hip adduction/internal rotation) during the elevated heel step-down (t test; $P = .008$). **CONCLUSION:** An association between a loss of ankle dorsiflexion and an increase in medial collapse during a functional loading test has been shown. **IMPLICATIONS:** Ankle dorsiflexion should be taken into account when assessing patients with aberrant frontal and transverse plane alignment. The elevated heel step-down should be further investigated as a clinical test to differentiate between a primary hip or ankle dysfunction.

INJURED TENDONS CONTINUE TO ATTEMPT TO HEAL, EVEN AFTER PROLONGED DAMAGE

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PURPOSE: To evaluate the gene transcript profile for extracellular matrix remodeling of tendon specimens from people with greater trochanteric pain syndrome (GTPS), compared to an age- and sex-matched reference group.

RELEVANCE: Tendinopathy is a difficult condition to treat successfully. Better understanding of the underlying cell processes may lead to more successful interventions.

METHODS: Tendon specimens were collected from 7 participants undergoing gluteal tendon reconstruction for longstanding (mean duration, 41 months) GTPS, and 8 participants from an age-matched reference group of hip OA patients asymptomatic for GTPS. Specimens were collected using sterile technique and placed in RNase free plastic molds and frozen in OCT on dry ice at the time of surgery. Specimens were stored at -80°C. RNA was isolated via laser capture microdissection of areas of tendon that typified the specimen. These were identified using light microscopy and H&E staining. Specimens were tested using the SABiosciences array (PAHS-013). Immunohistochemistry was used to confirm the site of a subset of the expressed genes.

RESULTS: In the GTPS group, genes that control cell adhesion (ITGAV and NCAM1), noncollagenous constituent of basement membrane (LAMC1), cell interaction regulatory peptides (CTNNA1, ITGB3), and various collagens were up-regulated by at least 5-fold in the GTPS compared to the reference group. Genes that control extracellular matrix modeling (MMP3) and basement membrane ECM proteins (LAMB3, VTN) were down-regulated at least 6-fold.

CONCLUSIONS: These results suggest that there is increased cell activity and collagen production, suggesting that the tendon is actively remodeling even when the damage is longstanding.

IMPLICATIONS: Evidence of ongoing active tendon remodeling suggests that by providing the appropriate advice regarding tendon loading and compression, exercises to strengthen the musculotendinous unit, and ongoing support to patients, recovery from tendinopathy may be possible, even in longstanding cases.

EFFECT OF GLENOHUMERAL FORWARD FLEXION ON UPPER-LIMB MYOELECTRIC ACTIVITY DURING SIMULATED MILLS MANIPULATION: RELATIONS TO PERIPHERAL NERVE BIOMECHANICS AND SPECIFICITY OF MILLS MANIPULATION

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PURPOSES: (1) To investigate muscle responses with the Mills manipulation for lateral epicondylalgia. (2) To establish whether upper extremity muscle responses are influenced by a position that is likely to reduce mechanical tension in the local peripheral nerves, 65° forward flexion of the shoulder (varied position) compared to the usual technique (standard position; 90° abduction in frontal plane).

RELEVANCE: Clinical relevance is provided by quantitative data supporting the modification of the technique.

METHODS: End-range premanipulative stretch was used to simulate the effects of Mills manipulation. Eight asymptomatic subjects were tested bilaterally ($n = 16$). Study design was a controlled laboratory study using single-group, within-subjects comparison. Electromyographic (EMG) signals were recorded with a 16-channel portable EMG unit and processed offline. To reconstruct and verify accuracy of body movements, joint positions were measured using 3 charge-coupled device (CCD) adjustable cameras sensitive to 10 mm reflective passive markers applied at specific locations on the subjects' bodies, and these data were correlated with the EMG parameters.

RESULTS: Compared with the standard position, the varied position produced significantly reduced EMG activity ($P < .001$) in all test muscles (brachioradialis, biceps brachii, upper trapezius, triceps brachii, pectoralis major). Therefore, the effects of these potentially protective muscles may be mediated by mechanical tension in the local peripheral nerves. Subjective data support this phenomenon, as the premanipulative stretch was reported to be considerably less painful in the varied position.

CONCLUSIONS: Changes in myoelectric activity during Mills manipulation suggest integration of muscle and neural mechanisms. Therefore, the addition of neural detensioning movements to the standard Mills manipulation is advised.

IMPLICATIONS: Sixty-five degrees of forward flexion of the shoulder may be used to reduce both mechanical stresses in the peripheral nerves and extraneous muscle activity, making the Mills manipulation potentially safer and more specific.

CAN ELBOW MANIPULATION AND EXERCISE CHANGE THE CLASSIC POORER LONG-TERM RECOVERY TRAJECTORY OF CHRONIC LATERAL EPICONDYLALGIA FOLLOWING CORTICOSTEROID INJECTIONS?

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PURPOSE: To investigate if the higher recurrence rates and success rates of corticosteroid injection in the long term: (a) can be ameliorated by addition of a multimodal physiotherapy program of manipulation and exercise, and (b) are not a placebo response.

RELEVANCE: Corticosteroid injections and multimodal physiotherapy for lateral epicondylalgia proffer short-term advantage in recovery beyond adoption of a wait-and-see policy. Corticosteroid injection, although superior early, has substantially higher prevalence of recurrences.

METHODS: A randomized placebo control trial with concealed allocation to 1 of 4 groups (corticosteroid injection [$n = 43$], placebo injection [$n = 41$], corticosteroid injection plus physiotherapy [$n = 40$], or placebo injection plus physiotherapy [$n = 41$]) was used to evaluate the addition of multimodal physiotherapy to injection, as well as the placebo effect of injection. Multimodal physiotherapy consisted of elbow mobilization with movement treatments plus an exercise program over 8 weeks; 165 patients with lateral epicondylalgia were recruited for the study and fol-

lowed up for 12 months. Analysis was on an intention-to-treat basis with significance set at .01.

RESULTS: Long-term success or recurrence rates were not altered by the addition of multimodal physiotherapy, despite the latter being superior to the placebo injection. Corticosteroid injections resulted in a 42% higher recurrence rate over the 12 months and 30% lower success rate (6 months), after exhibiting a 45% superiority in success at 4 weeks.

CONCLUSION: Multimodal physiotherapy added to corticosteroid injection does not ameliorate the trajectory following corticosteroid injection, which is substantially different from the trajectory of a placebo injection. The steroid medication appears responsible for the corticosteroid injection effects.

IMPLICATIONS: Patients ought to be made aware that for every 2 patients who have a corticosteroid injection, 1 will experience a recurrence within 12 months. This is no different with the addition of a multimodal physiotherapy program.

MANUAL THERAPY AND EXERCISES IN PATIENTS WITH SHOULDER IMPINGEMENT SYNDROME: A RANDOMIZED CONTROLLED TRIAL

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PURPOSE: To investigate the effectiveness of individualized manual therapy and supervised exercises compared with supervised exercises alone in patients with clinical signs of shoulder impingement syndrome (SIS).

RELEVANCE: This randomized controlled trial adds evidence to the knowledge about the effect of individualized manual therapy and supervised exercises in patients with SIS.

METHODS: Ninety patients with a clinical pattern of SIS of at least 4 weeks' duration were recruited through physiotherapists working in outpatient practices in Germany. Eligible participants were randomly allocated to groups using central randomization. The control group performed a standardized exercise protocol, supervised by a physiotherapist. The intervention group additionally received individualized examination-based manual therapy. Both groups had 10 sessions within 5 weeks. All participants continued their exercises at home for another 7 weeks. SPADI and the patient's global impression of change, rated on an ordinal scale from 1 (much worsened) to 5 (much better), were assessed at baseline, 5 weeks, and 12 weeks. Descriptive statistics were used for demographic and clinical baseline characteristics, and for baseline results of the outcomes and possible confounding variables. Differences between groups were calculated on the intention-to-treat principle. Linear regression analysis was used to adjust for the influence of covariates on outcomes. Additionally, mixed models for the long-term follow-up were used.

RESULTS: Groups did not differ on the most important factors at baseline. No significant differences could be detected after the intervention between groups. An influence of disability at baseline could be found but did not change results to a significant level.

CONCLUSIONS: Our results show no additional benefit of manual therapy when added to a supervised exercise regimen.

IMPLICATIONS: Patients with SIS should mainly be treated with supervised exercises.

THE COMBINED EFFECT OF UTILIZING MANUAL THERAPY AND MOTOR CONTROL TRAINING FOR 2 RECREATIONAL THROWERS WITH CHRONIC SHOULDER PAIN

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PURPOSE: To present the results of utilizing manual therapy and motor control training in 2 throwers with chronic shoulder pain.

RELEVANCE: Supervised exercise with manual therapy has been shown to reduce shoulder pain and disability. A motor control training program based on movement system impairment (MSI) diagnosis has been reported helpful in a patient with subacute shoulder pain. However, minimal evidence exists to support the use of the MSI model (with or without manual therapy) in throwers with chronic shoulder pain.

CASE DESCRIPTION: Case 1 was a 50-year-old male softball player with an 8-month history of shoulder pain during throwing activities. Shoulder Pain and Disability Index (SPADI) score at intake was 34 of 130 (26%). Case 2 was a 28-year-old male recreational football thrower with shoulder pain for 6 months. SPADI score at intake was 24 of 130 (18%). MSI diagnosis for both patients was anterior humeral glide syndrome. Therefore, interventions selected for both patients involved motor control training of precise humeral internal rotation (IR) in supine and centered humeral external rotation (ER) in prone, progressing to standing ER and IR exercises with resistive bands and finally to sport-specific throwing. In addition, manual therapy was also used to address cervical spine and/or shoulder mobility deficits (2 visits).

RESULTS: Both patients achieved their athletic goal: return to softball for case 1 (4 visits) and return to football for case 2 (6 visits). SPADI at discharge was 3 of 130 (2%) and 4 of 130 (3%) for case 1 and case 2, respectively (greater than MDC/MCID). Follow-up SPADI score was 0 of 130 (0%) and 4 of 130 (3%) for case 1 (4.5 months) and case 2 (1.5 months), respectively.

CONCLUSION: Motor control training with manual therapy was effectively applied in 2 recreational throwers with chronic shoulder pain.

IMPLICATION: Retraining the quality of functional motion may be a useful adjunct to manual therapy in managing chronic shoulder pain.

THE EFFECTIVENESS OF A MANUAL PHYSICAL THERAPY APPROACH VERSUS CORTICOSTEROID INJECTION FOR THE TREATMENT OF SHOULDER IMPINGEMENT SYNDROME: SHORT-TERM RESULTS FROM A RANDOMIZED CONTROLLED TRIAL

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PURPOSE: To assess short-term effects of 2 common interventions, manual physical therapy (MPT) and corticosteroid injections (CSI), for patients with shoulder impingement-related pain.

RELEVANCE: Shoulder impingement is a common limiting disorder with a point prevalence between 20% and 33%. Two common interventions are MPT and CSI, but their effectiveness has never been directly compared.

METHODS: Of 415 consecutive patients referred to PT with shoulder pain, 97 satisfied eligibility criteria and agreed to participate. Mean age of 41 years (range, 19-64) and symptom duration of 56 days (range, 3 days-3 years). Subjects were randomized to a CSI from a physician or 6 sessions of MPT from a manual physical therapist, and re-evaluated at 4 weeks. The primary and secondary outcome measures were the Shoulder Pain and Disability Index (SPADI) and the global rating of change (GRC), respectively. A linear mixed model with repeated-measures ANOVA was used to analyze data. The hypothesis of interest was the group-by-time interaction.

RESULTS: Baseline mean SPADI scores were not significantly different between groups (MPT, 47.8% and CSI, 45.1%; $P = .33$). There was no interaction effect between time and group. At 4 weeks, there was a significant improvement in both groups (MPT, 20.5%; 95% CI: 13.8%, 27.1% and CSI, 21.6%; 95% CI: 16.1%, 27.1%). Mean GRC scores were +3 (somewhat better) in both groups, with no significant difference between groups ($P = .78$).

CONCLUSION: Patients with shoulder impingement-related pain had significant improvements in pain, disability, and perception of improvement regardless of intervention. One treatment group was not superior at 4 weeks.

IMPLICATIONS: These findings support current published findings regarding short-term effects of these interventions. This emphasizes the need for further studies comparing long-term effects before making definitive conclusions as to the most beneficial approach.

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THE EFFECTIVENESS OF MANUAL THERAPY AND ECCENTRIC EXERCISE IN THE MANAGEMENT OF BICIPITAL TENDINOPATHY: A CASE SERIES

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PURPOSE/RELEVANCE: Bicipital tendinopathy, a common but often overlooked condition, can hinder performance and delay an individual's return to work following injury. Our study utilized a combination of manual therapy and eccentric exercise to determine the effectiveness of a standardized multimodal program on the clinical and functional outcomes in patients diagnosed with bicipital tendinopathy referred for work hardening intervention.

METHODS: All patients who presented with a primary complaint of shoulder pain were invited to participate in the study. Individuals who met inclusion criteria qualified for the treatment phase of the study and continued on to complete a numeric pain scale and the Shoulder Pain and Disability Index (SPADI) questionnaire preintervention and postintervention functional status.

RESULTS: Twelve consecutive patients with shoulder pain were examined, with 8 subjects meeting the inclusion criteria (67% incidence of bicipital tendinopathy). Of these, 6 completed the standard treatment protocol, with the mean number of treatments of 13.6. On average, numeric pain scale scores improved by 50% (5.83 to 2.92), with SPADI scores improving by 60% (56.08 to 22.75).

CONCLUSIONS/IMPLICATIONS: These results suggest that the use of a multimodal intervention program is effective in the treatment of bicipital tendinopathy; however, more subjects are needed to generalize the effectiveness of this treatment to a larger population.

REPEATABILITY OF VIBRATION THRESHOLDS AND PRESSURE PAIN THRESHOLDS IN INDIVIDUALS WITH SPINALLY REFERRED LEG PAIN

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PURPOSE: To assess if measurements of vibration thresholds (VTs) and pressure pain thresholds (PPTs) are repeatable in individuals with spinally referred leg pain.

RELEVANCE: Measurements of VTs are important, as they measure the activity of the A β afferent nerves, the first to deteriorate after minor peripheral nerve injuries. PPTs are an increasingly researched semi-objective measure of pain. VTs have been shown to have adequate repeatability, but not in individuals with referred leg pain. Good repeatability of PPT has been demonstrated, but there is uncertainty as to how many repetitions should be taken to ensure adequate repeatability.

METHODS: Eleven subjects (6 women; age range, 23-59 years) with spinally referred leg pain participated. VTs were taken from the lateral malleolus and plantar surface of the first metatarsal. PPTs were taken from the gastrocnemius, tibial nerve, and contralateral deltoid muscle. VTs were not normally distributed, so were log-transformed. ICC₁₁ was used to assess repeatability with standard error measurements (SEMs) and 95% confidence intervals (CIs). For the VT data, as SEM cannot be back-transformed, these were expressed as a percentage of the mean.

RESULTS: For VT, ICC for lateral malleolus was 0.9 (95% CI: 0.66, 0.97), percentage SEM was 9.1%; for the first metatarsal, ICC was 0.99 (95% CI: 0.96, 1), percentage SEM was 5.2%. For PPT, ICCs varied depending on which numbers of measures were taken and the site used. Using means of the second and third readings, ICC for deltoid was 0.85 (95% CI: 0.55, 0.96; SEM, 0.54), for gastrocnemius 0.9 (95% CI: 0.7, 0.97; SEM, 0.63), and for tibial nerve 0.9 (95% CI: 0.65, 0.97; SEM, 0.52).

CONCLUSION: The repeatability of VT was excellent, and PPT good to excellent in the sites measured.

IMPLICATIONS: VT and PPT in the sites used are repeatable in subjects with spinally referred leg pain.

ARE FACE RECOGNITION AND EMOTIONAL EXPRESSION OF CHRONIC FACE-PAIN PATIENTS DIFFERENT FROM A SAMPLE OF HEALTHY CONTROLS?

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PURPOSE: The purpose of this study was to determine (1) whether chronic facial pain is associated with abnormal recognition of facially expressed emotion (FER) and facial motor imagery (FMI), and (2) if FER and FMI are related.

RELEVANCE: There is evidence that nonverbal facial expression is disrupted in chronic pain conditions, but it is not known whether recognition of facial movements and postures is also disrupted.

METHODS: In this cross-sectional study, 20 patients (14 women) with long-term chronic (face) pain for more than 6 months were compared with 42 healthy controls. The subjects completed 2 questionnaires: the Beck Depression Index (BDI) and the research criteria of Diagnostic for TMD (RCD/TMD). To analyze the FER and FMI, 2 computer-based tests, the Facially Expressed Emotion Labeling (FEEL) and, for the FMI, the motor imagery test for face laterality were used.

RESULTS: The chronic (face) pain group showed significantly higher scores in the BDI than the healthy control group. Comparing the results of the FEEL test (FER), a significant difference between both groups was observed ($P < .05$). The chronic face-pain group was more depressed (mean \pm SD, 10.95 ± 5.9 ; control group, 3.67 ± 3.8 ; $P < .001$) and performed worse at both the FER (29.47 \pm 4.9; control group, 34.78 \pm 4.2; $P < .001$) and FMI (for response time left, 3.49 \pm 0.9689 seconds and right, 3.26 \pm 0.8852 seconds; control group, 2.40 \pm 0.9952 seconds; $P < .05$ and right, 2.42 \pm 1.0302 seconds; $P < .05$) tasks than the control group did. Performance on FER and FMI were related.

CONCLUSIONS: This study demonstrated that chronic (facial) pain patients are limited in the recognition of 6 basic facial emotional expressions and facial motor imagery.

IMPLICATIONS: Motor dysfunction associated with chronic facial pain may reflect problems upstream from motor outputs, most obviously emotional or perceptual processes, or the integration of these processes.

NEUROMODULATORY CORTICAL PRIMING: THE EFFECT OF TIME

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PURPOSE: To investigate whether the duration of peripheral neuromodulation, using motor electrical stimulation (ES), influenced its effect on corticospinal excitability.

RELEVANCE: Neuromodulatory techniques that prime the brain hold therapeutic promise for enhancing clinical outcomes in musculoskeletal conditions. A neuromodulatory technique, motor ES, has been demonstrated to increase corticospinal excitability. Although the duration of application is likely to influence the effect of stimulation, this has not been system-

atically investigated.

METHODS: A volunteer sample of 14 healthy subjects (9 women; mean \pm SD age, 23.07 \pm 7.10 years). Using a same-subject pretest-posttest design, transcranial magnetic stimulation (TMS) was used to measure the excitability of the corticomotor pathway to abductor pollicis brevis (APB) before and after 3 different durations (20, 40, and 60 minutes) of ES (30 Hz, ramped) applied to APB above motor threshold. Amplitudes of TMS-induced motor-evoked potentials (MEPs) from APB were normalized to maximal compound muscle action potentials (Mmax) to account for peripheral neuromuscular fatigue. A 2-way repeated-measures analysis of variance was performed with factors time (baseline, post1, and post2) and condition (20, 40, or 60 minutes of motor ES).

RESULTS: Twenty- and 40-minute applications of motor ES increased the excitability of corticospinal projection to APB (all, $P < .05$). This increase lasted at least 20 minutes following the intervention. A 60-minute application of motor ES did not alter corticospinal excitability ($P > .05$).

CONCLUSIONS: A 20-minute application of motor ES designed to mimic voluntary contractions is as effective as that applied for 40 minutes when the aim of the intervention is to increase corticospinal excitability.

IMPLICATIONS: Motor ES can be used as a peripheral neuromodulatory primer to facilitate motor learning and skill acquisition with rehabilitation. Short-duration application appears more effective than longer durations but requires confirmation in pathological populations.

THE EFFECT OF NEUROSCIENCE EDUCATION ON PAIN, DISABILITY, ANXIETY, AND STRESS IN CHRONIC MUSCULOSKELETAL PAIN

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OBJECTIVE: To evaluate the evidence for the effectiveness of neuroscience education (NE) for pain, disability, anxiety, and stress in chronic musculoskeletal (MSK) pain.

DATA SOURCES: Systematic searches were conducted on Biomed Central, BMJ.com, CINAHL, the Cochrane Library, NLM Central Gateway, OVID, ProQuest (Digital Dissertations), PsycInfo, PubMed/MEDLINE, ScienceDirect, and Web of Science. Secondary searching (PEARLing) was undertaken, whereby reference lists of the selected articles were reviewed for additional references not identified in the primary search.

STUDY SELECTION: All experimental studies, including randomized controlled trials (RCTs), nonrandomized clinical trials, or case series, evaluating the effect of NE on pain, disability, anxiety, and stress for chronic MSK pain were considered for inclusion.

ADDITIONAL LIMITATIONS: Studies published in English, published within the last 10 years, and patients over the age of 18. No limitations were set on specific outcome measures of pain, disability, anxiety, and stress.

DATA EXTRACTION: Data were extracted utilizing the PICO approach.

DATA SYNTHESIS: Methodological quality was assessed by 2 reviewers using the Critical Review Form – Quantitative Studies. This review includes 8 studies, comprising 6 high-quality RCTs, 1 pseudo-RCT, and 1 comparative study involving 401 subjects. The majority of papers were of good quality, with no studies rated as poor or fair. Heterogeneity across the studies, with respect to participants, interventions evaluated, and outcome measures used, prevented meta-analyses. Narrative synthesis of results, based on effect size, established compelling evidence that NE may be effective in reducing pain ratings, increasing function, addressing catastrophization, and improving movement in chronic MSK pain.

CONCLUSIONS: For chronic MSK pain disorders, there is compelling evidence that an educational strategy addressing neurophysiology and neurobiology of pain can have a positive effect on pain, disability, catastrophization, and physical performance.

THE INFLUENCE OF A MODERATE SPECIFIC-EXERCISE PROGRAM ON PORTUGUESE ELDERLY EXECUTIVE FUNCTION

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PURPOSE: To analyze the influence of a moderate specific-exercise program focusing on fall risk factors in a Portuguese elderly group executive function.

RELEVANCE: Aging affects cognition, in particularly executive function, including set shifting, working memory, selective attention, and conflict resolution. There is evidence that physical exercises improve cognitive performance; however, most of them are resistive exercise programs. This study used an easy-to-understand and -perform exercise program, without equipment and specifically focused on fall risk factors for the elderly.

METHODS: A controlled trial study was performed with 28 volunteer elderly (13 women and 14 men) aged over 65 years and community independents. Severe pathological conditions were excluded. Participants were divided in an experimental ($n = 15$) and a control group ($n = 13$). The experimental group initiated a moderate specific-exercise program, twice a week, during 6 months, whereas the control group was not submitted to any intervention. The trail-making test was applied to assess set shifting, the Stroop test was used to analyze the capability of selective attention and conflict resolution, and verbal digit span was used to measure the working memory. Both groups were assessed initially and after 6 months. **RESULTS:** Both groups were similar at baseline in all studied variables. Experimental group participants significantly improved the set-shifting capability ($z = -2.517, P = .008$), selective attention and conflict resolution ($t = 2.074, P = .024$), and working memory ($z = -1.990, P = .023$), compared with the control group.

CONCLUSION: In spite of study limitations that do not allow an extrapolation for the elderly population, moderate specific exercises seem to improve executive function in a Portuguese elderly group.

IMPLICATIONS: Elderly cognitive function decrease prevention is an important health promotion measure, and specific-exercise programs without any equipment that are easy to implement and affordable can be used at home or in a community center.

FUNCTIONAL IMPAIRMENTS IN PATIENTS WITH JOINT HYPERMOBILITY SYNDROME AND DEVELOPMENTAL COORDINATION DISORDER

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PURPOSE: The purpose of this study was to investigate functional difficulties in patients with joint hypermobility syndrome (JHS) and an association with developmental coordination disorder (DCD).

RELEVANCE: There is experimental evidence to show that patients with JHS have poor proprioception and balance. Clinical experience suggests that patients with JHS report “clumsiness,” tripping, and falling and that these motor skill impairments may be associated with DCD.

METHODS: A sample of 90 patients with JHS (mean \pm SD age, 34.7 \pm 9.9 years; 83 women) diagnosed according to the Brighton criteria were compared with 113 healthy volunteers (mean \pm SD age, 35.7 \pm 12.9 years; 82 women) with no musculoskeletal pain. Information relating to DCD and functional impairments was collected by means of the self-report functional difficulties questionnaire (FDQ-9). Numerical data were analyzed using independent-samples t tests and Mann-Whitney U . Individual items of the FDQ-9 were analyzed using a chi-square test.

RESULTS: Patients with JHS reported significantly higher functional difficulties scores (M, 22.28 \pm 4.90) than healthy volunteers (M, 17.97 \pm

3.72; $P < .001$), indicating greater functional difficulties. Patients with JHS were 3 times (95% CI: 2.0, 4.6) more likely to report DCD than healthy volunteers. Patients with JHS and DCD were significantly more likely to report impaired balance and obstacle-avoidance skills than healthy volunteers with DCD.

CONCLUSIONS: This study established that gross motor skill impairments reported by patients with JHS are associated with DCD. Patients with JHS and DCD are likely to report poor balance and therefore may be at risk of falls.

IMPLICATIONS: This study highlights the prevalence of functional difficulties reported by patients with JHS and DCD. It is suggested there is a requirement to assess and treat the perceptual impairments that contribute to these functional difficulties.

DEVELOPMENT AND VALIDATION OF THE FUNCTIONAL DIFFICULTIES QUESTIONNAIRE FOR ASSESSING DEVELOPMENTAL COORDINATION DISORDER IN ADULTS

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PURPOSE: The purpose of this study was to describe the development and preliminary psychometric evaluation of the Functional Difficulties Questionnaire (FDQ-9), an instrument designed to aid clinicians in the assessment of developmental coordination disorder (DCD) in adults.

RELEVANCE: There are currently no tools to assess DCD in adults with musculoskeletal pain. DCD is a neurodevelopmental disorder characterized by functional motor impairments described in childhood that, for some, persist into adulthood. Skill impairments in those with DCD include impaired perception and biomechanical dysfunction.

METHODS: The questionnaire was developed utilizing existing questionnaires, the *Diagnostic and Statistical Manual for the Diagnosis of Mental Disorders* (DSM-IV) criteria for the diagnosis of DCD, International Classification of Diseases (ICD-10), and International Classification of Functioning, Disability and Health (ICF). An initial 13-item pool was reviewed by an expert panel for face and content validity. This resulted in a 9-item questionnaire that was piloted on 3 groups ($n = 257$): (1) individuals with joint hypermobility syndrome, (2) convenience samples from a commercial company, and (3) staff and students of a university. Exploratory factor analysis was employed to assess the underlying factor structure. Aspects of validity and reliability were assessed.

RESULTS: Factor analysis using principal-axis factoring with oblimin rotation yielded 2 factors relating to fine and gross motor function. Overall internal reliability was high ($\alpha = .81$). Preliminary findings suggested satisfactory construct validity and test-retest reliability (ICC = 0.96; 95% CI: 0.92, 0.98).

CONCLUSIONS: Psychometric properties of this questionnaire appear promising, but further research is required to evaluate the validity of the questionnaire in new samples and audit its application in clinical practice.

IMPLICATIONS: This questionnaire has the potential to aid clinicians in their assessment of DCD and functional impairments in adults and therefore contribute to improved care planning.

MANUAL THERAPY FOR CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A SYSTEMATIC REVIEW OF CURRENT EVIDENCE

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PURPOSE: To systematically review evidence for manual therapy (MT) in chronic obstructive pulmonary disease (COPD) management.

RELEVANCE: COPD is an increasing global problem. Evidence-based non-pharmacological management approaches are limited. Evidence suggests MT may be beneficial; therefore, an evidence synthesis is required.

METHODS: Systematic review methodology (informed by Cochrane and

Centre for Reviews and Dissemination Guidelines [CRD]). Using a predefined protocol, key databases were searched (to January 2012). Included articles were RCT or quasi-experimental studies and included: (1) adults with COPD; (2) MT intervention; (3) a control, sham, or alternative MT intervention; and (4) physiological measure of lung function. Following screening, data extraction and risk-of-bias assessment were undertaken by 2 independent reviewers. Key authors, bibliographies, and citations were screened. Descriptive results were collated and tabulated. A risk-of-bias tool was devised for data synthesis. Pooling of data and meta-analysis were not possible due to study heterogeneity.

RESULTS: From 3598 articles, 25 full-text articles were evaluated. Eight studies were included (5 RCTs, 2 pre-post studies, 1 case series). Across COPD subjects ($n = 137$), interventions included osteopathic manipulative therapy (OMT) ($n = 106$), massage ($n = 5$), muscle stretching ($n = 14$), and passive movements ($n = 12$). Of the 8 studies, 7 were evaluated as high/moderate or unclear risk of bias, with 1 OMT study ($n = 25$) being evaluated as low risk of bias. Whereas FEV₁ and FVC changed minimally ($<1.5\%$, $P > .05$) immediately following OMT techniques, patient self-reported measures ("improved health" and "breathing difficulty") did improve following OMT (66%) compared to control (43%), although validated tools and statistical analysis were not included.

CONCLUSIONS: Evidence to support the use of manual therapy in COPD is lacking. Future exploratory work is required, or trials using validated patient-reported measures alongside physiological outcome measures with a longer-term follow-up period.

IMPLICATION: Evidence to support MT in COPD management is lacking.

CORRELATION BETWEEN FUNCTIONAL VARIABLES AND SYMPTOMS IN PATIENTS WITH HIP OSTEOARTHROSIS

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PURPOSE: To analyze the correlation between demographic variables, grade of osteoarthritis, pain, function, stiffness, and flexibility in patients with hip osteoarthritis.

RELEVANCE: Hip osteoarthritis is one of the most common dysfunctions among elderly people nowadays. Patients with hip osteoarthritis present pain, decrease in range of motion, muscle weakness, and decrease in quality of life. Literature shows that the relationship between pain and radiological findings is weak.

METHODS: Fifty-one patients aged 57 to 87 years with the diagnosis of hip osteoarthritis were recruited for the study. Demographic variables (sex, age, height, weight), grade of arthrosis following the Kellgren-Lawrence scale, pain (VAS, WOMAC pain subscale, and algometry), function (timed up-and-go test, pick-up test, 20-m walk test, WOMAC function subscale, range of motion), stiffness (WOMAC stiffness subscale), and flexibility (Ely test, Thomas test, Ober test, AKE test).

RESULTS: The study shows a significant correlation between internal rotation and extension ROM ($r = 0.424$, $P < .01$), between internal rotation and abduction ROM ($r = 0.505$, $P < .01$), and between extension and abduction ($r = 0.641$, $P < .01$). No significant correlation was found between the following variables: age and range of movement ($r = -0.433$, $P < .01$), age and grade of arthrosis ($r = -0.286$, $P < .01$), pain (measured by the WOMAC pain subscale) and grade of arthrosis ($r = -0.194$, $P < .01$), and pain measured with the VAS and grade of arthrosis following Kellgren-Lawrence scale criteria ($r = -0.08$, $P < .01$).

CONCLUSIONS: There is no correlation between pain and radiological findings in patients with hip osteoarthritis.

IMPLICATIONS: The targeted level of learning is intermediate. This study shows the importance of not directly relying on radiological findings when treating patients with hip osteoarthritis, as these findings may not correlate with patient symptoms.

DO SYMPTOMS OR RADIOGRAPHIC FINDINGS BEST PREDICT FUNCTION IN THOSE WITH AND WITHOUT PATELLOFEMORAL JOINT OSTEOARTHRITIS 7 TO 12 YEARS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION?

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PURPOSE: To explore the influence of radiographic patellofemoral joint (PFJ) osteoarthritis (OA) and symptom severity on physical function 7 to 12 years after anterior cruciate ligament reconstruction (ACLR).

RELEVANCE: ACLR is a well-recognized risk factor for developing knee OA. Most studies report radiographic changes and functional/symptomatic impairments concerning the tibiofemoral joint (TFJ), in spite of a small number of studies reporting high rates of PFJ OA after ACLR. The influence of radiographic PFJ OA and associated symptoms on functional performance after ACLR is not known.

METHODS: Eighteen individuals with confirmed radiographic PFJ OA (with no or less concomitant TFJ OA) according to the Osteoarthritis Research Society International atlas (56% men; mean \pm SD age, 46 \pm 9 years; BMI, 27.5 \pm 3.7 kg/m²) and 19 individuals free of knee OA (58% men; mean \pm SD age, 41 \pm 11 years; BMI, 26.3 \pm 4.1 kg/m²), all 7 to 12 years (mean, 9.2 years) after single-bundle hamstring graft ACLR, were recruited retrospectively. Functional measures (hop for distance, side hop, 1-leg rise) were recorded for all participants. Subjective knee-related symptoms were assessed by the Knee Osteoarthritis Outcome Score (KOOS) (symptoms, pain, function, sport and recreation, quality of life [QOL]). Linear regressions were performed on 3 functional tests. Radiographic PFJ OA (present or absent) and the 5 KOOS subscales were included as predictor variables, with age, gender, and height included as covariates where appropriate.

RESULTS: Three KOOS subscales were lower in those with PFJ OA than those without (symptoms, $P = .03$; sport and recreation, $P = .04$; QOL, $P = .04$). Regression analyses revealed that KOOS sport and recreation was the independent predictor for hop for distance ($R^2 = 0.254$, $P = .001$), KOOS pain was the independent predictor for side-hop ($R^2 = 0.281$, $P = .001$), and KOOS symptoms was the independent predictor for 1-leg rise ($R^2 = 0.268$, $P = .001$). Radiographic PFJ OA was not an independent predictor for any functional test.

CONCLUSIONS: PFJ OA symptoms are better predictors of physical function than radiographic PFJ OA 7 to 12 years after ACLR.

IMPLICATIONS: Awareness of PFJ OA after ACLR is important, as PFJ OA symptoms, more so than radiographic disease, can help predict functional performance.

THE RELATIONSHIP BETWEEN LUMBOPELVIC MUSCLE SIZE/MOTOR CONTROL AND LOWER-LIMB MUSCLE INJURIES AMONG ELITE AUSTRALIAN FOOTBALL LEAGUE PLAYERS

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PURPOSE: To examine the relationship between severity of preseason muscle injuries and lumbopelvic muscle size, asymmetry, and function at the start and end of the Australian Rules Football (AFL) preseason.

RELEVANCE: In AFL, muscle injuries of the hip, groin, and thigh (HGT) region (hamstrings, adductors, and quadriceps) have the highest prevalence and incidence. Deficits within the muscle system of the lumbopelvic region (eg, impaired motor control and muscle asymmetry) could contribute to injuries in the preseason.

METHODS: MRI examinations were performed on 47 male elite AFL players at the start and at the end of the football preseason. Cross-sectional areas (CSAs) of the multifidus, psoas major, and quadratus lumborum

muscles were measured, as well as change in trunk CSA due to voluntarily drawing in the abdominal wall (muscle test for the transversus abdominis muscle). Injuries that occurred during each preseason training session were routinely recorded by the football club's performance staff.

RESULTS: Analysis of variance indicated that players with more severe preseason muscle injuries (more training sessions missed) had significantly smaller multifidus muscle CSA compared with players with no injury ($P = .006$). No relationship was found for size or asymmetry of the quadratus lumborum or psoas muscles, or ability to contract the transversus abdominis muscle through drawing in of the abdominal wall ($P > .05$). Small size of the multifidus at L5 predicted 5 of 6 cases that incurred a more severe HGT injury.

CONCLUSIONS: An association between multifidus muscle size (relative to age, height, and weight) and preseason injury suggests a way to identify players at risk of severe HGT injuries.

IMPLICATIONS: This result needs to be replicated in a larger sample before resources are committed to intervention efforts. A study of this nature is currently under way.

EFFICACY OF COMMON PERONEAL NEURODYNAMIC MOBILIZATION AS AN ADJUNCT TO STANDARD PHYSICAL THERAPY IN TREATMENT OF PEOPLE WITH PAINFUL DIABETIC DISTAL SYMMETRIC POLYNEUROPATHY: A RANDOMIZED CLINICAL TRIAL

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PURPOSE: To study the efficacy of common peroneal neurodynamic mobilization (CPNM) as an adjunct to standard physical therapy (SPT) in treatment of people with painful diabetic distal symmetric polyneuropathy (PDDSP).

RELEVANCE: Neurodynamic properties of peripheral nerves were demonstrated to be affected in both animal and human studies of painful diabetic neuropathy, and neurodynamic mobilization was shown to be effective for peripheral neuropathic pain conditions.

METHODS: A parallel-group randomized clinical trial with concealed treatment allocation and block randomization was performed on 32 adult participants (18 women, 14 men) with medical-diagnosed type 2 diabetes mellitus (T2DM) and PDDSP and positive neurodynamic examination findings, who were randomly assigned to receive either a combined SPT (walking exercise prescription, diet and lifestyle modification) with CPNM (sliders and nerve massage) or SPT alone, for once-weekly 30-minute treatment sessions for 5 weeks. Premeasurements and postmeasurements included pain severity and pain interference on the brief pain inventory-diabetic peripheral neuropathy (BPI-DPN), vibration perception thresholds (VPT), heat and cold perception thresholds (HPT, CPT), and neuropathy-specific quality of life (NeuroQoL) instrument, which were collected by an independent blinded assessor.

RESULTS: The combined group (SPT+CPNM) had better improvements for between-group mean differences in PS (15.10 \pm 2.70), PI (17.10 \pm 3.50), BPI-DPN (32.21 \pm 5.08), VPT (10.89 \pm 3.69 volts), HPT (7.92 \pm 3.19 volts), CPT (13.50 \pm 3.01 volts), and NeuroQoL (31.24 \pm 6.48) measures than the SPT group. All the findings were statistically significant at $P < .05$ when analyzed using the Student t test at 95% confidence interval using SPSS Version 16 for Windows.

CONCLUSION: CPNM was effective as an adjunct to SPT in treatment of people with PDDSP secondary to T2DM.

IMPLICATIONS: The study findings imply better clinical manual physical therapy care in management of people with PDDSP using CPNM as a therapeutic adjunct.

BLOOD PRESSURE AND HEART RATE RESPONSE TO UNILATERAL POSTERIOR GLIDE OF THE CERVICAL SPINE IN NORMAL VOLUNTEERS: A PILOT CASE SERIES

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PURPOSE: To present the blood pressure and heart rate response of healthy volunteers to unilateral posterior glide of the cervical spine.

RELEVANCE: Manual therapists employ unilateral posterior glides of the cervical spine for various cervical-shoulder painful conditions. However, there is a paucity of literature describing the procedure and its safety profile, in particular, how it should be performed to avoid doing a carotid sinus massage causing vasodepression.

METHODS: Two men and 2 women (all coauthors; 24–36 years old) with no history of cervical-shoulder pain and cardiovascular disease volunteered for this pilot case series. Blood pressure (BP) and heart rate (HR) were measured in the following order: (1) 2 minutes before the placebo, (2) during the placebo (when light touch is applied at the right C6), (3) during the first set of posterior glide, (4) during the fifth set of posterior glide, and (5) 2 minutes after the final posterior glides. Blinded to the measurements collected, the primary author performed the same procedures on all supine-lying volunteers. Testing would immediately stop if the systolic BP dropped 50 mmHg or more below the baseline. Finally, a follow-up was done to determine if the participants had any adverse reactions from testing.

RESULTS: When compared to baseline measurements, all subjects demonstrated no change greater than: ± 10 mmHg for systolic BP, ± 15 mmHg for diastolic BP, and ± 7 beats for HR. Furthermore, none of the volunteers reported any adverse effects within 2 weeks of the testing date.

CONCLUSION: Performing posterior glides (as described in this pilot) did not cause vasodepression (systolic BP drop of ≥ 50 mmHg), thereby indicating its potential broad safety profile.

IMPLICATION: The results from this pilot would justify further study in more participants. Nevertheless, the findings, though promising, are preliminary and should be interpreted with caution.

DIFFERENTIAL DIAGNOSIS OF A PATIENT REFERRED TO PHYSICAL THERAPY WITH NECK PAIN: AN ATYPICAL PRESENTATION OF ANGINA

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PURPOSE: The purpose of this paper is to describe the clinical reasoning process that led to a differential diagnosis of nonmechanical pain in a patient with neck pain. The pathway for neck pain caused by angina pectoris is explored. Several diagnostic errors will be reflected upon.

RELEVANCE: Neck pain is a common reason patients seek physical therapy, and angina pectoris is an underrecognized differential diagnosis.

DESCRIPTION: The patient had an 8-week history of neck pain, which was worse with running and lifting objects. He presented with imaging of the cervical spine, which demonstrated degenerative changes. During the PT examination, several differential diagnoses were considered. A mechanical examination failed to reproduce his symptoms. At that time, the PT had a suspicion that the origin of the patient's neck pain was nonmechanical. Additional testing during the examination included having the patient exercise briefly on gym equipment; this reproduced his symptoms. After additional positional and postural changes did not alleviate the symptoms, he stopped exercising, and his pain ceased.

RESULTS: The patient was referred back to his primary care physician, who ordered cardiovascular testing. These tests revealed significant cardiac abnormalities, including multivessel blockage of the coronary arteries and evidence of myocardial infarction, which were causing angina pectoris. He underwent a coronary artery bypass graft 4 days later.

CONCLUSION: To make an appropriate differential diagnosis, therapists must use strong clinical reasoning and have an awareness of diagnostic

errors such that they can be avoided.

IMPLICATIONS: An accurate diagnosis is imperative to treating patients safely, effectively, and efficiently. Delays in accurately diagnosing a patient can lead to increased costs associated with inappropriate tests and referrals and to minimize mortality and morbidity.

THE VALIDITY OF RED FLAGS TO DIAGNOSE SPINAL NEOPLASMS IN SPINAL TRIAGE

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PURPOSE: The presence of red flags guides the clinical investigation of spinal pathology but does not specifically identify neoplasms. Despite a large body of epidemiological research into cancer, there is limited evidence to support the use of red flags in establishing a diagnosis. This retrospective clinical audit looked at the presence of red flags in patients subsequently diagnosed with spinal metastatic disease.

RELEVANCE: Physiotherapists working in spinal triage need to identify patients with serious spinal pathology, including benign and malignant neoplasms. Red flags may aid in this process.

METHODS: The study was retrospective and extended-scope physiotherapists were asked to document the presence of specific features in patients whose final diagnosis was of metastatic cancer in the spine. The specific features were chosen by analyzing the list of red flags in various clinical guidelines for the management of low back pain.

EVALUATION: Twenty (0.5%) patients (10 men and 10 women) were identified as having a serious spinal pathology. Sixty-five percent failed conservative physiotherapy treatment and 50% had a previous history of cancer. Unexplained weight loss was prevalent in 25% of patients.

CONCLUSIONS: The number of patients identified as having a neoplasm was consistent with the literature, which states a prevalence of 0.1% to 3.5%. Despite the number of red flags associated with malignancy within this group of patients identified as having malignancy, there was no common element.

IMPLICATIONS: In the cases identified within this group, there were few red flags. Clinical judgment has been suggested to be as important as other factors in identifying patients with sinister pathology, and further research looking at clinicians' reasoning for a higher index of suspicion in this group of patients may be of value.

THE EFFECTIVENESS OF NONINVASIVE INTERACTIVE NEUROSTIMULATION IN PATIENTS WITH CHRONIC NECK PAIN: A PILOT RANDOMIZED CONTROLLED TRIAL

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PURPOSE: To determine the effect of noninvasive interactive neurostimulation (NIN) on pain, cervical ROM, and activity of the sympathetic nervous system (SNS) in patients with chronic neck pain.

RELEVANCE: NIN is a new treatment that allows the combination of manual therapy and electrical stimulation. NIN can be moved over the skin and soft tissue during stimulation and can be tailored to each individual, as the device modifies treatment frequency based on skin impedance at the point of treatment. Areas of low impedance, identified by NIN, are believed to be indicative of amplified activity of the SNS. Although early studies show promising results in neck pain, research has not evaluated the SNS response.

METHODS: Thirty participants (8 men) experiencing chronic neck pain were randomized into a sham or treatment group. The treatment group received 15 minutes of NIN, whereas the sham group had the device applied in the same manner but switched off. Outcome measures included pain pressure thresholds, cervical ROM, VAS pain scales, and SNS response (skin conductance and temperature). Data were analyzed with a

2-way repeated-measures analysis of variance with 1 within factor, time (pre and post) and 1 between factor (treatment/sham group).

RESULTS: The study demonstrated a statistically and clinically significant improvement over time in right ($P = .02$) and left lateral flexion ($P = .003$) and a clinically significant improvement in flexion and extension in the treatment compared to the sham group. No significant difference was demonstrated between groups for all other measures.

DISCUSSION: This preliminary study demonstrated that NIN is effective in improving neck ROM in chronic neck pain participants. However, there was no difference between groups for all other outcome measures, including SNS measures. The placebo effect, sample size, and use of only 1 intervention session may account for these findings.

DOSE OPTIMIZATION FOR SPINAL TREATMENT EFFECTIVENESS (THE DOSE STUDY): HIGHER APPLIED MOBILIZATION FORCE ASSOCIATED WITH REDUCED PAIN AND SPINAL STIFFNESS IN PATIENTS WITH CHRONIC NECK PAIN

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PURPOSE: To determine whether the magnitude of force applied during posterior-to-anterior (PA) mobilization affects immediate and short-term outcomes in patients with chronic nonspecific neck pain.

RELEVANCE: Establishing a dose-response relationship will improve the effectiveness of mobilization treatment.

METHODS: Patients with neck pain for 3 months or longer ($n = 64$) were randomized to receive a single treatment of central PA mobilization applied with either 30 N or 90 N of mean peak force for 3 sets of 30 seconds, or a placebo of detuned laser on the spinous process at their painful spinal level. Pain (visual analog scale, 0-100 mm), pressure pain threshold (PPT over spinal level, trapezius, median nerve; summed), cervical range of motion (CROM instrument), and spinal stiffness (custom device applying standardized force while measuring resistance to movement and concurrent displacement) were measured before, immediately after, and 2 to 8 days following treatment. Analysis of covariance with Bonferroni-adjusted post hoc tests examined differences between groups for each outcome measure after treatment and at follow-up using baseline values as the covariates.

RESULTS: Immediately after treatment, the 90-N mobilization group reported less pain than the 30-N (mean difference, 13.6 mm; 95% CI: 0.8, 26.3; $P = .033$) or the placebo group (mean difference, 17.9 mm; 95% CI: 5.0, 30.8; $P = .003$); PPT was higher in the 90-N group compared to the placebo group (mean difference, 82.8 kPa; 95% CI: 3.3, 162.3; $P = .039$). At follow-up, the 90-N group was less stiff than the placebo group (mean difference, 17.5 N/mm; 95% CI: 4.2, 30.9; $P = .006$). There were no significant differences between groups in CROM or stiffness immediately after treatment, or in pain, PPT, or CROM at follow-up.

CONCLUSIONS: In patients with chronic neck pain, a greater force appears to be more effective in immediately reducing symptoms.

IMPLICATIONS: A particular threshold of force appears necessary for more effective mobilization treatment, suggesting that specific doses of mobilization should be further investigated.

ACKNOWLEDGEMENT: Physiotherapy Research Foundation, Australian Physiotherapy Association.

SENSORIMOTOR INCONGRUENCE EXACERBATES SYMPTOMS IN PATIENTS WITH CHRONIC WHIPLASH-ASSOCIATED DISORDERS: AN EXPERIMENTAL STUDY

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PURPOSE: The present study aimed at evaluating whether a visual mediated incongruence between motor output and sensory input aggravates symptoms and triggers additional sensory changes in patients with chronic whiplash-associated disorders (WAD).

RELEVANCE: Incongruence between sensory feedback and motor output may serve as an ongoing source of nociception inside the central nervous system, and hence may contribute to the development of chronic WAD. It has been demonstrated that sensorimotor incongruence exacerbates symptoms and provokes additional sensations in patients with chronic pain.

METHODS: Thirty-five patients with chronic WAD and 31 healthy controls were subjected to a coordination test. They performed congruent and incongruent arm movements while viewing a whiteboard or a mirror.

RESULTS: All patients with chronic WAD ($n = 35$) reported sensory changes such as increased pain, tightness, dizziness, or peculiarity at some stage of the test protocol. No significant differences were found between the various test stages ($P > .05$). In the control group, 18 (58%) subjects reported sensory changes at some stage of the test protocol, with the highest number during the incongruent mirror stage ($n = 17$), corresponding to the highest level of sensorimotor incongruence. The pattern of reported sensory changes during the congruent as well as the incongruent stages was significantly different between both groups ($P < .05$).

CONCLUSIONS: Patients with chronic WAD present an exacerbation of symptoms and additional sensations in response to visual mediated changes between sensory input and motor output during action. Healthy subjects reported sensations during the stage with the highest level of incongruence.

IMPLICATIONS: These findings indicate altered sensorimotor central nervous processing and altered perception of distorted visual feedback in patients with chronic WAD. The study supports the involvement of the CNS and suggests distorted body schema in chronic WAD.

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RADIOFREQUENCY NEUROTOMY RESULTS IN IMMEDIATE IMPROVEMENTS IN PHYSICAL IMPAIRMENTS IN INDIVIDUALS WITH CHRONIC WHIPLASH SYMPTOMS

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PURPOSE: To compare physical impairment measures pre/post-cervical radiofrequency neurotomy (RFN) in individuals with chronic whiplash-associated disorders (WAD).

RELEVANCE: Cervical RFN is a validated treatment for individuals with chronic WAD who do not respond to conservative physiotherapy. It is important that physiotherapists understand which, and to what degree, physical impairments may improve following successful RFN.

METHODS: This longitudinal study involved 43 individuals with chronic WAD, resistant to improvement with conservative physiotherapy, and who responded to cervical RFN. Measures were collected at T1 (entry to study), T2 (immediately prior to RFN), and T3 (1 month following RFN). Pain (VAS), disability (NDI, PSFS), and quality of life (SF-36) measures were collected. Quantitative sensory testing (pressure, PPT; thermal pain thresholds; brachial plexus provocation test [BPPT]) and nociceptor flexor reflex (NFR) measures were collected. Cervical range of motion (ROM)

and activity of the superficial neck flexors (EMG) during the craniocervical flexion test were also measured. Box plots (QST, sensorimotor and questionnaires) were generated. Log transformation was performed for PPT, NFR, and EMG measures. Repeated-measures ANOVA with Bonferroni post hoc tabulation was utilized.

RESULTS: No change in physical measures occurred prior to receiving cervical RFN. Cervical RFN resulted in immediate (within 1 month) improvements in pain and disability and quality of life ($P < .05$). Reduced widespread hyperalgesia to pressure ($P < .05$) and thermal stimuli ($P < .05$) were demonstrated. NFR threshold ($P < .05$) and BPPT ($P < .005$) measures significantly improved. Cervical RFN also resulted in increased neck ROM in all directions ($P < .005$). There was no change in local mechanical hyperalgesia to pressure ($P = .07$) or EMG levels of the superficial neck flexors ($P > .10$).

CONCLUSIONS: Decreasing peripheral nociception via cervical RFN resulted in significant improvement in most measures of physical impairment in individuals with chronic WAD.

IMPLICATIONS: Physical impairments observed in individuals with chronic WAD that are resistant to conservative physiotherapy may benefit from cervical RFN.

PHYSIOTHERAPY FOR ACUTE WHIPLASH INJURIES: A RANDOMIZED CONTROLLED TRIAL

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PURPOSE: The trial assessed whether provision of a package of up to 6 physiotherapy treatments was more effective than a single advice session from a physiotherapist in participants following a whiplash injury.

RELEVANCE: Whiplash injuries are common but effective treatments are lacking. This randomized controlled trial (RCT) assessed the benefit of physiotherapy treatment for whiplash injuries.

METHODS: Participants already enrolled in a larger RCT investigating emergency department treatments for whiplash were randomized to a physiotherapy package or an advice session if they had persistent symptoms 3 weeks postinjury. The primary outcome was the Neck Disability Index (NDI), collected at 4, 8, and 12 months by postal questionnaire. Analysis was intention to treat and included a cost-effectiveness analysis.

RESULTS: Five hundred ninety-nine participants were randomized to the physiotherapy package or advice session. There was a modest, statistically significant benefit from the physiotherapy package at 4 months (difference in NDI, -4; 95% CI: -6.1, -1.3), but no long-term difference. The number of work days lost was lower with the physiotherapy package (difference, -4 days; 95% CI: -7.5, -0.02). From an NHS cost-effectiveness perspective, intensive physiotherapy was not cost-effective.

CONCLUSION: A package of physiotherapy targeted to people with ongoing symptoms produces modest, short-term benefit and a substantial reduction in work days lost compared to an advice session but is not cost-effective from an NHS perspective.

IMPLICATIONS: Despite the modest effect on disability, the reduction in work days lost attributable to the physiotherapy package was substantial. So, although physiotherapy treatment was not deemed cost-effective from an NHS perspective, it is possible that fewer work days lost is an important societal benefit of early physiotherapy and should be considered for those patients struggling to return to work.

FUNDING: UK NIHR HTA program.

CURRICULA MODIFICATIONS IN THE POSTGRADUATE MUSCULOSKELETAL PROGRAM FROM ASSOCIATION BASED TO ACADEMIC MASTER LEVEL

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PURPOSE: Physical therapy education in Switzerland was elevated to an academic university level in 2006. This development enabled the establishment of postgraduate masters courses. Until this time, the manual therapy program (OMT) had been organized by the Manual Therapy Association. The first masters degree program for musculoskeletal physiotherapy at the Zurich University of Applied Sciences started in February 2010. This presentation describes the curriculum changes necessary following these developments.

RELEVANCE: The introduction of postgraduate clinical education at the masters level is important for the profession. However, it can be asked, what were the concrete changes made to the teaching curriculum? Can the anticipated higher level of professional skills be demonstrated in the course of study?

DESCRIPTION: The masters curriculum follows the role and competencies portfolio of IFOMPT and WCPT. The main changes to the academic curriculum are: a greater focus on evidence-based background studies; a higher proportion of self-learning (60% of workload); clearer performance measurement; and an emphasis on topics concerned with professional leadership, patient education, and communication. The earlier manual therapy program focused mainly on the development of clinical and manual skills.

EVALUATION: The students describe the academic environment as very demanding, but can recognize the importance of self-learning and more targeted performance scores, which guide them throughout the program.

CONCLUSIONS: In Switzerland, a conservative country with strong medical traditions, where physiotherapy has been seen more as an "assisting" profession, this change of culture is not easy. Understanding the aims of the academicization of the physiotherapy profession, greater recognition, lifelong learning, and increased career planning possibilities, however, make the commitment worthwhile.

IMPLICATIONS: In Switzerland, academic education in the physiotherapy profession is here to stay. Over the medium term, this will be a rewarding development for professional physiotherapists.

DIFFERENT KNOWLEDGE FORMS IN PERFORMING KNOWLEDGE TRANSLATION

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PURPOSE: To understand actions and activities of knowledge translations (KT) in participatory research.

RELEVANCE: A wide range of knowledge is used in physiotherapy, but we still lack understanding of how forms of knowledge are translated between research and clinical practice and how new knowledge is created in these processes. KT has traditionally been conceptualized in terms of a chain of knowledge translations accelerating the implementation of research-based knowledge with the intention to improve health outcomes. However, KT research has emphasized the results and knowledge generated within the stages of the chain, whereas the steps involved are still poorly investigated.

DESCRIPTION: The project explores new methodological approaches for studying KT between research and clinical practice. Our first case study of KT in physiotherapy explores knowledge exchange in repeated discussions between researchers and clinicians in a participatory research project. Data were obtained through observations. The project is based on an action research inspired design where observers suggest actions and activities that can promote the translation of knowledge, based on analyses of observations.

EVALUATIONS: Knowledge positions are not stable, but seem to alternate between the participants in the discussions. Researchers may defend what they think have clinical interests and clinicians may promote research interests. The difference between the epistemic cultures represented seems to be more a question of form than content. While the researchers communicate their knowledge in terms of general statements, the clinicians

tend to express their knowledge through examples.

CONCLUSIONS: Obstacles for KT between clinicians and researchers may be related to knowledge form more than differences in interests or content.

IMPLICATIONS: Acknowledgment of the difference in knowledge form used by clinicians and researchers may promote bidirectional translation and thus more clinically useful research and enhanced use of research knowledge in clinical practice.

INVESTIGATING THE USE OF RESEARCH EVIDENCE AMONG MANUAL AND MANIPULATIVE PHYSIOTHERAPISTS IN CANADA

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BACKGROUND: The ways in which research evidence (RE) is utilized and integrated with clinical expertise and patients' values are critical to evidence-based practice (EBP). Factors such as the clinicians' attitudes toward and patterns of RE utilization have been shown to impact how clinicians apply RE in practice. To date, there lacks evidence of which factors influence RE utilization for Canadian manual and manipulative physiotherapists. Examining these factors may help to determine the nature and extent of influence on the utilization of RE, and how EBP can be improved upon.

PURPOSE: To examine the current attitudes, patterns of use, and barriers toward the utilization of RE among Canadian manual and manipulative physiotherapists.

METHODS: A cross-sectional web-based survey was conducted among Fellows of the Canadian Academy of Manipulative Physiotherapists (FCAMPT) currently practicing in Canada.

RESULTS: Most FCAMPTs agreed that the application of RE is necessary in practice (92.1%) and assists with their decision making (85.6%). RE was used in clinical decision making fewer than 5 times (48.7%) and more than 10 times (34.2%) in a typical month. Clinical practice was most often influenced by personal experience (98.6%) and clinical experts (93.4%). The most commonly identified barrier was lack of time (59.2%). The strongest facilitator was access to up-to-date clinical practice guidelines (89.4%).

CONCLUSIONS: Canadian manual and manipulative physiotherapists demonstrated positive attitudes toward RE utilization in practice. While continuing education strategies were identified as potential facilitators to improving utilization of RE in clinical practice, specific implications for the dissemination of RE are also discussed.

IMPLICATIONS: Our study contributes to the field of knowledge translation and specifically the study of factors that impact on RE utilization. Attending to the barriers and facilitators to RE utilization among Canadian manual and manipulative physiotherapists has the potential to enhance EBP and patient outcomes.

ACKNOWLEDGEMENT: Approved by the University of Toronto Research Ethics Board.

SHORT-TERM RESULTS OF A RANDOMIZED CONTROLLED TRIAL ON SPECIFIC PHYSIOTHERAPY VERSUS ADVICE FOR SUBACUTE LOW BACK DISORDERS

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PURPOSE: The purpose of the Specific Treatment of Problems of the Spine (STOPS) trials was to evaluate the effectiveness of specific physiotherapy treatment compared to physiotherapy advice for subacute low back disorders (LBD) classified into 1 of 5 subgroups.

RELEVANCE: Few treatments have demonstrated clinically meaningful benefits for LBD. Clinical heterogeneity in randomized controlled trials may

reduce the likelihood of demonstrating treatment effects. Our physiotherapy classification and treatment protocol targeting pathoanatomical and psychosocial factors has the potential to reduce the impact of sample and treatment heterogeneity in clinical trials.

METHODS: Participants with subacute (6 weeks-6 months) low back pain and/or referred leg pain were classified into 1 of 5 subgroups. They were then randomly allocated to receive either physiotherapy advice or specific physiotherapy treatment over 10 weeks. Primary outcomes were the Oswestry Disability Index as well as leg and back pain intensity (0-10 numeric rating scales). Data were analyzed using linear mixed models for continuous outcomes and Mann-Whitney *U* tests for ordinal outcomes.

RESULTS: Ten-week follow-up data for all 300 participants will be presented. Analysis of 300 participants (153 men, 147 women) showed a mean \pm SD age of 44 ± 12 years and a duration of back and leg symptoms of 15 ± 10 and 11 ± 10 weeks, respectively. Linear mixed-model analyses of primary outcomes showed significant ($P < .001$) between-group differences favoring specific physiotherapy treatment over advice: Oswestry (4.7; 95% CI: 2.0, 7.4), back pain (1.3; 95% CI: 0.8, 1.8), and leg pain (1.1; 95% CI: 0.5, 1.7). This corresponded to effect sizes of 0.3, 0.6, and 0.5, respectively.

CONCLUSIONS: The analysis showed statistically significant short-term effects for specific physiotherapy compared to physiotherapy advice for subacute low back disorders at treatment completion. The size of effect was moderate for back and leg pain.

IMPLICATIONS: A classification approach to physiotherapy assessment and treatment is more effective than guideline-recommended advice.

PAIN LOCATION IS ASSOCIATED WITH PAIN AND DISABILITY IN PATIENTS WITH NONSPECIFIC LOW BACK PAIN

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PURPOSE: To quantify the correlations between pain location and pain intensity or function in patients with LBP exercising according (or not) to their directional preference (DP).

RELEVANCE: The McKenzie approach uses repeated movements in a preferred direction to promote proximal pain relocation, hoping to reduce pain and disability. Pain intensity and function are recommended for monitoring LBP treatments but not pain location.

METHODS: This is a secondary analysis of 121 volunteers with nonspecific LBP from 2 cohort studies on the effect of repeated flexion and extension exercises, respectively. Two raters independently reviewed baseline exams to determine DP. Patients treated according to their DP formed the matched group. Patients without a DP or treated in a direction other than their DP formed the unmatched group. At baseline and at 2 and 4 weeks, patients completed a pain diagram, numeric pain ratings, and the Modified Oswestry questionnaire. Spearman coefficients were used.

RESULTS: The matched group included 29 patients treated according to their DP (9 in flexion, 20 in extension). At baseline, only pain location and leg pain intensity were significantly correlated (matched $\rho = 0.47$, unmatched $\rho = 0.56$). At 2 and 4 weeks, all correlations between pain locations and pain intensity or disability were significant ($P < .05$), ranging from 0.39 to 0.63 for the matched group and from 0.24 to 0.55 for the unmatched group. At 2 weeks, the pain location/function correlation in the matched group was clinically (greater than 0.30) stronger than the unmatched group. Over time, correlations became stronger by a clinically (greater than 0.20) significant amount in both groups.

CONCLUSION: A more distal pain location was consistently associated with larger pain intensity and disability. In patients treated according to their DP, correlations were clinically more important than the unmatched group.

IMPLICATION: Results support the validity of the hypothesized association

between pain location and pain intensity or function in the McKenzie approach.

TARGETED BEHAVIORAL APPROACH FOR THE MANAGEMENT OF NSCLBP: A RANDOMIZED CONTROLLED TRIAL

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PURPOSE: Nonspecific chronic low back pain (NSCLBP) disorders have proven resistant to change, and there is still a lack of clear evidence for one specific treatment intervention being superior to another.

RELEVANCE: Possible reasons for the failure of current clinical practice to effectively manage NSCLBP are proposed to lie in 2 main domains: (1) the failure to adequately deal with NSCLBP within a multidimensional biopsychosocial framework, and (2) lack of a multidimensional classification system directing person-centered targeted management.

METHODS: This randomized controlled trial aimed to investigate the efficacy of a behavioral approach to management, classification-based cognitive functional therapy (CB-CFT), compared to traditional manual therapy and exercise (MT-EX). Linear mixed models were used to estimate the group differences in treatment effects. Primary outcomes at 12-month follow-up were Oswestry Disability Index (ODI) and pain intensity, measured with a numeric rating scale (PINRS). The trial included patients between 18 and 65 years of age, diagnosed with NSCLBP for greater than 3 months, localized pain from T12 to gluteal folds, provoked with postures, movement, and activities. At inclusion, ODI was greater than 14% and PINRS for the last 14 days was greater than 2/10. One hundred twenty-one patients with NSCLBP were randomized to either CB-CFT ($n = 62$) or MT-EX ($n = 59$). Twenty-seven patients withdrew, leaving 94 patients for analysis ($n = 51$ in the CB-CFT group and $n = 43$ in the MT-EX group).

RESULTS: The CB-CFT group displayed significantly superior outcomes to the MT-EX group, both statistically ($P < .001$) and clinically. For ODI, the CB-CFT group improved by 13.7 points, and the MT-EX group by 5.5. For PINRS, the CB-CFT improved by 3.2 points, and the MT-EX group by 1.5.

CONCLUSIONS: The results support that a behavioral approach that targets maladaptive cognitions, movement behaviors, and lifestyle factors produces superior outcomes for NSCLBP compared to traditional manual therapy and exercise.

IMPLICATIONS: This may call for a paradigm shift away from focusing less on symptoms and more focus on changing provocative cognitive, lifestyle, and movement behaviors.

PATIENTS' PERCEPTIONS OF A PHYSIOTHERAPY FUNCTIONAL RESTORATION TREATMENT PROTOCOL FOR PEOPLE WITH DISCOGENIC LOW BACK PAIN WITH OR WITHOUT RADICULOPATHY: A QUALITATIVE STUDY

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PURPOSE: To explore the perceptions of patients regarding a specific physiotherapy functional restoration program developed for people with discogenic low back pain with or without radiculopathy.

RELEVANCE: Functional restoration is a multimodal rehabilitation program with demonstrated effectiveness in people with subacute and chronic nonspecific low back pain. Modification of traditional functional restoration that accounts for pathoanatomical factors may increase effectiveness for people with significant discogenic pathology.

METHODS: A specific physiotherapy functional restoration program was developed to account for the presence of significant discogenic pathology (with or without radiculopathy). Key components of the program included the provision of pathoanatomical information relevant to disc injuries;

strategies for managing inflammation, pain, sleep disturbance, and psychosocial barriers to recovery; as well as specific motor control retraining exercises that were progressed into functional activities. Exercises were progressed on a pain-contingent rather than a time-contingent basis. Participants in a randomized controlled trial who undertook the functional restoration treatment underwent semi-structured interviews. Two researchers independently coded interviews using qualitative data analysis software and thematically analyzed the results.

RESULTS: A total of 38 participants were interviewed (20 men, 18 women), with a mean \pm SD age of 44 ± 12 years and a mean \pm SD duration of back and leg symptoms of 13 ± 7 and 11 ± 8 weeks, respectively. Most participants perceived the functional restoration program favorably, valuing exercises, information/knowledge gained, learned management skills, and the reported positive experience with their physiotherapist. Some participants noted negative features, including difficulties with specific exercises.

CONCLUSIONS: Participants with discogenic low back pain (with or without radiculopathy) who undertook a specific physiotherapy functional restoration program predominantly described positive perceptions.

IMPLICATIONS: Physiotherapy functional restoration programs can be modified for the presence of discogenic pathology (with or without radiculopathy) and be perceived favorably by most participants.

PRELIMINARY EVIDENCE FOR THE VALIDITY OF FEATURES OF NONREDUCIBLE DISCOGENIC LOW BACK PAIN: SURVEY OF AN INTERNATIONAL PHYSIOTHERAPY EXPERT PANEL WITH THE DELPHI TECHNIQUE

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PURPOSE: The objectives of this study were to obtain consensus from an expert panel on the features of discogenic low back pain (LBP), whether subgroups of discogenic LBP exist, in particular nonreducible discogenic pain (NRDP), and the associated features of NRDP.

RELEVANCE: The lumbar intervertebral disc is a known source of LBP. Aside from centralization, the clinical features of discogenic pain and related subgroups have not been validated. An expert panel using the Delphi technique has the potential to provide preliminary validation on the features of discogenic and nonreducible discogenic LBP.

METHODS: An international panel of 21 physiotherapists with expertise in LBP participated in a 3-round Delphi survey. Panelists listed and ranked features that they believed to be indicative of discogenic pain as well as NRDP. On completion of round 3, features with 50% or greater agreement between panelists were deemed to have reached consensus.

RESULTS: After 3 rounds, 10 features of discogenic LBP were identified, with the most prevalent features being directional preference, presence of a lateral shift, and symptoms aggravated by sitting. Nineteen of the panelists believed that NRDP was a subgroup of discogenic LBP, and 9 features of NRDP were identified, with no position or movement able to reduce symptoms and the absence of centralization being the most prevalent features.

CONCLUSIONS: This study provides preliminary validation for the features associated with discogenic LBP. It also provides evidence supporting the existence and features of NRDP as a separate clinical subgroup of discogenic LBP.

IMPLICATIONS: With further validation, the features identified during the Delphi survey may assist physiotherapists in clinical practice to identify and specifically treat people with discogenic pain and NRDP.

CLINICAL GUIDELINES FOR LOW BACK PAIN, RECOMMENDATIONS FOR PATIENTS WITH NEUROLOGIC INVOLVEMENT IN PRIMARY CARE

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PURPOSE: To compare national clinical guidelines on low back pain, the recommendations for patients with neurologic involvement.

RELEVANCE: Primary care guideline recommendations for patients with low back pain and neurologic involvement are essential, as this group of patients is likely to experience substantially more disability than those with nonspecific low back pain, to incur greater costs of care, and to require surgery. Early identification and accurate knowledge of neurologic status can inform decisions about conservative care and help to clarify which interventions produce neurological improvement and can also alert to a deterioration or absence of change in status that may indicate the necessity to refer. Guidelines have a role in improving referral decisions whether in a situation of medical emergency or for decisions about diagnostic imaging or additional studies.

METHODS: Guidelines were included that met the following criteria: the guideline concerned the diagnosis and clinical management of low back pain, recommendations were for clinical management by primary care health professionals, and the guideline was available in English.

RESULTS: Guidelines from 9 countries (1999-2008) were investigated. One guideline did not include recommendations for identification or referral of patients with neurologic involvement, and some only provided limited recommendations. There were guidelines with recommendations for the identification of cauda equina syndrome, nerve root syndrome, and spinal stenosis syndrome, including decision factors for each syndrome. Referral recommendations for imaging, additional studies, and consideration for surgery were provided in a few guidelines.

CONCLUSIONS: National guidelines were identified that did not distinguish between low back pain with neurologic involvement and nonspecific low back pain in assessment and referral. Practice, informed by guidelines that do identify neurologic involvement and that provide clear referral recommendations, may positively impact on outcomes for patients with neurologic involvement.

IMPLICATION: The effect of identifying neurologic involvement merits further investigation.

CLASSIFICATION ACCURACY OF MOTOR CONTROL TESTS OF THE LUMBAR SPINE FOR SUBGROUPS OF MECHANICAL LOW BACK PAIN

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PURPOSE: To investigate the classification accuracy of motor control tests of the lumbar spine in discriminating 5 subgroups of peripherally mediated mechanical low back pain (LBP) suggested in the classification system developed by Peter O'Sullivan.

RELEVANCE: Identifying clinically relevant subgroups is considered a prioritized area of LBP research. The current study addresses the issue of using accurate, reliable, and standardized tests to guide such classifications.

METHODS: Seventy subjects with nonspecific LBP were classified by an expert clinician into 5 subgroups based on the direction of motor control impairment and the assumed mechanism underlying the pain disorder (ie, flexion, lateral shift, active extension, passive extension, and multidirectional pattern). Thereafter, 5 standardized tests of motor control were performed under the supervision of 2 therapists blinded to the subgroup classification: "waiters bow," bilateral and unilateral sitting knee extension, and bilateral and unilateral prone knee flexion. A lack of ability to prevent a compensatory movement (motion give) when instructed to maintain neutral lumbar posture was judged as test failure. Multinomial logistic regression was used to analyze the association between tests and subgroups and to determine the tests' joint classification accuracy.

RESULTS: The motor control tests showed significant associations to the different subgroups ($\chi^2 = 37.08, P = .002$, Nagelkerke pseudo $R^2 = 0.431$)

and displayed significant discriminative ability, increasing the classification accuracy substantially, 95% above chance level overall, and for all subgroups except for the multidirectional pattern. The different subgroups were characterized by different association patterns, indicating different tests to be important for different subgroups.

CONCLUSIONS AND CLINICAL IMPLICATIONS: The results indicate a clinical utility of the motor control tests and suggest them to be useful to supplement in subgroup classification of what traditionally have been considered nonspecific mechanical LBP. The findings also support the clinical validity of the approach to subgroup patients according to the direction of motor control impairment.

INTERRATER AGREEMENT OF CLINICAL TESTS/SIGNS USED TO IDENTIFY PATIENTS WITH LUMBAR FUNCTIONAL INSTABILITY

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PURPOSE: To study the interrater agreement of several clinical tests/signs for lumbar functional instability (LFI). Furthermore, the interrater agreement in identifying patients who are likely to benefit from a stabilization exercise was also investigated.

RELEVANCE: Patients with LFI are considered to belong to a particular subgroup of subjects with low back pain (LBP). Although several clinical tests have been used in the literature to identify this subgroup of patients, evidence is lacking regarding their psychometric properties, especially interrater reproducibility.

METHODS: Nineteen middle-aged patients with chronic LBP attended 3 evaluation sessions. During the first one, several questions related to LFI were asked by a physical therapist (anamnesis). During both other sessions, spaced by 5 days on average, patients were examined by 2 experienced manual therapists, who looked for clinical signs and performed several LFI clinical tests while being unaware of each other's examination. Then, they had access to the anamnesis information of the patient and had to recommend stabilization exercises (or not). Interrater agreement was determined by calculating the proportion of agreement and the Cohen kappa coefficient (κ).

RESULTS: Interrater agreement differed widely from 1 sign/test to another; for example, the reversal of lumbopelvic rhythm sign had a very good interrater agreement (18/19; $\kappa = 0.826$), the passive accessory intervertebral motion test had a fair interrater agreement (13/19; $\kappa = 0.32$), whereas the prone instability test (6/19; $\kappa = 0$) and the increased muscle guarding/spasm sign (11/19; $\kappa = -0.186$) had very low kappa coefficients. A fair interrater agreement was observed regarding the identification of patients likely to benefit from stabilization exercises (14/19; $\kappa = 0.36$).

CONCLUSIONS: Although a low agreement was observed for several clinical signs/tests, a fair interrater agreement was observed regarding the clinical decision making. Further studies are needed to confirm our results.

IMPLICATIONS: The low interrater agreement of some clinical signs/tests used to identify LFI suggests caution when interpreting them.

PREDICTORS OF RESPONSE TO EXERCISE AND MANUAL THERAPY IN HIP OSTEOARTHRITIS

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PURPOSE: To identify which baseline variables could predict response to exercise (ET) and manual therapy (MT) for hip osteoarthritis (OA).

RELEVANCE: Various definitions of responders to treatment have been used in OA trials, with few evaluating physiotherapy specifically. The aim of

this study was to identify if there were any predictors of outcome to ET and MT for hip OA using different responder criteria.

METHODS: We analyzed data (n = 131) from a multicenter RCT that evaluated ET, and ET with additional MT, for hip OA. Four responder criteria were used: minimal clinically important difference (MCID) and 20% improvement in WOMAC physical function (PF) subscale, Likert global rating of change scale (GRCS), and OMERACT (Outcome Measures in Rheumatology group) responder criteria. Logistic regression was used to identify predictors of outcome for a range of baseline variables.

RESULTS: There was no significant difference in WOMAC PF (primary outcome) between ET and ET/MT groups at 9 weeks (mean difference, -0.91; 95% CI: -6.28, 4.44). The proportion of those responding to treatment varied according to the criterion, with GRCS having the highest number of responders (65%). Univariate regression identified baseline pain severity and WOMAC PF as predictors of outcome for all responders except MCID WOMAC. For every unit increase in pain/disability, the probability of responding to treatment reduced with worsening baseline scores. Odds ratios (ORs) varied from 0.12 to 0.24 (depending on responder criterion) with poorer baseline pain scores. Similarly, ORs of 0.23 to 0.35 occurred with poorer WOMAC scores.

CONCLUSIONS: Only baseline pain and self-report function were predictors of outcome. The probability of a positive treatment response reduced with higher pain (up to 88%) and functional limitation (up to 77%).

IMPLICATIONS: Understanding which variables influence response to treatment can be used to tailor treatments for hip OA of varying severity. A range of other variables did not influence treatment response.

WHAT DOES THE LANGUAGE WE USE ABOUT ARTHRITIS MEAN TO A PATIENT?

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PURPOSE: To determine patients' knowledge, awareness, and comprehension of the language used to describe arthritis, including gaining feedback on the emotional impact of the terms.

RELEVANCE: Research shows that more than 80% of patients have poor health literacy. To date, research has focused on language associated with back pain, with less on general musculoskeletal complaints, although these account for a large amount of physiotherapy consultations.

METHODS: Five qualitative focus groups of 6 to 8 respondents and 6 individual in-depth interviews were conducted among a purposive sample of: men and women (50/50 split across the sample), aged 45 years and older with a spread of ages in each group and within the overall sample of in-depth interviews, and with a range of socioeconomic groupings. Key terms such as *arthritis*, *degenerative*, *rheumatism*, *wear and tear*, and *rehabilitation* were used as stimulus materials. Focus groups and interviews were audio-recorded, transcribed verbatim, and underwent line-by-line coding and thematic analysis using interpretative phenomenological analysis.

RESULTS: Patients were familiar with many of the terms, such as arthritis, osteoarthritis, rheumatism, inflammation, etc, but their level of comprehension varied. Most terms had little emotional impact. Terms used to describe pathophysiology, such as *wear and tear* and *degenerative*, elicited negative emotional impact, especially in women. Terms such as *rehabilitation* and *self-management* were poorly understood and produced negative emotional impact.

CONCLUSIONS: Healthcare professionals should not assume that patients' familiarity with medical terms correlates to understanding the term. They should be aware of the potential for negative emotional impact related to some terms.

IMPLICATIONS: Cutting the jargon and checking understanding of seemingly simple medical terms is important to improve communication with patients.

EVALUATION OF PATIENT ACCEPTABLE SYMPTOM STATE ESTIMATES AMONG SELF-REPORT AND PHYSICAL PERFORMANCE OUTCOME MEASURES IN PATIENTS WITH HIP OSTEOARTHRITIS

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PURPOSE: To determine patient acceptable symptom state (PASS) estimates in outcome measures commonly used in hip osteoarthritis (OA).

RELEVANCE: PASS is the value beyond which patients consider themselves satisfied with their current symptom state. Identification of cut points associated with patient satisfaction (PASS) on commonly used outcome measures may be a useful alternative to the concept of minimal clinically important improvement when identifying patient response to treatment and in determining a plan for patient discharge.

METHODS: Seventy patients with a clinical diagnosis of hip OA received 9 sessions of physiotherapy and were randomly allocated to receive: (a) manual therapy, (b) exercise therapy, or (c) both. Upon completion of physiotherapy, patients assessed their response to treatment on the PASS. Patients also completed a combination of 3 self-report outcome measures and 4 physical performance measures. PASS estimates for each of the outcome measures were determined using receiver-operating-characteristic curves to discriminate between patients who were satisfied and those who were not.

RESULTS: PASS estimates were found to be significant ($P < .05$) for 4 of the 7 outcome measures. The following scores were best associated with our definition of PASS: a score of less than or equal to 10 on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale, a score less than or equal to 35 on the WOMAC physical function subscale, a score greater than or equal to 11 repetitions for the 30-second chair stand, and a score greater than or equal to 46 repetitions for the 20-cm step test.

CONCLUSIONS: Target cut points signaling patient satisfaction with their current symptom state following physiotherapy were determined for 4 outcome measures.

IMPLICATIONS: Research should attempt to identify cutoff scores that better reflect patients' perspective for their satisfaction of the current level of function.

PREDICTORS OF RESPONSE TO PHYSICAL THERAPY INTERVENTION IN PATIENTS WITH PRIMARY HIP OSTEOARTHRITIS: A COMPARISON OF PREDICTIVE MODELING BASED ON VARYING RESPONSE CRITERIA

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PURPOSE: To highlight the variability of predictive modeling within prognostic studies based on the definition of responder criteria.

RELEVANCE: In rehabilitation medicine, there is no generally agreed-upon definition of responder, and, often, the outcome measure used to determine success varies considerably across studies. The results of this study suggest that prognostic variables depend exclusively on the responder criterion selected and that tools such as clinical prediction rules may be specific singularly to the responder criterion.

METHODS: Seventy patients with a clinical diagnosis of hip OA were analyzed to determine which clinical measures, when clustered together, were most predictive of a favorable response to physiotherapy intervention. Four definitions of responder were used: OMERACT-OARSI response criteria, avoidance of surgery, positive response to patient acceptable symptom state (PASS), and global rating of change (GRoC). These data served as the responder criterion determining the predictive validity of baseline clinical examination variables. A comparison of predictive models using different responder criteria was identified using a standardized multivariate regression analysis.

RESULTS: Chi-square tests showed a lack of agreement among the 4 definitions of responder ($P < .05$). Different predictive models were associ-

ated with different responder criteria. The set of statistically significant predictors was dependent on the definition of the responder criteria. Duration of symptoms less than 1 year, age 58 years or younger, and 40-m self-paced walk time of 25.9 seconds or shorter were the most stable predictors across the 4 regression models with different response definitions. **CONCLUSIONS:** The variation in definition of responder results in different clusters of predictive variables. Researchers and clinicians should be aware that predictive variables are not fixed and may vary depending on the selection of the outcome variable. **IMPLICATIONS:** Current results may help researchers and clinicians to interpret prognostic studies with greater caution given the variability based on the definition of responder.

REHABILITATION FOLLOWING HIP RESURFACING ARTHROPLASTY: ARE OUTCOMES IMPROVED USING A TAILORED PHYSIOTHERAPY PROTOCOL?

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PURPOSE: To identify if a tailored hip resurfacing rehabilitation program is more effective than current standard practice at improving function in the year following surgery.

RELEVANCE: Currently, there is little evidence-based guidance on the rehabilitation of patients with hip resurfacing. Previous work suggests that there is frequently persistent muscle weakness and poor functional mobility.

METHODS: Single-blinded randomized control trial. Setting: hospital trust specializing in orthopaedic surgery. Participants: 80 patients undergoing elective hip resurfacing arthroplasty. Intervention: physiotherapy exercise program tailored to hip resurfacing, delivered in an outpatient setting. Comparison group of standard hip arthroplasty rehabilitation. Main outcomes: Oxford Hip Score (OHS); secondary measures of Hip disability and Osteoarthritis Outcome Score (HOOS); UCLA activity score; EQ-5D; range of motion of hip flexion, abduction, and extension. Measures were recorded at baseline and at 6, 16, and 52 weeks after surgery.

RESULTS: Linear regression model, adjusted by baseline OHS, detected a 5.8-unit change in OHS at 52 weeks when the exposure group moved from control to treatment ($P = .001$). There was a statistically significant increase in HOOS of 12.4 at 52 weeks ($P < .0005$) when comparing the treatment and control groups. The UCLA activity score showed an increase of 0.66 ($P = .019$) in favor of the treatment group at 52 weeks. The EQ-5D summary index increased by 0.07 ($P = .031$) at 52 weeks when moving from the control group to the treatment group. Hip flexion (increase of 17.9, $P < .0005$) and hip extension (increase of 5.7, $P = .004$) also showed a marked improvement between the treatment group and the control group.

CONCLUSIONS: A simple tailored exercise program resulted in marked increases in hip range of motion and self-reported function compared to the previous conventional rehabilitation program.

IMPLICATIONS: A change in the emphasis of postoperative rehabilitation could improve outcome for patients after hip resurfacing arthroplasty.

IDENTIFYING THE SEQUENCE OF SCIATIC NERVE EXCURSION DURING DIFFERENT NEURAL MOBILIZATION EXERCISES: AN IN VIVO STUDY UTILIZING ULTRASOUND IMAGING

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PURPOSE: To use ultrasound imaging to quantify whether a sigmoidal sequence of sciatic nerve excursion, at the level of the posterior mid thigh, occurs during different types of slump-sitting neural mobilization exercises.

RELEVANCE: Research suggests that peripheral nerves exhibit a sigmoidal

sequence of excursion during limb movements. Initially, slack is taken up before nerve excursion occurs, followed by a period of elongation. Knowledge of such a sequence of nerve excursion during neural mobilization exercises may enhance their design to maximize nerve excursion.

METHODS: A controlled laboratory study using single-group, within-subject comparisons was conducted to determine whether the sciatic nerve exhibits a sigmoidal sequence of excursion in vivo during different types of neural mobilization exercises. High-resolution ultrasound imaging of sciatic nerve excursion, at the posterior mid thigh, was synchronized with cervical and knee joint range-of-motion data during the performance of 3 different neural mobilization exercises in 30 healthy participants.

RESULTS: A sigmoidal sequence of nerve excursion was identified for the 2-ended slump-slider and slump-tensioner exercises but not the 1-ended slump slider. A significant difference in regard to the maximum rate of nerve excursion was seen between all exercises, once 73% to 80% of each exercise had been completed (during a 3-second exercise period) ($P < .05$).

CONCLUSIONS: These findings support previous cadaveric research that sciatic nerve excursion exhibits a sigmoidal sequence during 2-ended slump-slider and slump-tensioner neural mobilization exercises.

IMPLICATIONS: Appreciation of the sequence of nerve excursion during different neural mobilization exercises may enhance their prescription and design in an effort to maximize nerve excursion.

COMPARISON OF DIFFERENT NEURAL MOBILIZATION EXERCISES UPON LONGITUDINAL SCIATIC NERVE MOVEMENT: AN IN VIVO STUDY UTILIZING ULTRASOUND IMAGING

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PURPOSE: To use ultrasound imaging to quantify whether different types of slump-sitting neural mobilization exercises result in different amounts of sciatic nerve excursion.

RELEVANCE: Neural mobilization has been advocated for conditions where peripheral nerve movement is thought to be compromised. Recent cadaveric and in vivo research has concluded that median nerve excursion differs significantly between different types of neural mobilization exercises. Clinically, it is important to understand the mechanical influence on the peripheral nervous system when prescribing neural mobilization. To date, this has not been examined for the sciatic nerve.

METHODS: A controlled laboratory study using single-group, within-subject comparisons was conducted to determine whether different types of neural mobilization exercises are associated with differing amounts of longitudinal sciatic nerve excursion. High-resolution ultrasound imaging and frame-by-frame cross-correlation analysis were utilized to assess longitudinal sciatic nerve excursion at the posterior mid thigh. Four different neural mobilization exercises were examined in 31 healthy participants. A repeated-measures analysis of variance and isolated means comparisons were used to analyze the data.

RESULTS: The findings of this study concluded that different neural mobilization exercises induced significantly different amounts of sciatic nerve excursion ($P < .001$). The 2-ended slider was associated with the largest sciatic nerve excursion (3.2 ± 2.0 mm) and was significantly greater ($P < .02$) than seen with a 1-ended slider (2.6 ± 1.4 mm, $P < .02$) and a tensioner (2.6 ± 1.5 mm).

CONCLUSIONS: Different types of slump-sitting neural mobilization exercises generate different amounts of sciatic nerve excursion, with slider mobilization resulting in the greatest amount of excursion. The findings of this research refer to normal, healthy participants and do not reflect the situation of any specific symptomatic or pathological populations.

IMPLICATIONS: It is valuable for the design and use of neural mobilization exercises to appreciate that different exercises will have different mechanical influences on peripheral nerves, such as the sciatic nerve.

REPEATABILITY AND NORMATIVE VALUES OF MEASURING SCIATIC NERVE EXCURSION DURING THE STRAIGHT LEG RAISE WITH B-MODE ULTRASOUND

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PURPOSE: To assess the repeatability and normative values for sciatic nerve excursion measured with B-mode ultrasound during SLR.

RELEVANCE: SLR assesses the mechanosensitivity of the lumbosacral nerve roots and sciatic nerve. However, no in vivo data exist on how much nerve motion occurs during SLR. Nerve motion has been repeatedly measured in the upper-limb nerves and sciatic nerve during a modified slump test using a process called speckle tracking. However, small movements occurred during the slump test, and these may be more amenable to successful tracking. Because greater movement is likely during SLR using knee extension, repeatability is required.

METHODS: Sixteen asymptomatic subjects (9 men; range, 16-68 years) lay on a randomly selected side, and the sciatic nerve was scanned in the midposterior thigh. Nerve excursion was measured during knee extension from 90° to 0°, with the ankles in plantar grade, with the hip flexed (HF) to 30° and 60°. Subjects returned 1 week later, and measurements were repeated. Ultrasound data were analyzed offline using frame-by-frame cross-correlation analysis. ICC_{1,1} was used to assess repeatability with standard error measurements (SEMs) and 95% confidence intervals (CIs).

RESULTS: In 30° of HF, excursion ranged from 6.4 to 14.7 mm (mean ± SD, 9.92 ± 2.2 mm), ICC was 0.92 (95% CI: 0.79, 0.97), and SEM was 0.69. In 60° of HF, excursion ranged from 5.1 to 20.2 mm (mean ± SD, 12.4 ± 4.4 mm), ICC was 0.96 (95% CI: 0.90, 0.99), and SEM was 0.87.

CONCLUSIONS: Excellent repeatability of measures was found. Large variations in sciatic nerve excursion during the SLR occurred. Greater nerve excursion ensued with increased ranges of HF, which is in contrast to studies in the upper limb, when less nerve excursion occurred with more proximal tensioning.

IMPLICATIONS: Measurement of sciatic nerve excursion during SLR using speckle tracking is repeatable. Values found can be compared to future studies on symptomatic populations.

SONOGRAPHY ASSESSMENT OF THE MEDIAN NERVE DURING CERVICAL LATERAL GLIDE AND LATERAL FLEXION: IS THERE A DIFFERENCE IN NEURODYNAMICS?

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PURPOSE: The purpose of this study was to show that a cervical lateral glide (CLG) causes a larger amount of median nerve movement in the arm and hand region than contralateral flexion (CLF) of the cervical spine.

RELEVANCE: There is clinical evidence that the CLG improves neurodynamics and alleviates pain in patients who suffer from neurogenic arm pain. However, effective nerve movement has not been investigated using ultrasound imaging (US).

METHODS: In this study, 27 healthy volunteers (mean ± SD age, 24.7 ± 3.25 years; 19 women) were recruited. The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire was answered. Transverse and longitudinal median nerve movement during CLF and CLG were measured by US. In the longitudinal plane at the middle and distal forearm. Transverse at upper arm and wrist.

RESULTS: In the transverse plane, CLG produced a significantly larger amount of median nerve movement than CLF (ie, at the wrist: CLF, 0.9 ± 0.30 mm; CLG, 1.2 ± 0.35 mm; *P* = .005). Even in the longitudinal plane, the amount of median movement is larger for both locations of measurement when applying the CLG compared to the application of CLF (ie, at the middle forearm: CLF, 2.2 ± 0.64 mm; CLG, 3.3 ± 1.0 mm; *P* = .005).

CONCLUSIONS: The results of this study show that CLG resulted in a sig-

nificantly larger amount of nerve movement in the arm and hand region compared to the movements observed with CLF.

IMPLICATIONS: Manual therapists may be aware that CLG and CLF both influence the median nerve in the arm and hand region. In clinical decision making, it should be taken into account that CLG results in a larger movement of the median nerve in the wrist/forearm and the upper arm.

IMPROVING THE MECHANICAL VALIDITY OF RADIAL AND ULNAR NERVE NEURODYNAMIC TESTING: AN OBSERVATION OF STRAIN DURING UPPER-LIMB POSITIONING

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RELEVANCE: The mechanical validity of the radial and ulnar nerve neurodynamic tests is based on their ability to selectively increase strain of the intended nerve. However, this has not been established.

PURPOSE: To determine which upper-limb position results in the greatest strain of the radial and ulnar nerves, respectively, and the greatest difference in strain between the intended nerve and the other 2 nerves.

METHODS: Strain of the median, radial, and ulnar nerves was measured using buckle-force transducers bilaterally in 10 embalmed human cadavers. Each limb was placed in the currently used test position for the radial (scapular depression, elbow extension, arm internal rotation, and wrist flexion) and ulnar (shoulder depression, abduction and external rotation, elbow flexion, forearm pronation and wrist/finger extension) nerves, as well as variations of these tests. Multiple 1-way analyses of variance with Bonferroni post hoc tests compared the mean strain differences between each position for a given nerve and between the 3 nerves in each position.

RESULTS: The current radial nerve test with shoulder abduction and extension, wrist ulnar deviation and thumb flexion (composite position [radial]) produced significantly greater strain of the radial nerve than the current test alone (*P* < .05) and created the greatest difference in strain between the radial and the other 2 nerves (*P* < .05). The current ulnar nerve test with shoulder horizontal abduction and the composite position (ulnar) (the current test with shoulder horizontal abduction and internal rotation) produced significantly greater strain of the ulnar nerve compared to the current test alone (*P* < .05).

CONCLUSION: The composite position (radial), the current ulnar nerve test with shoulder horizontal abduction, and the composite position (ulnar) are mechanically valid.

IMPLICATIONS: The clinical application of these positions should improve detection of radial or ulnar nerve pathology and allow differentiation between the 3 major nerves of the arm in patients with cervicobrachial pain.

CAN PATIENTS WITH SEVERE TENNIS ELBOW BE DIFFERENTIATED ON THE BASIS OF CERVICAL SPINE PALPATION AND NEURODYNAMIC TESTS?

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PURPOSE: To evaluate cervical palpation and neurodynamic test responses in people with unilateral lateral epicondylalgia (LE) of varying pain and disability.

RELEVANCE: Previous studies have shown beneficial effects of treatment by manual therapy applied to the neck or upper-limb neural tracts, but it is unknown whether cervical joint signs or neurodynamic test responses differ according to severity in individuals with and without LE.

METHODS: A cross-sectional, case-control cohort study was used to evaluate physical examination responses of the cervical spine and radial nerve in 164 patients with unilateral LE and 62 age- and gender-matched healthy control participants. Participants were excluded if they had experienced neck pain that interfered with daily activities, work, or saw a healthcare practitioner. Cluster analysis was used to subgroup the LE participants into mild, moderate, or severe subgroups based on the Patient-Rated Tennis Elbow Evaluation (PRTEE) questionnaire. Physical exam-

ination involved palpation of the cervical and thoracic spines from C4-5 to T1-2, with scoring based on abnormal motion and tissue resistance as well as provocation of pain. Neurodynamic testing of the radial nerve was scored positive if symptoms were reproduced (at least partially) and altered by structural differentiation, as well as there being a side difference in range of motion.

RESULTS: Positive responses to cervical palpation of C5-6 and C6-7 levels were more common in moderate and severe LE ($P < .01$) than an age-matched, healthy control population, whereas mild LE was no different from controls. Severe LE exhibited more frequent positive radial neurodynamic tests (66.7%) than those with mild (23.1%) or moderate (33.7%) severity ($P < .001$).

CONCLUSION: Cervical and radial nerve neurodynamic responses differ in participants with more severe LE.

IMPLICATIONS: Greater prevalence of neck and radial nerve involvement in severe cases of LE may have implications on the physical therapy management plan.

A COMPARISON OF 3-POINT BENDING AND DISPLACEMENT METHODS OF STIFFNESS MEASUREMENTS IN THE LUMBAR SPINE

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PURPOSE: Determine the reliability of and relationship between 3-point bending and displacement methods of lumbar stiffness measurement.

RELEVANCE: Three-point bending and displacement methods of measurement of spinal stiffness are present in the literature without discussion of their relative merits. The 3-point bending method measures the change in angle of sensors placed on L1 and the sacrum, whereas the displacement method measures vertical displacement at the point of force application. This is the first study to compare measurements collected simultaneously using both methods.

METHODS: Twenty-nine subjects (15 asymptomatic and 14 with low back pain) participated. Stiffness was measured simultaneously via 3-point bending (force/angle) and displacement (force/displacement) methods. To compare reliability of the methods, measurements were taken 3 times on 2 occasions, in asymptomatic participants. For symptomatic participants, responsiveness to treatment was assessed by correlating percentage change after both 3 and 6 minutes of treatment.

RESULTS: Within-day ICCs for stiffness were 0.56 to 0.77 (SEM, 0.46%-1.46%), between-day ICCs for stiffness were 0.47 to 0.61 (SEM, 0.72%-1.36%). Correlation analysis on asymptomatic participants demonstrated that there was a significant ($P = .01$) but moderate ($r = 0.64$; 95% CI: 0.20, 0.87) correlation between the 2 methods. On symptomatic participants, the correlation using baseline data revealed dissociation between the 2 methods ($P = .167$, $r = 0.376$). There was dissociation between percentage changes in the 2 stiffness measurement methods after 3 minutes of treatment ($P = .751$, $r = 0.090$); however, there was a significant correlation between the percentage changes after 6 minutes of treatment ($P = .004$, $r = 0.693$).

CONCLUSIONS: Reliability statistics suggest that stiffness measurements are not sufficiently reliable to monitor the changes observed with treatment. The varying relationship between the 2 methods suggests they are not measuring the same behavior, highlighting the need for further investigation into their validity.

IMPLICATIONS: The usefulness of stiffness measurement in assessing response to mobilization treatment warrants further investigation.

MEASURING TOTAL LUMBAR SPINE RANGE OF MOTION THROUGH 2 VARIABLES: A PILOT RELIABILITY STUDY

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PURPOSE: To assess the reliability of a novel approach to describe the total available lumbar spine range of motion (ROM), using 2 variables.

RELEVANCE: Lumbar spine ROM is conventionally described using multiple measures, focusing on the cardinal planes. This is impractical for clinical research, because not all patients present with the same impairments, and these impairments may not be evident with cardinal plane movements.

METHODS: Eleven participants with a recent history of low back pain (LBP) were recruited for 3 testing sessions. In each session, participants performed 3 series of 8 randomly ordered lumbar spine movements (at 45° intervals around the full circle), through the full pain-free ROM. Movements were acquired using a 3-D electromagnetic motion-capture system (TrakSTAR), with sensors at L1 and S1, and measured based on the position of L1 in the transverse plane of S1. For each series of 8 movements, an ellipse (least-squares fit) and a cubic spline were fit to the end-range positions to provide an approximation of the available ROM about the full 360°. The area of these shapes provides a measure of overall ROM, whereas the center point provides a measure of movement distribution/symmetry. Between-session reliability was determined for these 2 variables using the intraclass correlation coefficient (ICC_{3,1}) model.

RESULTS: ICC values were moderate: for ellipse center position, 0.57 and for area, 0.58. For spline center position, 0.64 and for area, 0.57.

CONCLUSION: These results, for both the ellipse and spline fit, do not support the use of this measure in its current form.

IMPLICATIONS: These results may have been influenced by the novelty of the movement patterns, as many subjects displayed movement patterns that deviated from the instructions provided. Future research will focus on improving the reliability of these measures by providing subjects with visual feedback during the movement testing.

INTERPRETING THE ROTATION STRESS TEST FOR THE ALAR LIGAMENTS: WHAT SHOULD BE CONSIDERED NORMAL RANGE?

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PURPOSE: The rotation stress test has been proposed as 1 technique for premanipulative screening for alar ligament disruption. Although authors agree that some rotation will occur during the test, estimates of range of rotation during a normal test are subject to variation, with published opinions ranging between 20° and 40°. No formal evaluation has been undertaken to examine the range of rotation occurring during testing of individuals with intact alar ligaments.

RELEVANCE: Understanding maximum range of rotation achieved during a normal rotation stress test is necessary in order to assess whether a test response is indicative of ligament incompetence.

METHODS: Sixteen individuals underwent MRI in neutral and end-range rotation stress test positions using proton density-weighted sequences in a 3-Tesla system. Rotation stress tests were performed in supine lying within the MRI bore. Measurements made followed a standardized protocol relative to position of the axis in axial section, whereby the foramina transversaria were in alignment, creating a reference plane. The position of the occiput in the head-neutral position was estimated by calculating the angle formed between a line joining the foramina lacerum and the reference plane. Measurements were repeated in the test position. Total rotation of the occiput was calculated as the difference in measured angles between the neutral and test positions. The procedure was repeated and measurements recorded on 4 separate occasions. Reliability of measurements for each image was assessed by estimation of ICCs.

RESULTS: Rotation of the occiput relative to a stabilized axis ranged between 1.7° and 21.5°. The mean \pm SD range of rotation calculated was 10.6° \pm 5.1°. Reliability of measurements ranged from 0.75 to 0.96.

CONCLUSIONS: Normal range of rotation occurring during this alar liga-

ment test tends toward the lower end of previously reported estimates.
IMPLICATIONS: Interpretation of this test based on range should be more conservatively judged than previously indicated.

THE ANTERIOR SHEAR AND DISTRACTION TESTS FOR CRANIOCERVICAL LIGAMENT INSTABILITY: AN ASSESSMENT OF CONSTRUCT VALIDITY

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PURPOSE: Premanipulative screening for craniocervical ligament integrity has been advocated prior to the treatment of the upper cervical spine. Neither the anterior shear test for the transverse ligament nor the distraction test for the tectorial membrane have been subject to validation. This study sought to examine the direct effect of these clinical tests on these ligaments in a normal population.

RELEVANCE: Exploration of construct validity provides a first step in the validation process by assessing whether the tests are capable of influencing the target ligaments.

METHODS: Sixteen skeletally mature individuals underwent MRI in neutral and end-range test positions using proton density-weighted sequences in a 3-Tesla system. All ligament tests were performed in supine lying within the MRI bore. The anterior shear test was assessed using changes in atlantodental interval and distance from the anterior arch of the atlas to the posterior aspect of the odontoid process. Distraction testing for the tectorial membrane was assessed by changes in basion-dental interval and by direct measurement of the tectorial membrane. Differences were compared using the Wilcoxon signed-rank test or paired *t* test. Reliability of measurements for each image was assessed by estimation of ICCs.

RESULTS: Anterior shear testing resulted in a 0.41-mm mean increase in atlantodental interval ($P = .03$) and a 0.35-mm mean increase in axial plane distance ($P = .05$). Distraction testing for the tectorial membrane resulted in a 0.64-mm increase in basion-dental interval ($P < .01$) and a 1.11-mm increase in direct ligament-length measurement ($P = .02$). Reliability of measurements ranged from 0.74 to 0.99.

CONCLUSIONS: The screening tests examined produced a direct effect on the transverse ligament and the tectorial membrane consistent with their theorized clinical mechanism.

IMPLICATIONS: This is the first study to demonstrate a direct effect of these screening tests on the transverse ligament and tectorial membrane, providing support for their construct validity.

RISK FACTORS AND CLINICAL FEATURES OF CRANIOCERVICAL ARTERIAL DISSECTION: PRELIMINARY RESULTS OF A PROSPECTIVE STUDY

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PURPOSE: To identify risk factors, examine the preceding events, and describe the presenting clinical features of craniocervical arterial dissection in order to assist clinicians to more readily detect patients at risk of or experiencing this serious condition.

RELEVANCE: Craniocervical arterial dissection is a common cause of ischemic stroke in young people, and has in rare cases been associated with neck manipulation. The mechanism is considered to involve pre-existing arterial susceptibility and a precipitating event such as minor trauma. Identification of individuals at risk or early recognition of a dissection in progress could help expedite medical intervention and avoid inappropriate treatment.

METHODS: Prospective case-control design. Participants were patients aged 55 years or younger from the Hunter region of New South Wales, Australia, with vertebral or internal carotid artery dissection. Participants were interviewed about risk factors, preceding events, and clinical features of their stroke. Connective tissue clinical examination was undertaken.

RESULTS: Thirteen dissection participants (54% vertebral artery) with a mean age of 43 years have entered the study thus far. Seventy-seven percent ($n = 10$) of participants reported recent minor mechanical head or neck trauma, with 30% ($n = 3$) reporting neck manipulation. Fifty percent ($n = 3$) of internal carotid artery dissection participants reported recent infection. Thirty-eight percent ($n = 5$) of participants were smokers, and 15% ($n = 2$) had hypertension. No evidence of connective tissue disorder was identified clinically. Ninety-two percent ($n = 12$) of participants reported headache, the intensity described as severe by 50% ($n = 6$). Sixty-nine percent ($n = 9$) of participants reported transient neurological symptoms (imbalance, speech and visual disturbance) within the month preceding their stroke.

CONCLUSIONS: Preliminary results suggest that recent mechanical head or neck trauma and infection may be associated with dissection. Preceding transient neurological symptoms commonly occur.

IMPLICATIONS: Clinicians should be alert to possible symptoms of transient neurological dysfunction, particularly in headache or neck pain patients reporting head or neck trauma.

THE EFFECT OF SELECTED MANUAL THERAPY INTERVENTIONS FOR MECHANICAL NECK PAIN ON VERTEBRAL AND INTERNAL CAROTID ARTERIAL BLOOD FLOW AND TOTAL CEREBRAL PERFUSION

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PURPOSE: To examine the effects of selected manual therapeutic interventions on blood flow in the craniocervical arteries and total blood supply to the brain using magnetic resonance imaging (MRI).

RELEVANCE: Manual therapy of the cervical spine has occasionally been associated with serious adverse events involving compromise of the craniocervical arteries. Some ultrasound studies have shown that certain neck movements can alter craniocervical arterial blood flow velocities; however, findings are conflicting. Knowledge about the effects of particular neck positions on blood flow may assist clinicians to avoid potentially hazardous practices. MRI provides a more accurate method of simultaneous craniocervical arterial flow measurement.

METHODS: Healthy adult participants were imaged using MRI in the following cervical spine positions: neutral, rotation, rotation and distraction (similar to a Cyriax manipulation), C1-C2 rotation (similar to a Maitland or osteopathic localized C1-C2 rotation manipulation), and distraction/traction. Two-dimensional time of flight angiography and flow quantification measures were recorded for each position.

RESULTS: Twenty healthy participants with a mean age of 33.5 years were imaged using 3-T MRI. All participants had normal vascular anatomy, 50% having a dominant left vertebral artery. Average inflow to the brain in neutral was 5.84 mL/s and was not significantly changed by any of the test positions. There was no significant difference in flow in any of the 4 arteries between the 2 manipulation positions (Maitland localized C1-C2 rotation and Cyriax rotation/distraction) and distraction, despite large individual variations. Distraction tended to slightly reduce flow in the internal carotid arteries (4%-6%) and increase it in the vertebral arteries (46%-69%).

CONCLUSIONS: Blood flow to the brain does not appear to be compromised by typical positions used in manual therapy in the presence of an intact cerebral circulation.

IMPLICATIONS: Techniques using neck rotation and distraction do not appear to be more hazardous to cerebral circulation than more localized techniques.

DYNAMIC STABILITY OF THE LUMBAR SPINE DURING THE SIT-TO-STAND MOVEMENT TASK

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PURPOSE: To describe the performance of the stabilizing system of the lumbar spine during repeated sit-to-stand trials.

RELEVANCE: Performance, as measured from the deviation from a planned movement trajectory, reflects the accuracy and precision of motor control, and may be a relevant factor in low back pain (LBP).

METHODS: A 29-year-old male with a history of recurrent LBP performed 8 sit-to-stand repetitions as rapidly as possible. Electromagnetic motion sensors were placed over the spinous processes of S1, L4, L2, and T12. Surface reaction forces were acquired at the seat and under the feet, and were used to subdivide the movement pattern into sit-to-stand (up) and stand-to-sit (down) phases. An expanding-window singular value decomposition (SVD) was used to analyze the data. Eigenvalues for each resulting eigenvector reflect the variance in the original data set. The effect of adding data from an additional trial was assessed by comparing the cumulative variance explained by each eigenvector across the trials.

RESULTS: More than 99% of the variance in lumbar spine motion data was explained by 3 eigenvectors, reflecting a highly coordinated movement pattern. The variance explained by the first eigenvector, however, differed substantially as data for additional trials were added. One notable change was a general drop in the variance explained by the first eigenvector at the transition from the up to the down phase of the movement, reflecting a brief decrease in the performance of the system at this transition point.

CONCLUSIONS: These data indicate variable performance of the spine-stabilizing system at different phases of the sit-to-stand movement, suggesting that the challenge to spine stability differs over the course of this functional task.

IMPLICATIONS: This insight into the performance of the stabilizing system of the spine may be useful for the assessment of movement dysfunction in LBP and other clinical pathologies.

RESPONSES TO ACTIVE STRAIGHT LEG RAISE TEST IN PREGNANCY ARE ASSOCIATED WITH SERUM LEVELS OF RELAXIN IN PREGNANCY

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PURPOSE: To investigate whether symptoms and responses to clinical tests for pelvic girdle pain (PGP) are associated with serum relaxin levels in pregnancy, and to examine if relaxin level is a risk factor for disability or pain postpartum.

RELEVANCE: There is a common belief that the laxity of pelvic joints increases in pregnancy. The hormone relaxin is suggested to be one of the most influential factors implementing this effect. Furthermore, increased laxity is assumed to induce PGP.

METHODS: Data from clinical tests and blood samples were collected once in pregnancy (gestation weeks 5-24) from 212 women. Self-reported disability and pain were assessed by the Disability Rating Index (DRI) and pain intensity (VAS) in pregnancy and 12 weeks postpartum. Serum from blood samples was analyzed by ELIZA to determine the concentration of relaxin. Clinical examinations included the active straight leg raise (ASLR) test and pain provocation tests. An ANOVA was used to assess the effect of gestation age and multivariable statistics to examine the association between relaxin levels and the symptoms or responses to clinical tests.

RESULTS: The serum levels of relaxin varied widely between individuals and were only marginally influenced by the gestation age. Serum concentration of relaxin showed a significant association with positive score on the ASLR test ($P = .025$), but no significant associations with responses to pain provocation tests, pain intensity, or DRI. Serum levels of relaxin were not associated with pain or disability 12 weeks postpartum ($P > .30$).

CONCLUSIONS: The results indicate that relaxin contributes to laxity of pelvic joints in pregnancy. Yet, no evidence of relaxin having an impact on symptoms or perceived disability was found, neither during pregnancy

nor 12 weeks postpartum.

IMPLICATIONS: The results can contribute in the process of understanding PGP. More research is necessary to further explore the association between joint laxity and pain.

TRUNK MUSCLE ACTIVITY IN LOW BACK PAIN SUBGROUPS

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PURPOSE: Does trunk activity differ between LBP subgroups and do these muscle profiles match biomechanical rationales?

RELEVANCE: The relationship between subgrouping theory and potential changes of muscle activity may reveal if a biomechanical rationale serves treatment decision making.

METHODS: One hundred two LBP patients underwent an examination for subgrouping using treatment-based classification (TBC) and movement-system impairment (MSI) schemes. Ultrasound images of lumbar multifidus (LM; L4-S1), transversus abdominis (TrA), and obliquus internus abdominis (OI) muscles were captured during prone and crook-lying leg raise. Percentage muscle thickness change ($\% \delta$) was compared (t tests) between TBC stabilization and "nonstabilization" and between MSI flexion-directed (Flx) and extension-directed (Ext) subgroups. LM activity in subgroups was compared with previous data from controls ($n = 10$). Trunk muscle profiles were also subdivided by the mean into higher and lower activity.

RESULTS: LM/TrA/OI muscle activity did not differ between TBC and MSI subgroups. For TBC stabilization (treatment aimed to increase trunk activity), $\% \delta$ was below the mean in 41% to 47% (LM L4-S1) and 55% to 62% (TrA/OI) of cases. For MSI Flx (decreased posterior/increased anterolateral activity), LM was below the mean in 41% to 45% of cases and TrA/OI was above the mean in 35%. For MSI Ext (increased posterior/decreased anterolateral activity), 51% to 58% (LM L5-S1:L4-5) were above the mean and 56% to 63% (TrA/OI) were below. LM activity did not differ between controls and TBC stabilization, or MSI Flx or Ext, but there was a nonsignificant tendency for greater LM $\% \delta$ in all LBP subgroups.

CONCLUSIONS: Trunk muscle profiles varied within subgroups. Trends for reduced TrA/OI activity for TBC stabilization and increased LM/decreased TrA/OI activity for MSI Ext are in line with biomechanical rationales for proposed interventions.

IMPLICATIONS: Activation of deeper trunk muscles was not specific to LBP subgroups. Changes cannot be predicted from allocation to a subgroup and require separate assessment.

EFFECTS OF VARIOUS PROPRIOCEPTIVE DISTURBANCES ON THE REPOSITIONING SENSE OF THE LOWER SPINE DURING ACTIVE TRUNK FORWARD BENDING

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PURPOSE: Study the ability to influence the proprioception of the lower spine with external stimuli during a repositioning error (RE) task in active trunk motion within healthy and NSCLBP subjects. Compare the accuracy of the spine reposition sense between both groups.

RELEVANCE: Postural and motor control disorders are regularly present in NSCLBP patients; the hypothetical underlying mechanism could be a deficit of proprioception of the spine.

METHODS: Forty subjects were enrolled in the experiment, 30 in the healthy group and 10 in the NSCLBP group. Every subject underwent 4 different proprioceptive stimuli during the trunk forward-bending RE motor task from a standardized sitting position. To compare accuracy of RE, 10 healthy subjects were matched with the NSCLBP group. The RE was measured with a kinematic 3-D camera track system (Elite-BTS) at 30° of target position during 10 trials. The first motor task was executed without any disturbance and the 4 were performed with 4 stimuli inputs, as electrostimulations, vibrations, taping, and unstable sitting surface.

RESULTS: Within-healthy group comparison showed significantly al-

tered RE measurement for 3 of 4 proprioceptive inputs. The 4 input disturbances had almost no significant effects on RE assessments in the NSCLBP group. Between-group comparison showed that NSCLBP patients had larger significant RE for 3 RE tasks.

CONCLUSION: Proprioceptive disturbances had the greatest effects on the repositioning sense of the lower spine in the healthy group, creating significant increases of RE. In the NSCLBP group, almost all stimuli seemed to have effects on RE. Comparison between groups confirmed the literature's evidence that NSCLBP patients had larger RE.

IMPLICATIONS: The interest of management in a subgroup of NSCLBP with specific motor control exercises in reducing amplitude of training is supported. This outcome measure could be used in future clinical trials to evaluate the efficacy of manual therapy management on a proprioceptive system.

MOVEMENT CONTROL OF THE BACK IS IMPAIRED IN PATIENTS WITH PAIN IN OTHER BODY REGIONS

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PURPOSE: A movement control test battery was developed to evaluate lumbar movement control ability. Movement control is disturbed by patients with LBP. However, does pain elsewhere in the body also disturb lumbar movement control ability?

RELEVANCE: There is preliminary evidence that pain itself causes disturbances in different regions of the brain. To test this hypothesis, a cross-sectional study was conducted to compare lumbar movement control in patients with pain in the neck or upper extremity but without pain in the back and healthy controls. Lumbar movement control was evaluated in 52 subjects without LBP but with elbow, shoulder, or neck pain. Results were compared with those in 68 healthy controls. All persons performed a test battery that has been shown to be reliable.

METHODS: A case-control study was conducted. Using a set of 6 tests, physiotherapists tested the ability of the subjects to control their movements in the lumbar spine. We observed the number of positive tests out of 6. We used the nonparametric Mann-Whitney *U* test for the between-group comparison and computed between-groups effect sizes.

RESULTS: The analysis revealed that the subjects with pain elsewhere but not in the back had significantly ($P < .01$) more positive tests than healthy controls (mean tests positive, 1.45; 95% CI: 1.16, 1.76; healthy controls: mean, 0.78; 95% CI: 0.52, 1.04; ES, 0.92).

CONCLUSIONS: The findings are in line with earlier studies that have shown disturbances in higher cortical-level control, such as in postural balance, fine coordination, or recognizing the affected body part. Musculoskeletal pain seems to generally disturb brain areas responsible for body awareness and movement control. Future studies further testing this hypothesis are warranted.

IMPLICATIONS: Pain in a body part also disturbs movement control elsewhere in the body. This study illustrates the contributing role of central nervous system changes, predominantly in the brain, in patients with musculoskeletal pain.

ELECTROMYOGRAPHIC FATIGUE CHARACTERISTICS AND MUSCLE RECRUITMENT PATTERNS DURING TRUNK ENDURANCE TESTS IN HEALTHY SUBJECTS

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PURPOSE: To investigate the effect of age and gender on the duration, fatigue, and muscle recruitment patterns in 2 trunk endurance tests.

RELEVANCE: Although endurance tests are frequently used in healthy individuals and patients with low back pain, most research was only conducted

ed on young men.

METHODS: Ninety-nine healthy subjects (equal distribution of men and women in the different age categories of 20–65 years) performed an abdominal endurance test in an unsupported, straight-knee sitting position, with the trunk held at a 45° angle and a modified Biering-Sorensen back muscle endurance test. Surface electromyographic signals of 2 abdominal (internal and external obliques [IO and EO]) and 2 back muscles (lumbar multifidus [MF] and the thoracic part of iliocostalis lumborum [ICLT]) were recorded.

RESULTS: Age group was not a significant factor. The duration of the back muscle endurance test was significantly larger in women (193.20 ± 60.51 seconds) than in men (152.70 ± 49.79 seconds), and the abdominal muscle endurance test duration (126.10 ± 65.94 seconds) was not significantly different between genders. The slope normalized to the intercept (SlopeN) of the MF was significantly larger than the SlopeN of the ICLT, and no significant difference was found between the SlopeN of the IO and EO. The ratio of relative local to global back (MF/ICLT) and abdominal (IO/EO) muscle activity amplitudes was 1.18 ± 0.25 and 1.05 ± 0.37 , respectively.

CONCLUSIONS: Although both men and women seem to use similar muscle recruitment strategies, with focus on the local, more distally located trunk muscles, women hold the back endurance test position longer than men.

IMPLICATIONS: The mean endurance times can easily be memorized and applied in clinical practice stopwatch tests. Focus on local trunk muscles can be achieved in these exercises. Further research on specific differences between the individual muscles and exploring the gender differences is recommended.

RELIABILITY OF MOVEMENT CONTROL TESTS IN THE CERVICAL SPINE

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PURPOSE: The aim of this study was to determine the interrater reliability of movement control dysfunction tests of the cervical spine.

RELEVANCE: Movement control dysfunction (MCD) reduces active control of movements. Patients with MCD might form an important subgroup among patients with mechanical cervical pain. The diagnosis is based on the observation of active movements. Although widely used clinically, only a few studies have been performed to determine the test reliability.

METHODS: Forty-five patients were filmed while performing a standardized test battery consisting of 20 active movement tests for motor control in 30 patients with mechanical neck pain and 15 subjects without neck problems. Two experienced physiotherapists independently rated test performances as correct or incorrect per observation. One of them was blinded to all other patient information and both to each other. The study was conducted in a private physiotherapy outpatient practice in the German-speaking part of Switzerland. Kappa coefficients for interrater results were calculated.

RESULTS: The kappa values for interrater reliability ranged between 0.23 and 1.0. Of the 20 tests, 3 had perfect ($\kappa = 1.0$), 4 almost perfect ($\kappa = 0.81-0.99$), 10 substantial ($\kappa = 0.61-0.80$), 2 moderate ($\kappa = 0.41-0.60$), and 1 fair ($\kappa = 0.21-0.40$) reliability.

CONCLUSIONS: The physiotherapists were able to reliably rate most of the tests in this series of motor control tasks as being performed correctly or not, by viewing films of patients with and without neck pain performing the task.

IMPLICATIONS: Until now, there are a few studies that describe the treatment of movement control impairment problems. In contrast, only some studies involve the assessment of this subgroup of cervical dysfunction. The results of this study should help to perform the objective examination more specifically and to identify MCD earlier.

TRUNK-HEAD COORDINATION IN NECK PAIN SUBJECTS

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PURPOSE: This study investigated trunk-head coordination ability in subjects with neck pain compared to asymptomatic controls.

RELEVANCE: Decreased neck motion and sensorimotor deficits such as altered neck movement and position sense and eye-head coordination have been identified in those with neck pain. It is thought that these might be related to altered reflex mechanisms between the neck, eyes, and the vestibular system. Trunk-head coordination might also be altered in neck pain.

METHODS: Twenty-four subjects with neck pain and 26 age- and gender-matched healthy control subjects. Wireless motion sensors positioned over the sternum and the forehead were used to measure trunk and head range of motion and velocity during 2 trunk movements: (1) alternate trunk movement to the left and right while trying to keep the head still (trunk LR), and (2) trunk movement to either the left or right while attempting to keep the head still (trunk HS). A generalized linear model was used to compare trunk and head range of motion and velocity during the 2 tasks. The mean of 3 trials in trunk LR and 6 trials (3 left and 3 right) for trunk HS were used.

RESULTS: Neck pain subjects had significantly less trunk movement ($P < .05$) and velocity ($P < .02$) as well as significantly increased head movement ($P < .03$) during both tasks when compared to control subjects.

DISCUSSION: The results of the study suggest that neck pain subjects have difficulty moving their trunk independently of their head. They are less able to keep the head still while moving the trunk, limit the range of motion of the trunk, and perform the tasks more slowly. These findings might be related to altered activity of the cervicocollic reflex and sensorimotor control disturbances in neck pain. Further research is required.

INTEROBSERVER RELIABILITY OF HEAD AND EYE MOVEMENT CONTROL TESTS

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PURPOSE: The aim of this study was to determine the interobserver reliability of observing head-eye movement control dysfunction in patients with neck pain and healthy controls.

RELEVANCE: Head-eye control dysfunction is a typical problem in patients with neck pain. Diagnosis is based on the observation of active movements. No studies have been performed to determine test reliability.

METHODS: The study was conducted in 2 private physiotherapy outpatient practices in Switzerland. Informed consent was obtained from all participants. We videotaped 23 patients with mechanical neck pain and 19 healthy subjects performing a standardized test battery consisting of 10 active movement tests for head-eye control. Tests included gaze stability, sequential head and eye movements, adapted smooth pursuit torsion tests, and isolated eye movements. All tasks were performed in sitting and standing with feet closed. Two experienced musculoskeletal physiotherapists blinded to all other patient information and to each other independently rated videotaped test performances as correct, lightly positive, or clearly positive. Weighted kappa coefficients and 95% CIs were calculated. Acceptable reliability was defined as kappa greater than 0.6 with the lower boundary of the 95% CI greater than 0.4.

RESULTS: Weighted kappa values for interobserver reliability ranged between 0.54 and 0.86. Three tests showed almost perfect ($\kappa > 0.8$), 5 substantial ($\kappa = 0.6-0.8$), and 2 moderate ($\kappa = 0.4-0.6$) reliability. As in 2 tests the lower bound of the 95% CI was kappa less than 0.4, 8 of the 10 tests had substantial reliability.

CONCLUSIONS: Physiotherapists are able to reliably rate 8 of 10 evaluat-

ed tests for head-eye movement control in sitting and standing in subjects with and without neck pain. Further research should evaluate validity to distinguish healthy persons and patients, test-retest stability, and responsiveness.

MULTIMODAL PHYSIOTHERAPY IN THE TREATMENT OF INDIVIDUALS WITH PERSISTENT SYMPTOMS FOLLOWING A SPORT-RELATED CONCUSSION: A RANDOMIZED CONTROLLED TRIAL

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PURPOSE: The purpose of this study was to determine if a combination of cervical and vestibular physiotherapy is an effective treatment for individuals with persistent symptoms of dizziness, neck pain, and headaches following a sport-related concussion (SRC).

RELEVANCE: Concussion is a commonly occurring injury in sport. Many individuals are left with persistent symptoms. Physiotherapy treatment may facilitate recovery in individuals who have suffered an SRC and have persistent symptoms.

METHODS: Thirty-one patients between the ages of 12 and 30 who attended the University of Calgary Sport Medicine Centre for a sport-related concussion and had persistent symptoms of dizziness, neck pain, and/or headaches were randomly allocated to a treatment group (ie, multimodal physiotherapy including vestibular rehabilitation, manual therapy, neuromotor and sensorimotor retraining exercises) or a control group (ie, rest followed by gradual exertion as per International Consensus on Sport Concussion). Participants in both groups were seen by the study physiotherapist once weekly for 8 weeks or until the time of medical clearance. A sport medicine physician who was blinded to treatment group determined time to medical clearance. The Fisher exact test and a Kaplan-Meier survival curve were used to evaluate the effect of treatment.

RESULTS: One of 14 subjects (7.1%) in the control group and 11 of 15 subjects (73.3%) in the treatment group were medically cleared to return to sport at 8 weeks ($P < .001$). Groups were similar at baseline. Two individuals in the control group were lost to follow-up.

CONCLUSIONS: Multimodal physiotherapy treatment decreased the time to medical clearance to return to play when compared with rest in individuals with persistent symptoms following an SRC.

IMPLICATIONS: Physiotherapy treatment should be considered in individuals with persistent symptoms of dizziness, neck pain, and/or headaches following a sport-related concussion.

CHARACTERISTICS OF VISUAL DISTURBANCES REPORTED BY SUBJECTS WITH NECK PAIN

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PURPOSE: This study aimed to report the characteristics of visual disturbances reported by subjects with idiopathic neck pain and whiplash compared to healthy individuals.

RELEVANCE: Visual symptoms along with the complaint of dizziness and unsteadiness are often reported by patients with neck pain. To date, limited research has been conducted to determine the most common types of visual complaints associated with neck pain.

METHODS: Fifty subjects with neck pain and 70 healthy control subjects. Participants answered questions about the presence, frequency, and severity of 18 visual symptoms that have been noted to be associated with neck pain and/or in those with disordered vision. Descriptive statistics were used to compare the visual symptoms reported by each group. A visual symptom index (VSI; out of 216) was generated from the sum of the product of the frequency (0-4) and severity (0-3) rating for each of 18 symptoms, and a *t* test was used to compare the groups.

RESULTS: Neck pain subjects had significantly greater VSI frequency and severity of visual complaints (mean, 38.32) compared to control subjects

(mean, 8.3). The most frequently reported symptoms were headache, decreased concentration, need to concentrate to read, and sensitivity to light. The least common were double vision, spots in eyes, and red eyes. The most troublesome symptoms were headache, decreased concentration, visual fatigue, need to concentrate to read, difficulty judging distances, and sensitivity to light, whereas the least troublesome were double vision, red eyes, spots, and words moving.

DISCUSSION: Characteristics of the visual symptoms were mostly consistent for those reported for a cervical cause of the symptoms. These symptoms might be related to eye movement control disturbances in neck pain, and further research is required.

USING THE CROM TO ASSESS HEAD REPOSITIONING ACCURACY IN INDIVIDUALS WITH CERVICAL DISC DISEASE IN COMPARISON TO REFERENCE VALUES IN NECK-HEALTHY INDIVIDUALS

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PURPOSE: To assess head repositioning accuracy (HRA) with the cervical-range-of-motion device (CROM) in individuals with cervical disc disease (CDD) in comparison to reference values in neck-healthy individuals, but also to report reliability of the CROM in individuals with CDD and in relation to the gold standard laser pointer in neck-healthy individuals.

RELEVANCE: Assessment of HRA is recommended in the management of individuals with neck disorders but has not previously been studied in individuals with CDD. Today, there is no agreement on the best method. The CROM presents many advantages, although its reliability in relation to the laser pointer has not previously been reported, and reference values in neck-healthy individuals are lacking.

METHODS: HRA in 71 individuals with CDD was compared to reference values obtained from 173 neck-healthy individuals. Reliability was estimated with ICC and SEM, for the CROM in individuals with CDD, and between the CROM and the laser pointer in neck-healthy individuals.

RESULTS: There was a significant difference between individuals with CDD and reference values for both rotation sides ($P < .004$); 31% of individuals with CDD were classified with impairment in HRA. Test-retest reliability of the CROM in individuals with CDD was substantial to almost perfect (ICC = 0.79-0.85; SEM, 1.4°-2°). Reliability between the CROM and the laser pointer in neck-healthy individuals was variable, from moderate to almost perfect (ICC = 0.43-0.91; SEM, 0.8°-1.3°).

CONCLUSIONS: Impairment in HRA was identified with the CROM in individuals with CDD and could be important to consider in rehabilitation.

IMPLICATIONS: Impairment in HRA could reflect disturbances in sensorimotor function in individuals with CDD.

THE INFLUENCE OF NECK PAIN ON SENSORIMOTOR FUNCTION IN THE ELDERLY

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OBJECTIVE: To investigate the influence of neck pain on sensorimotor function in elders.

BACKGROUND: Sensorimotor disturbances have been substantially demonstrated in younger to middle-aged groups with both idiopathic and whip-lash-induced neck pain. However, a comprehensive range of sensorimotor functions is yet to be investigated specifically in the elderly with neck pain.

METHODS: Cross-sectional design. Twenty elders with neck pain (12 wom-

en and 8 men) and 20 healthy elder controls (14 women and 6 men) aged 65 years and older were recruited from the general community. Tests for sensorimotor function included cervical joint position sense (JPS), computerized rod-and-frame test (RFT), smooth pursuit neck torsion test (SPNT), standing balance (under conditions of eyes open, eyes closed on firm and soft surfaces in comfortable stance), step test, and 10-m walk test with and without head movement.

RESULTS: Elders with neck pain had greater deficits in the majority of sensorimotor function tests after controlling for effects of age and comorbidities. Significant differences were found in the SPNT ($P < .01$), error in the RFT (frame angled at 10° and 15° counterclockwise; $P < .05$), standing balance (amplitude of sway): eyes open on a firm surface in the ML direction ($P = .03$), and total number of steps on the step test, both left and right sides ($P < .01$). There was also a tendency for increased amplitude of sway with eyes open and closed on a firm surface in the AP direction ($P = .07$). No significant differences were found in JPS and gait parameters.

CONCLUSION AND IMPLICATIONS: Elders with neck pain have greater sensorimotor disturbances than elders without neck pain, supporting a contribution of altered afferent information originating from the cervical spine to such disturbances. The findings may inform fall prevention and management programs.

COMPUTER-BASED ASSESSMENT AND TREATMENT OF CERVICOCEPHALIC KINESTHETIC SENSIBILITY

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PURPOSE: To demonstrate audiovisually how 2 clinically important aspects of cervicocephalic kinesthesia, sensitivity for positions, and sensitivity for movements can be documented and treated in clinical practice.

RELEVANCE: Subtle sensorimotor impairments, like cervical position sense and cervical movement sense, cannot be detected or fully treated by hands-on approaches.

DESCRIPTION: The laser pointer can be substituted by more reliable and valid computerized methods. A 3-D wireless orientation sensor is mounted on the patient's head and connected to specially written software programs with a standard Bluetooth interface.

EVALUATION: Research indicates that the relocation to the normal head position and to follow an unpredictable moving object on the computer screen by moving the head/neck as accurately as possible are the most appropriate clinical tests for deficits of cervical position sense and cervical movement sense, respectively.

CONCLUSION: The observed individuality in sensorimotor disturbances in patients with neck pain disorders emphasizes the importance of developing specific rehabilitation programs for specific dysfunctions, and of using objective and quantitative methods for evaluation of rehabilitation.

IMPLICATIONS: Conventional physical therapy/manual therapy approaches may be sufficient only for patients with neck pain and minimal sensorimotor disturbances. Clinical experience and research indicate that significant sensorimotor disturbances might be an important factor in the maintenance, recurrence, or progression of various symptoms in patients with neck pain. In these cases, additional new assessment and treatment methods are needed to avert the course of chronicity.

PRAGMATIC APPLICATION OF LOGIC AND THE SCIENTIFIC METHOD TO CLINICAL REASONING EXPOSES SOME AVOIDABLE TRAPS FOR YOUNG AND OLD PLAYERS

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PURPOSE: To explore the rationale and underlying reasoning associated with some clinical decision making.

RELEVANCE: Common clinical reasoning practices can lead to unsubstantiated conclusions through flaws in logic or the application of evidence.

Clinical examples will be presented and methods discussed that can be incorporated in everyday practice to improve the integrity of the reasoning process.

DESCRIPTION: Examples of reasoning processes used in clinical decision making will be used as illustrations of the underlying processes. (1) A patient with neck pain has improvement in the most limited range of motion following mobilization to C6; therefore, mobilization to C6 should be continued. (2) Patients with chronic back pain have altered patterns of muscular activity; therefore, treatment should target improving patterns of muscular activity. (3) Patients with neck pain improve with thoracic spine manipulation and there are minimal risks associated with thoracic manipulation; therefore, patients with neck pain should receive thoracic manipulation. (4) Patients with back pain get greater improvement with exercise and manual therapy combined than when receiving either individually; therefore, patients with back pain should receive both treatments.

EVALUATION: The above propositions will be evaluated by the application of logic, the scientific method, statistical inference, and principles of evidence-informed practice. Methods of overcoming questionable reasoning processes will be presented, including (1) rigorous interpretation of evidence from the literature; (2) application of all 3 pillars of evidence-informed practice, including clinical expertise and patient values/preferences; and (3) structuring assessment and reassessment to reduce the risk of bias.

CONCLUSIONS: Many common clinical reasoning practices are potentially unreliable. Flawed or incomplete reasoning does not necessarily mean that interpretations are wrong, rather that the interpretations are not necessarily right.

IMPLICATIONS: Robust clinical reasoning processes combined with small changes in clinical practice could improve our ability to be confident in the accuracy of clinical judgments.

CORRELATIONS BETWEEN CHANGES IN PATHOANATOMICAL MRI FINDINGS AND CHANGES IN PAIN WITH A BOUT OF FLEXION EXERCISES IN PERSONS WITH LOW BACK PAIN

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PURPOSE: To determine the correlations between normalized changes in lumbar MRI findings and low back pain (LBP) changes with a bout of flexion exercises.

RELEVANCE: Canal or foramen stenosis and disc herniations have been associated with LBP. Flexion exercises are used to treat LBP, but it is unclear if pathoanatomical changes explain pain improvements. Flexion can modify pathoanatomical finding dimensions but may not have the same effect depending on patient size.

METHODS: Fifty-eight volunteers with LBP, aged 18 to 65 years and with an Oswestry score greater than 20%, completed a 4-week repeated flexion-exercise program. At baseline, lumbar MRI (T12-S1) and pain ratings were obtained in the neutral supine position immediately before and after performing flexion exercises. Most patients did 30 repetitions of flexion-in-lying exercises. Lumbar vertebrae cross-lengths and canal diameter were digitized on midsagittal images. Disc perimeters, lateral foramen diameters, and canal area were digitized on midsagittal axial images. Normalizing consisted of dividing the absolute measurements by total vertebra cross-lengths to account for subject size. Pearson correlation coefficients were used.

RESULTS: Five of 60 correlations involving nonnormalized measures of MRI changes were statistically significant compared to 6 of 60 correlations involving normalized MRI changes. Significant correlations were small ($r = 0.29-0.39$ for absolute measures and $r = 0.24-0.31$ for normalized measures). Pain improved with decreases in disc perimeter (L3-L4 normalized) and increases in canal area (L2-L3 and L5-S1). Surprisingly, pain improved with decreases in canal diameter (L1-L2 absolute and normalized) and decreases in lateral foramen diameter (pain dominant:

T12-L1, absolute; L4-L5, normalized; nondominant: L1-L2, normalized; L4-L5, absolute).

CONCLUSION: Correlations between changes in MRI findings and pain responses with flexion exercises weren't significantly larger using normalized changes in MRI measures compared to absolute measurements.

IMPLICATION: Using different MRI findings, normalizing methods, or using multivariable analysis may help better explain changes in pain with flexion exercises.

MANUAL THERAPY FOR LOW BACK PAIN: THE PATIENT'S PERSPECTIVE

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PURPOSE: To explore patient perspectives of a specific manual therapy treatment program for patients with subacute low back pain considered to be of lumbar zygapophyseal joint origin.

RELEVANCE: Manual therapy is a common treatment for low back pain. To date, much of the manual therapy research has used quantitative designs. Given the multifactorial and complex nature of low back pain, investigation using qualitative methods may provide valuable insight into patient perceptions of manual therapy and its effects.

METHODS: A specific manual therapy program was developed that primarily targeted the symptomatic lumbar zygapophyseal joints. The program also included the provision of pathoanatomical information relevant to lumbar zygapophyseal dysfunction, strategies for managing pain, inflammation, sleep disturbance, and psychosocial barriers to recovery, as well as specific motor control retraining exercises. Participants in a randomized controlled trial who undertook this program underwent a semi-structured interview. Two researchers independently coded interview data using qualitative data-analysis software and thematically analyzed the results.

RESULTS: Twenty participants were interviewed (7 men, 13 women), with a mean \pm SD age of 43 ± 13 years and a mean \pm SD duration of LBP symptoms of 16 ± 6 weeks. Participants reported improvements in their condition that included reduced pain, return to activity, improved knowledge, and increased confidence. Some participants reported negative experiences, including posttreatment soreness, but for most, these were discussed in the context of an overall positive experience. Participants placed particular importance on individual aspects of the program, including the manual therapy, exercise, information, and their experience with the physiotherapist.

CONCLUSIONS: Participants with persistent LBP considered to be of lumbar zygapophyseal joint origin identified a range of perceived improvements after participating in a specific manual therapy program.

IMPLICATIONS: A specific manual therapy program may be a suitable treatment option for patients with persistent LBP of lumbar zygapophyseal joint origin.

THE EFFECT OF EMOTIONAL DISTRESS ON PERSISTENT PELVIC GIRDLE PAIN AFTER DELIVERY: A LONGITUDINAL POPULATION STUDY

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PURPOSE: To study the association between presence of emotional distress during pregnancy and pelvic girdle syndrome (pain in the anterior pelvis and in the posterior pelvis bilaterally) 6 months postpartum.

RELEVANCE: The direction of the association between emotional distress and persistent pain is debated; therefore, longitudinal studies are needed.

METHODS: This population follow-up study included 41,421 women in the Norwegian Mother and Child Cohort Study who reported pelvic girdle pain at pregnancy week 30 during the years 1999 to 2008. Data were ob-

tained by self-administered questionnaires in pregnancy weeks 17 and 30, and 6 months postpartum.

RESULTS: Six months postpartum, 78.0% of the women had recovered, 18.5% reported persistent pain in 1 to 2 pelvic locations, 3.0% reported pelvic girdle syndrome, and 0.5% reported severe pelvic girdle syndrome. Being emotionally distressed at 2 time points during pregnancy was associated with pelvic girdle syndrome (adjusted odds ratio = 1.5; 95% confidence interval: 1.2, 1.9) and severe pelvic girdle syndrome (adjusted odds ratio = 2.0; 95% confidence interval: 1.4, 2.9), after adjustment for pain severity in pregnancy, medical conditions, body mass index, age at menarche, previous low back pain, and smoking. A high level of pain severity in pregnancy and high comorbidity were the main confounders of the associations, but no interaction between these factors and emotional distress regarding the risk of pelvic girdle syndrome was estimated.

CONCLUSIONS: In this population follow-up study of women with pregnancy-related pelvic girdle pain, we report that presence of emotional distress during pregnancy was independently associated with persistence of pain 6 months postpartum. However, a high level of pain severity in pregnancy was the most significant predictor of nonrecovery.

IMPLICATIONS: Healthcare workers should be aware of the increased risk of persistent pain after delivery in emotionally distressed women presenting with severe pelvic girdle pain during pregnancy.

BACK PAIN BELIEFS ARE RELATED TO THE IMPACT OF LOW BACK PAIN IN 17-YEAR-OLDS: A CROSS-SECTIONAL STUDY FROM THE RAINE COHORT

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PURPOSE: The relationship between back pain beliefs and the impact of low back pain during adolescence has not been investigated.

RELEVANCE: Negative back pain beliefs in adults with nonspecific chronic low back pain may be associated with higher levels of disability. These beliefs can be positively influenced with education, resulting in reduced disability. Low back pain commonly develops during adolescence and is associated with disability at this age, but back pain beliefs in this age group have not been documented.

METHODS: One thousand two hundred ninety-nine adolescents from the longitudinal Raine study provided cross-sectional data at the 17-year-old follow-up on back pain beliefs (back beliefs questionnaire), specific impacts related to low back pain (care-seeking behaviors, activity modification behaviors), and a number of covariates.

RESULTS: Subjects who had never experienced low back pain had more negative beliefs than those who reported low back pain (mean difference, 1.63; 95% CI: 1.01, 2.26; $P < .001$). There was no difference in beliefs among subjects who did/did not report care-seeking behaviors. In contrast, those who reported activity modification behaviors had significantly poorer beliefs than those who did not (mean differences, 1.3-2.6; $P < .001-0.005$). The greater the number of activity modification behaviors reported, the poorer back pain beliefs were. Covariate analysis determined more positive beliefs to be associated with female gender, lower body mass index, higher family income, better SF-36 mental health scores, and more positive primary carer beliefs.

CONCLUSION: At 17 years of age, differences in back pain beliefs are associated with different levels of impact.

IMPLICATIONS: Assessment of low back pain beliefs may help identify potential targets for intervention. Addressing beliefs in adolescence may arrest a potential pathway to adult low back pain disability.

COMORBIDITIES, HEALTH-RELATED QUALITY OF LIFE, AND SPECIFIC LOW BACK PAIN-RELATED IMPACTS AT 17: CROSS-SECTIONAL STUDY FROM THE RAINE COHORT

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PURPOSE: Little is known of the presence and/or impact of low back pain comorbidities in adolescents.

RELEVANCE: Low back pain comorbidities in adults may result in increased levels and duration of physical disability, contributing to poorer outcomes and increased medical costs. Characterization of low back pain comorbidities in adolescence is needed to improve the understanding of the development of these relationships from a lifespan perspective.

METHODS: Subjects from the Raine study at the 17-year follow-up ($n = 1391$) provided self-report of diagnosed medical conditions and data on health-related quality of life (SF-36) and low back pain impacts (taking medication, missing school/work, interference with normal activities, interference with physical activities). Latent class analysis was used to define clusters of comorbidities based on the diagnosed medical conditions. The SF-36 and the specific low back pain impacts were compared between comorbidity clusters ($n = 1191$).

RESULTS: Four distinct clusters were identified: (1) low probability of low back pain or any other medical condition (79.7%), (2) high probability of being diagnosed with low back pain and neck pain but low probability of other health conditions (9.6%), (3) moderate probability of low back pain and high probability of an anxiety/depression disorder (6.9%), and (4) moderate probability of low back pain and high probability of a behavioral/attention disorder (3.8%). These clusters were associated with variability in health-related quality of life and negative low back pain impacts.

CONCLUSION: These findings in adolescents support previous adult studies linking low back pain, psychological status, and disability levels.

IMPLICATIONS: These findings suggest the drivers of pain and healthcare behaviors relating to low back pain develop at an early age. Clinicians should understand the role of comorbidities in low back pain to help them provide individualized, patient-focused interventions from a biopsychosocial perspective.

HEALTHCARE UTILIZATION BY PEOPLE WITH CHRONIC BACK DISORDERS: A POPULATION-BASED ANALYSIS OF THE 2008 CANADIAN COMMUNITY HEALTH SURVEY

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PURPOSE: (1) To investigate the association of a self-reported chronic back disorder (CBD) with utilization of physiotherapists (PTs), family physicians, and chiropractors. (2) To determine which demographic, socioeconomic, and other factors were associated with utilization of each provider group.

RELEVANCE: Improving the understanding of healthcare utilization for CBD is important because it describes the demands on the primary healthcare system, it informs clinicians about the characteristics of patients who consult them, and it provides researchers with knowledge about potential sampling differences between clinical and general populations.

METHODS: The 2008 Canadian Community Health Survey was analyzed using logistic regression. The outcome of interest was the self-reported presence/absence of at least 1 contact with each provider group in the past year. Analyses were conducted for: (a) general sample composed of all individuals 18 years or older, and (b) restricted sample composed of individuals 18 years or older with no self-reported hospitalizations in the previous 12 months and no other self-reported chronic medical disorders.

RESULTS: In the general sample, people with CBDs were more likely than those without to report using all 3 types of healthcare providers (ORs = 1.6-3.1). In the restricted sample, this association was only statistically significant for PT (OR = 2.3) and chiropractic care (OR = 3.8). PT usage was associated with female gender, higher socioeconomic status (SES), as well as the presence of functional limitations, depression, and arthritis.

CONCLUSION: People with CBDs reported significantly greater use of fam-

ily physician, chiropractic, and PT services compared to those without. However, differential patterns of utilization among those with CBDs were evident between provider groups with respect to age, gender, SES, residence, body mass index, functional limitations, and other comorbidities.

IMPLICATIONS: Further study is needed to examine whether differential patterns of usage relate to problems of access to PT services relative to other provider groups.

THE BACK PAIN BELIEFS OF PHYSIOTHERAPISTS ARE MORE POSITIVE AFTER BRIEF BIOPSYCHOSOCIALLY ORIENTATED WORKSHOPS

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PURPOSE: To examine the low back pain (LBP) beliefs of physiotherapists, before and after brief educational workshops. To compare LBP beliefs between countries and identify the factors that facilitate changes in LBP beliefs.

RELEVANCE: Negative LBP beliefs among patients with LBP are associated with greater disability, and are linked to the LBP beliefs of their physiotherapist. Although intensive education improves both the LBP beliefs of physiotherapists and their stated management of LBP, the effectiveness of shorter educational workshops is unclear.

METHODS: One hundred fifty physiotherapists attending a brief biopsychosocially orientated workshop in 1 of 3 countries (Ireland, England, Germany) participated. Physiotherapists completed the Back Beliefs Questionnaire (BBQ) before and after the workshop, and were asked to identify the key perceived mediators of change in their LBP beliefs. A Kruskal-Wallis 1-way repeated-measures ANOVA compared BBQ scores between the different countries, both at baseline and follow-up. Overall BBQ scores were compared before and after the workshop using a Wilcoxon signed-rank test. Qualitative comments on the facilitators of change were categorized into common themes.

RESULTS: Significant ($P < .05$) differences in LBP beliefs existed between countries, both at baseline and follow-up. There was a significant ($P < .001$) increase in overall BBQ scores across the 3 countries after the workshop. Qualitatively, combining the scientific evidence with live patient presentations was identified as an important mediator of changing LBP beliefs.

CONCLUSIONS: The LBP beliefs of physiotherapists vary between countries, and were improved across all 3 countries after the brief workshops.

IMPLICATIONS: Brief biopsychosocially orientated workshops are an effective means of modifying the LBP beliefs of physiotherapists. Key factors in facilitating changes in LBP beliefs were identified and may guide further training of physiotherapists. A further study is evaluating if the improved beliefs are associated with improved clinical outcomes.

FUNDING: Health Research Board of Ireland.

ELECTROMYOGRAPHY AND SONOGRAPHY ASSESSMENT OF ABDOMINAL MUSCLE FUNCTION IN INDIVIDUALS WITH AND WITHOUT LUMBOPELVIC PAIN

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PURPOSE: This study investigated the correlations between changes in electromyographic (EMG) signal amplitude and muscle thickness (measured with ultrasound imaging [USI]) in 4 abdominal muscles (rectus abdominis, external oblique, internal oblique, and transversus abdominis) during 2 clinical tests (active straight leg raise test [ASLR] and abdominal drawing-in maneuver [ADIM]) in adults with and without lumbopelvic pain (LPP).

RELEVANCE: There is a trend in physiotherapy to use USI to determine the extent of muscle contraction in individuals with LPP while they perform

clinical tests, and in response to exercise or manual therapy. However, as the literature investigating the relationship between changes in abdominal muscle thickness and activity is inconclusive, this practice may be premature.

METHODS: Simultaneous recordings of fine-wire EMG and USI data were gathered from 4 abdominal muscles in 7 (mean \pm SD age, 29.7 ± 12.0 years) adults with and 7 (mean \pm SD age, 32.0 ± 10.6 years) without LPP while they performed the ASLR and ADIM. Cross-correlation functions (magnitude, r ; time lag, τ) were used to determine the relationship between the 2 signals. Analyses of variance (ANOVAs) were used to compare measures between cohorts ($P = .05$).

RESULTS: Across all muscles, peak r values were low (ASLR, $r = 0.28 \pm 0.09$; ADIM, $r = 0.35 \pm 0.11$), and there was large variability in associated time lags (ASLR, $\tau = 0.69 \pm 2.56$ seconds; ADIM, $\tau = 0.53 \pm 3.75$ seconds), suggesting a weak relationship between EMG amplitude and muscle thickness. ANOVAs revealed no significant differences between cohorts.

CONCLUSIONS: These results suggest that abdominal muscle thickness changes during these tests cannot be used as a measure of change in level of muscle activity.

IMPLICATIONS: These results point to the complexity of the relationship between muscle activity and thickness, and suggest that the interpretation of muscle thickness change with USI must involve consideration of all factors that influence the shape of the muscle.

EVIDENCE OF ALTERED LOADING OF THE ABDOMINAL WALL? A SONOGRAPHIC STUDY COMPARING PEOPLE WITH AND WITHOUT LUMBOPELVIC PAIN

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PURPOSE: Connective tissues remodel in response to loading; consequently, their morphological characteristics can provide insight into their loading history. This study aimed to compare the sonographic characteristics of the abdominal muscles, and perimuscular connective tissue (PMCT), of individuals with and without lumbopelvic pain (LPP).

RELEVANCE: Altered motor control of the abdominal muscles has been identified with low back and pelvic pain. Ultrasound imaging (USI) can quantify muscle and PMCT morphology, and thereby indicate differences in the loading history of the abdominal wall of individuals with LPP.

METHODS: Abdominal muscle and PMCT thickness, as well as interrecti distance (IRD), were obtained from ultrasound images taken from 25 individuals with (mean \pm SD age, 46.6 ± 8.0 years) and 25 without (mean \pm SD age, 36.3 ± 9.4 years) LPP. Univariate correlation analysis was used to identify covariates. Analyses of covariance were used to compare cohorts ($P = .05$).

RESULTS: The LPP cohort had less total abdominal muscle thickness (LPP, 18.9 ± 3.0 mm; control, 20.3 ± 3.0 mm; $P = .03$), thicker PMCT (LPP, 5.5 ± 0.2 ; control, 4.3 ± 0.2 ; $P = .007$), and wider IRD (LPP, 11.5 ± 2.0 ; control, 8.4 ± 1.8 ; $P = .005$). Analysis of individual muscle thickness revealed no difference in the EO, IO, and TrA, but a thinner RA (LPP, 7.8 ± 1.5 ; control, 9.1 ± 1.2 ; $P < .047$) in the LPP cohort.

CONCLUSIONS: This is the first study to compare morphological difference of all 4 abdominal muscles and PMCT in individuals with LPP. The results indicate altered loading that may be secondary to an altered motor control strategy that involves a reduced contribution of the RA, and increased PMCT and IRD load.

IMPLICATIONS: Clinical practice may be enhanced by expanding the focus of management to consider the role of the RA muscles and abdominal PMCT in the development and persistence of LPP.

THE EFFECT OF LOW BACK PAIN ON LUMBAR MULTIFIDUS MUSCLE SIZE AND ACTIVITY USING REHABILITATIVE ULTRASOUND IMAGING AND THEIR CORRELATION WITH FUNCTIONAL OUTCOMES

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PURPOSE: To determine if differences exist in both resting thickness (RT) and percentage thickness change (PTC) during activation of the lumbar multifidus (LM) muscle between symptomatic patients and controls using rehabilitative ultrasound imaging (RUSI). The relationship between LM characteristics with functional disability was also examined.

RELEVANCE: The importance of optimal paraspinal muscle function for stability and functional movement of the vertebral column has been examined comprehensively in the literature. This study may support the need for specific LM rehabilitation among patients with certain classifications of LBP.

METHODS: Twelve participants were studied, 6 with first episode of low back pain (LBP) and 6 controls. Both groups included 2 men and 4 women (18-58 years). RUSI was used to measure the LM RT and PTC at L4 and L5 during LM activation. Functional disability was assessed using Simmonds tests, that is, timed forward flexion, sit-to-stand, and 50-ft walk tests. Independent *t* tests were used to determine between-group differences in LM RT and PTC. The Pearson correlation test was used to investigate the relationship between LM characteristics and functional disability.

RESULTS: There was no difference between groups in LM RT or PTC. There was no correlation between LM RT and functional disability. A strong correlation was found between LM PTC of right LM and the Simmonds sit-to-stand test in participants with LBP ($r > 0.94$, $P < .05$).

CONCLUSION: Findings suggest a possible relationship between LM activation and functional disability in LBP. Raw data implied that as percentage muscle size increases, the length of time to carry out certain functional tasks decreases.

IMPLICATIONS: Further research involving an adequately powered study is required to establish if a definite association exists between back-related disability and LM PTC. This, in turn, may support the need for specific LM rehabilitation among patients with certain classifications of LBP.

TRANSVERSE PERINEAL ULTRASOUND IMAGING OF PELVIC FLOOR MUSCLE ACTIVATION IN MEN FOR ASSESSMENT AND TREATMENT OF LOW BACK AND PELVIC PAIN

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PURPOSE: Assessment and training of pelvic floor muscle function are frequently considered in management of low back and pelvic pain (LBPP) because of their role in lumbopelvic control and the potential for dysfunction. Ultrasound (US) imaging is used for assessment/training in women, but limited work has considered its use in men. Current transabdominal US techniques lack reliable landmarks and cannot differentiate between 3 muscle mechanisms (striated urethral sphincter, levator ani, and bulbocavernosus) responsible for continence control in men. This study aimed to: (1) develop a transperineal US technique to evaluate pelvic floor muscles in men, (2) evaluate the method's reliability, and (3) examine the relationship between the multiple muscle mechanisms.

RELEVANCE: Objective measures of pelvic floor muscle function are required to evaluate their function in men with LBPP and as a potential feedback tool.

METHODS: Urethral displacement at different regions based on anatomy and mechanics of the 3 muscle mechanisms was measured with 2-D US (7-MHz curved transducer) in 10 continent males (28-41 years). Intraclass correlation coefficients assessed reliability between days. Pearson correlation coefficient investigated the relationship between discrete muscle mechanisms.

RESULTS: Measures were repeatable between days (ICC_{2,2} range, 0.85-0.97). Data show individual variation in distal urethra (striated urethral sphincter contraction) and urethra-vesical junction (levator ani contraction) displacement, but the strong inverse linear relationship (0.723) be-

tween these points indicates 2 alternative yet coordinated strategies for urethral movement.

CONCLUSIONS: This study has developed a reliable method to simultaneously measure urethral motion related to activation of multiple muscles, which control urinary continence in men. We show 2 unique strategies, each focused on a discrete component of the continence system.

IMPLICATIONS: Transperineal US is a viable tool to begin investigation of pelvic floor muscle function in men with LBPP.

THE TREATMENT OF CERVICOGENIC DIZZINESS WITH MANUAL THERAPY: PRELIMINARY RESULTS OF A RANDOMIZED CONTROLLED TRIAL

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RELEVANCE: Cervicogenic dizziness is a common problem in the community. Previously, we provided evidence for the short-term efficacy of sustained natural apophyseal glides (SNAGs) in its treatment. However, it is not known whether SNAGs have similar effects to other manual therapy treatments such as Maitland passive joint mobilizations (MMs).

PURPOSE: The aims of this study were to evaluate and compare the effects of SNAGs and MMs in reducing symptoms of cervicogenic dizziness compared to a placebo.

METHODS: A randomized controlled trial was conducted with 85 participants diagnosed with chronic cervicogenic dizziness randomized into 3 groups: SNAG treatment, including self-SNAG exercises (n = 29); MM with range-of-motion exercises (n = 28); and a placebo of detuned laser (n = 28). Participants were treated for 2 to 6 weeks, with assessments compared at baseline, immediately posttreatment, and 12 weeks posttreatment. Participants and the research assistant conducting the assessments were blinded, but the treating therapist was not blinded. The primary outcome measure was the visual analog scale (VAS) for dizziness. The results of the interventions were compared using 2-tailed *t* tests.

RESULTS: Eighty-five participants have completed the posttreatment assessment and 38 have completed the 12-week follow-up. There was a significant decrease in the dizziness VAS score in the SNAG group (from 42 to 21, $P < .01$) and the MM group (from 49 to 30, $P < .01$) immediately posttreatment. These changes were still evident at the 12-week follow-up (SNAG group, from 42 to 12, $P < .01$; MM group, from 49 to 31, $P < .05$). There was no significant change in the placebo group posttreatment (from 49 to 44, $P > .05$) or at 12 weeks (from 49 to 42, $P > .05$).

CONCLUSION: Manual therapy and related exercises are effective in reducing cervicogenic dizziness, and the effect is maintained for 12 weeks after treatment.

IMPLICATIONS: This trial provides evidence for 2 types of manual therapy in treating cervicogenic dizziness.

MUSCULOSKELETAL FUNCTION OF THE UPPER CERVICAL SPINE IN CHILDREN WITH AND WITHOUT CERVICOGENIC HEADACHE: A CROSS-SECTIONAL STUDY

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PURPOSE: To investigate the posture and movement of the upper cervical spine in children with and without cervicogenic headache (CeH).

RELEVANCE: Headache and neck pain is a common complaint in children. Despite this, few studies have investigated the function of the upper cervical spine in children suffering headaches, in particular CeH.

METHODS: In this study, 30 children with CeH (19 girls, 11 boys) and 34 asymptomatic children (26 girls, 8 boys), all aged between 6 and 12 years, were evaluated. A cervical-range-of-motion device was used to measure range of motion, including range during the flexion-rotation test (FRT). A validated method using photography was used to measure the CVA, and a colored analog scale (CAS) was used to rate the pain intensity during the FRT.

RESULTS: The CeH group had less active cervical range for all physiological movements (all, $P < .000$), a smaller CVA ($P < .000$), higher FRT pain intensity scores ($P < .000$), and less range recorded during the FRT ($P < .000$) when compared to the asymptomatic group. In the CeH group, FRT range of motion was significantly less toward the dominant headache side compared to the nondominant headache side ($P < .000$). This study also found a strong significant negative correlation between the ranges recorded during the FRT and the FRT pain intensity scores ($r_s = -0.758$, $P < .000$).

CONCLUSION: Children with CeH have a smaller CVA, less active range of cervical motion, more pain during the FRT, and reduced range recorded during the FRT when compared with children who were asymptomatic. These findings confirm evidence of musculoskeletal dysfunction in pediatric CeH.

IMPLICATIONS: In children presenting with headaches, manual therapists should screen for musculoskeletal dysfunction using the CVA, active range of motion, and the FRT. Identified impairment may form the basis for monitoring treatment outcome.

TREATMENT TO ADDRESS TEMPOROMANDIBULAR DYSFUNCTION IN ADDITION TO USUAL CARE IMPROVES CERVICOGENIC HEADACHE AND CERVICAL MOBILITY

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PURPOSE: The purpose of this study was to determine whether orofacial manual therapy treatment in addition to usual manual therapy care was more beneficial than usual care alone for people who suffer from cervicogenic headache (CGH) with associated features of temporomandibular dysfunction (TMD). An additional purpose was to determine the influence of orofacial manual therapy on measures of cervical movement impairment.

RELEVANCE: There is evidence that TMD may be a contributing factor to CGH, but no previous studies have investigated the effect of orofacial manual therapy on CGH symptoms or upper cervical movement impairment.

METHODS: In this study, 43 patients (27 women) with CGH for more than 3 months and with features of TMD were randomly assigned to receive either cervical manual therapy (usual care) or orofacial manual therapy to address TMD in addition to usual care. All subjects were assessed at baseline, after 6 treatment sessions (3 months), and at 6 months' follow-up. Thirty-eight subjects (25 women) completed all analyses at 6 months' follow-up. The outcome criteria were: headache intensity, disability, cervical spine range of movement (including the C1-2 flexion-rotation test), and manual examination of the upper 3 cervical vertebrae.

RESULTS: The group that received orofacial treatment in addition to usual care showed significant reduction in headache intensity, disability, and all aspects of cervical impairment after the treatment period and 6-month follow-up ($P < .001$), but were not observed in the usual care group at any point.

CONCLUSIONS: Orofacial manual therapy treatment in addition to usual care was significantly better than usual manual therapy care alone for management of people with CGH with associated TMD.

IMPLICATIONS: Manual therapists should look for features of TMD when examining patients with CGH. Including orofacial treatment in management of patients with CGH and signs of TMD will likely lead to long-term reduction of pain, disability, and upper cervical movement impairment.

ASSOCIATION BETWEEN MOVEMENT CONTROL DYSFUNCTION OF THE PELVIS, POSITIVE SCORING IN ASLR, AND TENDERNESS IN THE DORSAL SI LIGAMENT

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PURPOSE: Movement control dysfunction (MCD) is associated with reduc-

tion of active movement control and nonoptimal stability of lumbopelvic structures in load-bearing situations, and valid clinical tests are needed to recognize the condition. Positive scoring in the active straight leg raise (ASLR) test has been shown in patients with pelvic girdle pain and with rotational MCD of the lumbar spine and in connection with tenderness of the long dorsal sacroiliac ligament. Asymmetry of the lateral movement of the pelvis during single-leg stance (lateralization) refers to rotational MCD of the lumbar spine.

RELEVANCE: This study was to verify whether there is an association between lateralization of the pelvis in single-leg stance, positive scoring in ipsilateral active ASLR, and tenderness in the ipsilateral dorsal sacroiliac ligament.

METHODS: The study group consisted of 66 patients with unilateral low back/pelvic pain and 49 healthy controls. Lateralization of the pelvis during single-leg stance was evaluated by measuring the lateral transfer of the S1 processus spinosus from normal stance, feet together, to single-leg stance. Comparisons with ASLR, tenderness of the long dorsal sacroiliac ligament, and lateral movement of the pelvis during single-leg stance were carried out.

RESULTS: Patients with low back/pelvic pain had greater asymmetry in lateralization of the pelvis during single-leg stance than healthy controls, and over 1.5 cm difference between sides was associated with the symptomatic side ($P = .01$). Ipsilateral positive ASLR and lateralization were also connected ($P = .002$). Association with long dorsal ligament tenderness and symptomatic side was shown ($P < .001$).

CONCLUSION: This study shows a clear association between lumbopelvic movement dysfunction in load-bearing and non-load-bearing (ASLR) situations and their interconnection with long dorsal sacroiliac ligament tenderness.

IMPLICATIONS: Lateralization of the pelvis during single-leg stance is a simple test to evaluate movement control dysfunction and lack of force closure in pelvic girdle pain patients.

PELVIC GIRDLE PAIN AND DISABILITY AFTER DELIVERY: DO SOME GROUPS OF WOMEN HAVE POTENTIAL UNFAVORABLE DEVELOPMENT?

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PURPOSE: Explore if groups of pregnant women (based on self-reported pain and response to clinical examination) differ in the course of recovery from pain and disability between late pregnancy and 1 year postpartum.

RELEVANCE: Pelvic girdle pain (PGP) is common in pregnancy, and many women seek manual therapy treatment. To prioritize follow-up and prevent chronic conditions, it seems important to identify groups of women with possible adverse development.

METHODS: Two hundred eighty-three pregnant women (mean \pm SD age, 31 ± 4 years; 56% nulliparous) were examined in gestation week (GW) 30, and 263 again 12 weeks postpartum. Two hundred fifteen returned questionnaires 1 year postpartum. Disability, measured by the Disability Rating Index (DRI; 0-100; 100 is worst), and bodily pain from the SF-36 (BP, 0-100; 0 is worst) were used as outcomes. Clinical examination in GW 30 and 12 weeks postpartum included the active straight leg raise (ASLR) test and the posterior pelvic pain provocation (P4) test. The women were divided into groups in 4 different ways, based on examination in GW 30: (1) presence/absence of PGP, (2) pain location derived from pain drawings (no pain, symphysis pain, posterior pelvic pain, combined symphysis and posterior pain), (3) response to P4 test (negative, unilateral positive, bilateral positive), and (4) response to the ASLR test (0, >0). The course of DRI and BP were analyzed by a linear mixed model for repeated measures.

RESULTS: There were only marginal differences in mean DRI and BP between the groups 1 year postpartum. Significantly faster recoveries of DRI and BP were seen for those with positive clinical findings, that is, most afflicted women.

CONCLUSION: Having positive responses to clinical tests or reporting PGP in late pregnancy does not predict a less favorable course of recovery the first year postpartum.

IMPLICATIONS: Identification of those with slower recovery from PGP needs other assessments than those tested here.

SYMMETRY OF TRUNK AND FEMOROPELVIC MOTION DURING SINGLE-LEG LOADING TESTS

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PURPOSE: To examine differences in trunk and femoropelvic movement between legs during 4 single-leg loading tests (single-leg stand [SL], single-leg squat [SS], hip hitch [HH], and hip drop [HD]) in asymptomatic women, and to compare observational and quantitative assessments of the associated trunk movement.

RELEVANCE: Single-leg loading tests are used clinically to examine balance and loading strategies in individuals with lower-limb pain. Interpretation of these tests is through comparison of responses with the asymptomatic leg. Thresholds for significant between-leg differences in motion response have not been defined.

METHODS: Thirty-one asymptomatic women (mean \pm SD age, 21.7 \pm 3.7 years) performed each test in a random sequence, and quantitative analysis of coronal plane trunk lean (magnitude and direction) and femoropelvic angle (FPA) was conducted using photographic image analysis. Between-side minimal significant differences (MDs) for FPA were defined for each test. Agreement between observational and quantitative assessments of trunk lean in SS was also tested.

RESULTS: All tests had excellent within-side reliability (ICC = 0.87-0.97; SEM, 0.6°-1.2°). The between-side MDs for the FPA were 6.3°, 6.5°, 9.7°, and 6.7° for the SL, SS, HH, and HD tests, respectively. The magnitude of trunk shift was small, increased with test complexity, and was not consistent in relation to the stance leg. Excellent agreement for direction of trunk movement between observers (87%-93%) and between observational and quantitative analysis (80%-96%) was established for the SS test.

CONCLUSIONS: Trunk and femoropelvic movement asymmetry is common in single-leg loading tests in asymptomatic individuals. Observational assessment of direction of trunk motion during these tests appears accurate relative to quantitative evaluation.

IMPLICATIONS: The thresholds for significant between-side differences in FPA established in this study will assist the interpretation of single-leg loading tests in individuals with lower-limb pain disorders.

DEVELOPMENT OF A CLINICAL PREDICTION RULE TO IDENTIFY PATIENTS WITH NECK PAIN LIKELY TO BENEFIT FROM CERVICAL SPINE MANIPULATION

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PURPOSE: To develop a clinical prediction rule (CPR) that could accurately identify patients with neck pain who would respond favorably to cervical spine manipulation (CSM).

RELEVANCE: CSM has been shown to be effective for some patients with neck pain. It would be useful for clinicians to have a decision-making tool, such as a CPR, to identify patients who are more likely to benefit from CSM.

METHODS: A prospective cohort study of patients with neck pain. Eligible patients completed self-report measures, received detailed standardized history and physical examinations, and then received a standardized treatment regimen consisting of CSM and exercise for 1 to 2 treatments over 1 week. Patients were classified as having experienced a successful outcome or not based on the global rating of change scale. Sensitivity,

specificity, and positive and negative likelihood ratios were calculated for all potential predictor variables. Univariate techniques and stepwise logistic regression were used to determine the most parsimonious set of variables for prediction of treatment success. Variables retained in the regression model were used to develop a multivariate CPR to identify patients with neck pain likely to benefit from CSM.

RESULTS: Eighty-two patients were included in data analysis, of whom 32 (39%) had achieved a successful outcome. A CPR with 4 variables (symptom duration less than 38 days, positive expectation that manipulation will help, difference in cervical rotation range of motion to either side of 10° or greater, and pain with spring [PA] testing of the middle cervical spine) was identified. If 3 of the 4 variables (+LR = 13.5) were present, the chance of experiencing a successful outcome improved from 39% to 90%.

DISCUSSION: The CPR should improve decision making for patients with neck pain by providing the ability to a priori identify patients with neck pain who are likely to benefit from CSM.

IS BEHAVIORAL GRADED ACTIVITY MORE EFFECTIVE IN COMPARISON WITH MANUAL THERAPY IN PATIENTS WITH SUBACUTE NECK PAIN?

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PURPOSE: To compare the effectiveness and cost-effectiveness of a behavioral graded activity program with manual therapy in patients with subacute nonspecific neck pain.

RELEVANCE: Neck pain is common and poses an important socioeconomic burden to society. Many conservative therapies are available in primary care, such as manual therapy combined with exercises. Psychosocial factors are also believed to play an important role in pain patients. The evidence of the effectiveness of a program focused on these factors is scarce, as are data on cost-effectiveness.

METHODS: A randomized controlled trial was conducted involving 146 patients with subacute neck pain. Clinical outcomes included global perceived effect, pain, disability, and quality-adjusted life-years. Data were analyzed according to the intention-to-treat principle using multilevel analysis. Cost-effectiveness planes and cost-effectiveness acceptability curves were estimated.

RESULTS: The success rates at 52 weeks, based on the GPE, were 89.4% for the BGA program and 86.5% for the MT. The differences were not statistically significant. Cost-effectiveness analysis showed that BGA is not cost-effective in comparison with MT for recovery and QALYs gained.

CONCLUSIONS: Based on this trial, it can be concluded that there are no statistical differences in effect between both interventions; also, BGA is not cost-effective in comparison with MT.

IMPLICATIONS: For future research, it seems advisable to select patients based on diagnostic algorithms or a classification system in which patients with a more psychosocial profile are better off with a BGA program and patients with a more biomedical profile with MT.

THE EFFECTIVENESS OF CONSERVATIVE TREATMENT FOR PATIENTS WITH CERVICAL RADICULOPATHY: A SYSTEMATIC REVIEW

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BACKGROUND: Cervical radiculopathy (CR) is a term used to describe neck

pain associated with pain radiating into the arm. Little is known about the effectiveness of conservative treatment for patients with CR.

OBJECTIVES: The aim of this systematic review is to assess the effectiveness of conservative treatments for patients with CR.

METHODS: We electronically searched the Cochrane Controlled Trials Register, MEDLINE, Embase, and CINAHL for randomized clinical trials. The conservative therapies consisted of physiotherapy, manipulative therapy, collar, traction, etc. Two authors independently assessed the risk of bias using the criteria recommended by the Cochrane Back Review Group and extracted the data. If studies were clinically homogeneous, a meta-analysis was performed. The overall quality of the body of evidence was evaluated using the GRADE method.

RESULTS: Fifteen articles were included, which corresponded to 11 studies. Two studies scored low risk of bias. There is low-level evidence that a collar is more effective than physiotherapy at a short-term follow-up, and very low-level evidence that a collar is no more effective than traction. There is very low-level evidence that traction is no more effective than placebo traction, and low-level evidence that intermittent traction is no more effective than continuous traction.

CONCLUSION: There is a lack of high-quality RCTs. Based on low- to very low-level evidence, no one intervention appears to be superior or consistently more effective than other interventions. Regardless of the intervention assignment, patients seem to improve over time, indicating a favorable natural course.

THE EFFECT OF DIFFERENT DURATIONS OF LUMBAR SPINE POSTEROANTERIOR MOBILIZATIONS ON PRESSURE PAIN THRESHOLDS

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BACKGROUND: Spinal mobilizations are a common form of treatment intervention applied by physiotherapists in clinical practice to manage musculoskeletal pain and/or dysfunction. Previous research has demonstrated that mobilizations cause a hypoalgesic effect. However, there is very little research investigating the optimal treatment dose inducing this effect. **AIM:** To investigate the effect of the number of sets (up to 5) and different durations (30 versus 60 seconds) on pressure pain thresholds (PPTs) at different sites.

METHODS: This single-blinded, randomized, subject repeated-measures crossover design included 19 asymptomatic healthy volunteers. The participants received 5 sets of either 30 or 60 seconds of posteroanterior mobilizations to L4 on different days. PPTs were measured immediately before, between, and after the intervention at 4 different standardized sites.

RESULTS: A 4-way ANOVA revealed that there was no statistically significant difference between 30 versus 60 seconds of mobilizations. However, there was a tendency for PPT values to be higher for the 60-second intervention. All PPT measurements after the interventions were significantly higher than the baseline. Only the measurement after the fourth set of mobilizations was significantly higher than the measurement after the first set ($P = .035$).

CONCLUSIONS: The results suggest that in order to induce the greatest local hypoalgesia, at least 4 sets of mobilizations are required. The different durations of 30 versus 60 seconds of mobilization may not change the extent of the hypoalgesic effect.

INTRATER RELIABILITY OF 2-POINT DISCRIMINATION TEST ON THE LUMBAR SPINE

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PURPOSE: The aim of this study was to measure the intertester reliability of the 2-point discrimination (TPD) test on the lumbar spine.

RELEVANCE: The TPD test is a simple way to assess the brain's representa-

tion of a certain body part. TPD has been used in studies to map cortical representation, and significant differences between healthy subjects and patients with chronic pain have been found. TPD could be a valuable outcome measurement for clinical practice and studies addressing body awareness. However, intertester reliability reports of TPD have not yet been published.

METHODS: Two experienced physiotherapists examined 29 subjects on their TPD on the lumbar spine. The measurement was done horizontally and vertically on level L2 right and left. The examination was done with a plastic caliper ruler by 2 blinded therapists within 30 minutes. Thirteen subjects were healthy and 16 were patients with LBP. ICC statistics to evaluate intertester reliability and standard error of the measurement (SEM) and smallest detectable change (SDD) were calculated.

RESULTS: We observed substantial reliability, ICC being between 0.60 and 0.84 for the 4 different measurement localizations. SEMs were between 10.59 and 14.55 mm, and SDDs were 20.7 to 28.5 mm.

CONCLUSIONS: Clinical tests to evaluate TPD on the lumbar spine have substantial reliability. However, SDD being up to almost 3 cm in clinical practice used as an outcome, the change has to be at least this to be clinically meaningful. In an adequately powered RCT, TPD can be used as an outcome, as the sum of measurement error will be zero.

IMPLICATIONS: Measurement of TPD is a simple and quick way to test cortical representation. The intertester reliability is substantial, and it can be used as an outcome measurement. In clinical practice, the clinically meaningful change needs to be up to 3 cm.

MORE THAN UNDERSTANDING RELIABILITY: THE ACCURACY OF SPINAL PALPATION IN STUDENTS AND CLINICIANS

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PURPOSE: The objective of this study was to compare palpation accuracy in the lumbar spine between physical therapy students and experienced physical therapists.

RELEVANCE: Although the reliability of spinal palpation has been shown to be moderate in most applications, the accuracy of spinal palpation is largely unknown.

METHODS: Ultrasonic imaging was used in conjunction with optical tracking to identify the reference coordinates of the spinous processes of L1, L3, and L5, and the transverse processes of L2 (right) and L4 (left) in 2 asymptomatic subjects. A cohort of physical therapy students ($n = 18$) and a cohort of practicing clinicians ($n = 5$) blinded to the reference data were then asked to identify each landmark using their preferred method of palpation. Palpation error was calculated as the absolute difference in the superior/inferior direction between the ultrasonic reference location and the palpated point.

RESULTS: The mean palpation error (with 95% CI) for all landmarks was 22.1 mm (19.3, 24.8) for the student group and 16.1 mm (11.6, 20.6) for the clinician group. Overall, the students correctly identified the spinal level 21.2% of the time, whereas the clinicians did so 31.1% of the time. A 2-way ANOVA demonstrated significantly higher palpation error in the student group versus the clinician group ($P = .018$), as well as a significant main effect of landmark on accuracy ($P < .001$). The interaction between experience and landmark was not significant.

CONCLUSIONS: These results suggest that palpation accuracy improves with experience and that some landmarks have higher palpation error regardless of experience.

IMPLICATIONS: Palpation is a skill required by a wide range of clinicians for the identification of certain anatomic landmarks. Improving palpation accuracy may ultimately improve treatment efficacy and safety.

DOES ADVANCED CERTIFICATION INFLUENCE HOW PHYSICAL THERAPISTS MANAGE PATIENTS WITH WHIPLASH-ASSOCIATED DISORDER?

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PURPOSE: The purpose of this study was to compare the clinical practice of physical therapists with and without an advanced-training certification in the management of patients with an acute whiplash-associated disorder (WAD).

RELEVANCE: Knowledge and skill in evidence-based assessment and treatment methods may enable physical therapists to select the most effective and efficient treatments for patients with WAD. A survey was sent to 1484 therapists, 237 of whom responded.

METHODS: A cross-sectional electronic survey was conducted with a sample of licensed physical therapists from the Orthopaedic Section of the American Physical Therapy Association (APTA) and the American Academy of Orthopaedic Manual Physical Therapists (AAOMPT) databases. The survey included general demographic data and a clinical vignette describing a patient 4 weeks post-whiplash injury. The Pearson chi-square test was used to analyze responses.

RESULTS: Overall response rate was 15.97%. Seventy-five percent of respondents ($n = 178$) reported having at least 1 advanced certification (APTA Board-Certified Orthopaedic Specialist, Manual Therapy Certification, Fellow of the AAOMPT or Mechanical Diagnosis and Treatment [McKenzie]); 25% ($n = 59$) reported no advanced certification. Statistically significant differences ($P < .05$) were found between those with and without advanced certification. Therapists with advanced certification were more likely to use the Fear-Avoidance Beliefs Questionnaire ($P = .02$), Sharp-Purser ($P = .01$), deep neck flexor endurance ($P = .001$), and joint position error tests ($P = .02$) in their examination. They were more likely to report using thoracic spine high-velocity thrust manipulation ($P = .002$), deep neck flexor training ($P = .02$), and aerobic activity ($P = .02$), and less likely to use therapeutic ultrasound ($P = .003$) and cervicothoracic stretching interventions ($P = .03$).

CONCLUSIONS: Physical therapists with advanced certification are more likely than those without to report the use of evidence-based examination and intervention procedures in the management of a patient with acute WAD.

IMPLICATIONS: Advanced clinical certification influences physical therapists' clinical practice. Further research is needed to explore clinical outcomes based on advanced training and clinical certification.

IMPROVING ACCESS: A SPINAL TRIAGE PROGRAM DELIVERED BY PHYSIOTHERAPISTS IN COLLABORATION WITH ORTHOPAEDIC SURGEONS

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PURPOSE: To describe characteristics of users of a spinal triage program, to compare the profiles of people for whom surgery was and was not recommended by a surgeon after triage, and to determine the surgical yield among people referred to surgeons.

RELEVANCE: Models of care provision that involve physiotherapists (PTs) collaborating with surgeons to provide care to people with musculoskeletal problems are being increasingly reported; however, there are few PT triage services that focus solely on spinal conditions described in the literature.

METHODS: Data were collected retrospectively by reviewing charts of people who used the service over a 3-year period (2003-2006). Data from 1096 people were used in the analysis, with complete data available for 299 people. Descriptive statistics were used to summarize the demographics, clinical features, and management recommendations. Characteristics among those with and without a management outcome of surgery were examined using the Pearson chi-square test or Fisher exact test.

RESULTS: Most of the 746 participants were classified as "mechanical spine" (92.5%), 2.9% were "other body part," 2.5% were "medical/other," and only 2% were classified as "surgical spine." Recommendations for sur-

gery (by a surgeon) were independent of the patient's age, sex, duration of symptoms, residence (ie. urban/rural), source of healthcare funding, and diagnosis. The surgical yield was 80%.

CONCLUSIONS: Most people were not considered to be surgical candidates. Triage assessment by PTs can increase the efficiency of an orthopaedic surgeon's caseload by reducing the number of nonsurgical referrals and help to ensure more timely access to appropriate healthcare.

IMPLICATIONS: Further study is required to enhance our understanding of effective and efficient management and healthcare utilization for low back-related conditions. This retrospective study is but a first step to understanding the potential impact of a spinal triage assessment program delivered by PTs.

DEVELOPMENT AND IMPLEMENTATION OF A DEDICATED ADVANCED PRACTICE EDUCATION PROGRAM FOR MUSCULOSKELETAL PHYSIOTHERAPISTS WITHIN QUEENSLAND HEALTH

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PURPOSE: To develop workforce capacity for advanced scope of practice (ASP) roles in physiotherapy-led screening clinics in orthopaedics and neurosurgery in the public health sector at Queensland Health (QH).

RELEVANCE: ASP roles in musculoskeletal physiotherapy (MskPT) are increasing internationally, creating the requirement for directed and ongoing clinical development of physiotherapists.

DESCRIPTION: ASP roles in physiotherapy-led screening clinics in specialist outpatient orthopaedic and neurosurgery services commenced within QH in 2005. Difficulty has been experienced in recruiting suitably qualified staff, particularly in regional areas of the state.

EVALUATION: Experience from recruitment processes statewide prompted a survey of the QH physiotherapy workforce in 2008 ($n = 239$; response rate, 29%). Results identified a high level of interest in MskPT but insufficient numbers of QH physiotherapists with qualifications or postgraduate experience required for potential ASP roles. Barriers to postgraduate MskPT education identified included financial and accessibility issues. Workforce development strategies have resulted in a 6-fold increase in QH physiotherapists' enrollment in postgraduate MskPT education in the 5 years from 2007 to 2011, compared with 2001 to 2006. Further capabilities required for these ASP roles have been developed through a targeted education program, piloted across a regional and metropolitan hospital in 2011. These were the first dedicated training positions for advanced roles in QH, and a multisite program is proposed for 2012.

CONCLUSIONS: Targeted workforce development has been required in the Queensland public sector to ensure sustainability of advanced scope of practice MskPT roles. This has included strategies to increase participation rates in postgraduate masters programs in MskPT and the development of an extension education program targeting the additional knowledge and skills required by ASP roles.

IMPLICATIONS: Workforce development strategies need to be considered in planning for long-term sustainability of advanced-scope roles.

THE BENEFITS OF PHYSIOTHERAPISTS IN ADVANCED PRACTICE ROLES TO MANAGE PATIENTS WITH MUSCULOSKELETAL DISORDERS: A SYSTEMATIC REVIEW OF THE LITERATURE

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PURPOSE: To systematically review the literature regarding the evaluation of physiotherapists in advanced physiotherapy practice (APP) roles in the management of patients with musculoskeletal disorders.

RELEVANCE: Physiotherapists in APP roles are now working in new models of care that involve performing extended-scope activities. With these new competencies, their training, and traditional skills in manual therapy and exercise prescription, physiotherapists may be able to treat more effectively and efficiently patients with musculoskeletal disorders. However, evidence of the systematic evaluation of APP models of care is scarce.

METHODS: A structured literature search of 3 databases (MEDLINE, CINAHL, and Embase) was conducted. Studies that presented quantitative data that addressed the impact of APP care were included. Sixteen studies that met all inclusion criteria were included. Each study was evaluated by a pair of raters using 1 of 4 structured quality-appraisal methodological tools, selected depending on the study design.

RESULTS: Included studies could be categorized into 4 areas: diagnostic agreement or accuracy compared to physician providers, treatment effectiveness, economic efficiency, or patient satisfaction. There was a wide range in study quality (from 25% to 93%), with only 43% of papers reaching or exceeding a score of 70% on the quality rating scales. However, their findings are consistent and suggest that APP care may be as beneficial as or more beneficial than usual care by physicians for patients with musculoskeletal disorders, in terms of diagnostic accuracy, treatment effectiveness, use of healthcare resources, economic costs, and patient satisfaction.

CONCLUSION: At present, there is limited evidence evaluating the APP role. Emerging evidence suggests that for patients with musculoskeletal disorders, physiotherapists in APP roles provide equal or better care in comparison to physicians.

IMPLICATION: Although APP care has been implemented in many settings, there is a need for more methodologically sound studies to evaluate the effectiveness of this new role.

PATIENT-HELD BELIEFS ABOUT INJURY AND RECOVERY FOLLOWING A WHIPLASH INJURY: AN EXPLORATORY INTERVIEW STUDY

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PURPOSE: Beliefs held by patients about injury and recovery can potentially influence recovery. The aims were to: (1) compare beliefs about injury and recovery of participants recovering well following a whiplash injury and those recovering slowly, and (2) understand how participants form these beliefs.

RELEVANCE: By identifying differences between patients recovering well and those recovering slowly, there is potential to identify new treatment strategies for patients with whiplash-associated disorders (WAD).

METHODS: Twenty participants enrolled in a randomized controlled trial of conservative treatments for subacute WAD were purposively sampled to take part in this study. The interviews explored their experiences of having a whiplash injury. Interpretative phenomenological analysis was used.

RESULTS: Twelve participants were classified as recovering well and 8 participants were classified as recovering slowly. Six themes emerged where differences were observed: attribution of recovery, beliefs about activity, self-efficacy, personal situation, what is needed now, and prognosis. Those recovering well demonstrated greater confidence to self-manage their condition, were more likely to exercise or be active early on, and were more optimistic about outcome. Participants recovering slowly were less confident to self-manage their condition, less optimistic about outcome, and more likely to hold unhelpful beliefs about pain. Beliefs were influenced by previous experiences of illness and injury, health professionals, and the symptoms they experienced. The concept of self-efficacy is suggested as a framework for patient management.

CONCLUSIONS: Beliefs about injury and recovery differed between participants recovering well following a whiplash injury and those recovering slowly. Understanding how patients form beliefs should be considered when developing treatment strategies.

IMPLICATIONS: Assessing beliefs held by patients with WAD may assist in identifying barriers to recovery. Assessment should include confidence to self-manage, expectations of recovery, and beliefs about pain. It is hoped that addressing unhelpful beliefs will improve outcomes.

TWO DIFFERENT COURSES OF IMPAIRED CERVICAL KINESTHESIA FOLLOWING A WHIPLASH INJURY. A 1-YEAR PROSPECTIVE STUDY

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PURPOSE: To reveal the prospective development of cervical kinesthesia in persons with neck pain after motor vehicle collisions (MVC).

RELEVANCE: A significant proportion of persons develop chronic whiplash-associated disorders (WAD) following whiplash injury from an MVC. Sensorimotor impairments, both cervical movement and position sense, are thought to be an important factor in the maintenance of various symptoms.

METHODS: A longitudinal study was conducted to observe persons with neck pain after MVCs. Two different cervical kinesthetic tests, the fly test and the head-neck relocation test, measured movement control and the relocation accuracy of the cervical spine, respectively. Self-assessment measures included pain intensity, neck pain and disability, fear of reinjury, and psychological distress. Seventy-four subjects entered the study, but 47 were eligible, as they participated in all 4 measurements at 1, 3, 6, and 12 months postcollision.

RESULTS AND CONCLUSION: According to the performances on the 2 kinesthetic tests, the subjects could be classified into improvement and non-improvement groups, respectively. The result revealed, for the first time, 2 different courses of deficient cervical kinesthesia. About half of the participants showed significant deteriorating performances in both kinesthetic tests throughout the year ($P < .002$), whereas the other half improved their performances ($P < .02$). Generally, the relationships between the kinesthetic tests and the self-assessment scores were not significant, irrespective of the performances on the 2 kinesthetic tests. The organic causes of the 2 different kinesthetic courses need to be scrutinized in future research. Hypothesis about the 2 different courses will be discussed.

IMPLICATIONS: Describing the course of deficient cervical kinesthesia is an important step for identifying a possible modifiable prognostic factor for recovery, such that interventions may be more specifically directed, and potentially mitigating the course of chronicity.

ONLINE EDUCATION IS EFFECTIVE IN IMPROVING GENERAL PRACTITIONERS' KNOWLEDGE OF CLINICAL GUIDELINES FOR WHIPLASH

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PURPOSE: The aims of this study were to evaluate the effect of online education for general practitioners (GPs) managing whiplash. A secondary aim was to identify factors that would predict learning to inform future implementation strategies.

RELEVANCE: GPs are the most commonly consulted professionals for people with whiplash. Despite this, whiplash represents a small part of their patient load and GPs are generally time poor. Attendance at face-to-face continuing education, although effective, is costly and not pragmatic in Australia. This study therefore sought to use online education as a means to educate GPs about managing whiplash. In turn, it is hoped that improvement in knowledge may translate into practice and ultimately better health outcomes for people with whiplash.

METHODS: Participants were 200 GPs. All participants completed an on-

line educational activity developed by the authors and hosted by the Royal Australian College of General Practitioners (RACGP). The primary outcome measure was a change in professional knowledge measured by the difference between baseline and follow-up online questionnaires. A secondary outcome measure was confidence of knowledge. Predictors of learning were analyzed using multiple linear regression.

RESULTS: The mean \pm SD change in knowledge was significant between baseline (4.8 ± 1.8) and postintervention scores (7.0 ± 1.3 , $P < .001$). The effect was considered large, with 55.9% of GPs demonstrating more than a 30% improvement in knowledge. Baseline knowledge was the only predictor of learning ($F_{1,138} = 15.59$, $P = .001$). The model explained 63.5% (adjusted R^2) of the variance in learning.

CONCLUSIONS: Online education resulted in a significant and large effect on changing GPs' knowledge to be consistent with clinical guidelines for whiplash. Greater learning was observed in GPs with low baseline knowledge.

IMPLICATIONS: Future implementation strategies for clinical guidelines should consider online mediums due to accessibility, low cost, and large effects on learning.

EVIDENCE FOR CENTRAL SENSITIZATION IN CHRONIC WHIPLASH: A SYSTEMATIC LITERATURE REVIEW

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PURPOSE: It has been suggested that sensitization of the central nervous system plays an important role in the development and maintenance of chronic (pain) complaints experienced by whiplash patients. This study was aimed at reviewing and evaluating the existing clinical evidence to establish if there is sufficient evidence for the presence of central sensitization in chronic whiplash.

RELEVANCE: Identifying whether central sensitization is present in chronic whiplash. Making suggestions for future research.

METHODS: According to the PRISMA guidelines, a systematic review was performed to screen and evaluate the existing clinical evidence for the presence of central sensitization in chronic whiplash. Predefined key words regarding central sensitization and chronic whiplash were combined in the electronic search engines PubMed and Web of Science. Full-text clinical reports addressing studies of central sensitization in human adults with chronic complaints due to a whiplash trauma were included and reviewed for methodological quality by 2 independent reviewers.

RESULTS: From the 58 articles that were identified, 19 met the inclusion criteria, and 17 articles achieved sufficient scores (40% or greater) on methodological quality and were discussed. These studies evaluated the sensitivity to different types of stimuli (mechanical, thermal, electrical) and established the presence of persistent pain complaints, local and widespread hyperalgesia, referred pain and (thoracic) allodynia, decreased spinal reflex thresholds, inefficient DNIC activation, and enhanced temporal summation of pain in chronic whiplash patients.

CONCLUSIONS: Findings suggest that although different central mechanisms seem to be involved in sustaining the pain complaints in whiplash patients, hypersensitivity of the central nervous system plays a significant role. Important methodological shortcomings were identified.

IMPLICATIONS: Although the majority of the literature provides evidence for the presence of central sensitization in chronic whiplash, underlying mechanisms are still unclear. Therefore, future studies with good methodological quality and international guidelines for the definition, clinical recognition, assessment, and treatment of central sensitization are warranted.

LOW- VERSUS HIGH-LOAD MOTOR CONTROL EXERCISE TO REDUCE DISABILITY IN PATIENTS WITH PERSISTENT PERIPHERALLY MEDIATED MECHANICAL LOW BACK PAIN

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According to recent research guidelines, different treatments should be evaluated in defined subgroups of patients with low back pain. The aim of the present study was to compare the effects of low-load motor control (LLMC) versus high-load motor control (HLMC) training on pain, disability, and physical performance in patients with peripherally mediated mechanical low back pain due to motor control impairment. Prior to the training and 12 months after the training period, the patients rated their pain, answered the Patient-Specific Functional Scale, and performed tests of muscular strength, endurance, and movement control. Seventy patients were randomized into one of two 12-session exercise groups. All physiotherapists in charge of the training focused on movement quality. In the LLMC group, therapists addressed the patients' posture, teaching them to avoid provocative movement patterns and training them to reduce activity in overactive muscles and increase activity in local and global stabilizers. The physiotherapists of the HLMC group taught the patients the deadlift exercise that, after a period of technique training and neural adaptation, was progressed by increasing the weights. The Mann-Whitney U test showed that pain and LBP-related disability decreased and that muscular endurance increased in both groups. In the LLMC, movement control also increased. Using linear regression to analyze between-group effects, the only significant difference was that patients in the LLMC performed a higher number of movement control tests correctly. We conclude that exercises with an emphasis on keeping neutral lumbar posture improve pain and disability regardless of the load of the exercises. Our study adds insights into the role of different rehabilitation strategies to changes in pain, disability, movement control, muscular endurance, and strength. Whether high- or low-load exercises may be preferred to reduce pain and disability is still unclear and should be addressed in future studies.

THE EFFECTIVENESS OF SUBGROUP-SPECIFIC MANUAL THERAPY FOR LOW BACK PAIN: A SYSTEMATIC REVIEW

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PURPOSE: To determine the effectiveness of specific manual therapy provided to subgroups of participants identified as likely to respond to manual therapy.

RELEVANCE: Manual therapy is frequently used to treat low back pain (LBP), but evidence of its effectiveness is limited. One explanation may be sample heterogeneity and inadequate subgrouping of participants in randomized controlled trials (RCTs), where manual therapy has not been targeted toward those likely to respond.

METHODS: A systematic search of electronic databases of MEDLINE, Embase, CINAHL, and the Cochrane Central Register of Controlled Trials (CENTRAL) was conducted. Identified trials were assessed for eligibility. RCTs that provided manual therapy to participants identified as belonging to a subgroup of LBP likely to respond to manual therapy were included. Data from included trials were extracted by 2 authors independently, and the methodological quality of each trial was graded using the PEDro scale. Treatment effect sizes and 95% confidence intervals were calculated for pain and activity, and the overall quality of evidence was rated according to the GRADE domains.

RESULTS: Seven RCTs were included in the review. Clinical and statistical heterogeneity precluded meta-analysis. Significant treatment effects were found favoring subgroup-specific manual therapy over a number of comparison treatments for pain and activity at short and intermediate follow-up. However, the overall GRADE quality of evidence was very low.

CONCLUSIONS: This review found preliminary evidence supporting the effectiveness of subgroup-specific manual therapy; however, the overall quality of the evidence was very low.

IMPLICATIONS: Further high-quality research on LBP subgroups is required.

THE NEUROPHYSIOLOGICAL EFFECTS OF SPINAL MANIPULATIVE THERAPY ON PATIENTS WITH ACUTE AND SUBACUTE LBP

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PURPOSE: The purpose of this clinical study was to explore the neurophysiological response of low back pain patients (of 0-12 weeks' symptom duration) to manual therapy.

RELEVANCE: No previously published study has quantified the sympathetic nervous system (SNS) changes occurring in the lower limbs following manipulation, mobilization with movement (MWM), or McKenzie extension in lying (EIL) treatments within a clinical patient population.

METHODS: A quasi-experimental design recruited 59 patients who fulfilled the inclusion criteria. SNS recording of skin conductance response (SCR) was the primary outcome measure (OM), with recordings of pain levels (narrative pain rating scale [NPRS], 0-10) and function (Oswestry Disability Index [ODI], 0%-100%) being secondary OMs. Recordings were taken at treatment inception and at discharge.

RESULTS: Results revealed that a patient population had significantly greater SCRs than normal healthy subjects ($P < .005$) to all treatments and that manipulation, if performed in the first 6 weeks of symptom onset, resulted in greater SCRs and faster pain reduction and functional restoration ($P < .005$) than those treated from 6 to 12 weeks of symptom onset. The greatest SCRs were recorded following the manipulative technique, followed by MWM, then EIL. SCRs in excess of 163% at inception were able to predict a positive outcome (in pain reduction and ODI improvement greater than 50%) at discharge.

CONCLUSION: There is evidence to suggest that SCRs are a feasible method of quantifying treatment response at inception and of predicting a positive treatment outcome at discharge in patients with LBP of up to 12 weeks' symptom duration. Patients treated with lumbar manipulation within the first 6 weeks of symptom onset require fewer treatments and have better pain and functional outcomes than those treated after 6 weeks from onset of symptoms.

IMPLICATIONS: Clinical implications of this research would support the current clinical guidelines that early treatment with manipulative therapy improves and hastens patient outcomes.

EARLY USE OF THRUST MANIPULATION VERSUS NONTHRUST MANIPULATION: A RANDOMIZED CLINICAL TRIAL

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PURPOSE: The purpose of this study was to investigate the comparative benefit of early thrust or nonthrust manipulation.

RELEVANCE: One study exists that has compared the outcomes of thrust versus nonthrust manipulation in patients with low back pain (LBP). That study reported that the outcomes of thrust manipulation were much better than those that used nonthrust manipulation, but used a nonthrust technique that was markedly different from what is typically performed during clinical practice.

METHODS: The study was a single-blinded, randomized clinical trial that involved 103 patients, 18 years of age or older, with mechanically reproducible LBP with no signs of red flags or nerve root involvement. After randomization, patients received either thrust or nonthrust manipulation and a standardized home exercise program from physiotherapists with advanced training in manual therapy. After the first 2 visits, the physiotherapists were allowed to perform any treatment procedure they felt would be beneficial for the patient in addition to manual therapy. Pain,

perceived recovery, function, total visits, and total days of care were the outcomes assessed. A 2-way ANCOVA (which controlled for patient expectations and clinician personal equipoise) was the analysis tool.

RESULTS: There were no significant differences in the thrust and nonthrust groups' baseline characteristics ($P > .05$) or for any of the 5 outcome measures ($P > .05$).

CONCLUSIONS: The study demonstrates that early use of either thrust or nonthrust manipulation, used in a manner that is consistent with clinical practice, results in no differences in outcomes between groups.

IMPLICATIONS: For clinicians who either lack the training for thrust manipulation or are required to abstain from thrust manipulation secondary to state requirements, early use of nonthrust manipulation appears to be a useful alternative.

WHAT FACTORS ARE ASSOCIATED WITH A SUCCESSFUL OUTCOME IN PATIENTS WITH LOW BACK PAIN WHO RECEIVE A MANUAL THERAPY APPROACH?

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PURPOSE: The purpose of this study was to identify whether selected characteristics were associated with good prognosis (50% change or greater in Oswestry Disability Index [ODI]).

RELEVANCE: Identifying prescriptive treatment selections using single-arm analyses is not recommended when developing decision rules. Rather than influences from prescriptive treatment, findings of associations could be purely related to prognosis, which is a compliancy accorded to many recent clinical decision rules. Consequently, if a patient meets a decision rule that is affiliated with a specific intervention, one may erroneously apply that intervention alone when others may also be useful. Understanding prognosis is not without value. Determining the prognosis of a patient has been identified as a key evaluation objective during the client-patient management cycle.

METHODS: Data from 103 patients from a randomized controlled trial that involved 2 arms of manual therapy intervention (thrust and nonthrust manipulation) were pooled to form 1 group. A multivariate logistic regression analysis was used to identify prognostic factors among the baseline characteristics of duration of symptoms, irritability, pain score, fear-avoidance score, initial ODI score, met a clinical prediction rule (CPR) for thrust manipulation, and between-session changes (which involved a change from baseline to follow-up). Fifty percent change or greater in ODI was used as the outcome measure.

RESULTS: Significant prognostic variables included less than 20 weeks, duration of symptoms (OR = 14.1; 95% CI: 2.8, 70.4), positive between-session change (OR = 9.4; 95% CI: 1.8, 49.9), met CPR (OR = 3.3; 95% CI: 1.1, 9.7), and a negative finding of irritability (OR = 2.7; 95% CI: 1.0, 7.1).

CONCLUSION: The most compelling prognostic variable was duration of symptoms followed by a positive between-session change. A between-session change and meeting the CPR appear to be both prognostic and prescriptive.

IMPLICATIONS: Further work needs to clarify findings that are both prescriptive and prognostic.

CONSTRAINT-INDUCED THERAPY AND MOTOR CONTROL RETRAINING IN THE TREATMENT OF MUSICIANS' FOCAL HAND DYSTONIA: LONG-TERM FOLLOW-UP

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PURPOSE AND RELEVANCE: Focal hand dystonia (FHD) in musicians is a

painless task-specific motor disorder characterized by involuntary loss of control of individual finger movements. It is associated with decreased cortical inhibition and maladaptive cortical reorganization showing fusion of the representational zones of the digits in the primary somatosensory cortex. The aim of this study was to investigate the long-term effects of a combined behavioral therapy intervention, aimed at normalizing finger movement patterns.

METHODS: Eight musicians with FHD volunteered to take part. One year of intensive constraint-induced therapy and motor control retraining at slow speed were the interventions. A quasi-experimental repeated-measures (within-subjects) design was used, with 9 testing sessions over 4 years. Video recordings of the subjects playing 2 pieces were used for data analysis. The frequency of abnormal movements scale (FAM) was the main outcome measure. It was hypothesized that there would be significant differences in FAM scores achieved over the 4-year period.

RESULTS: The results from the 2-factor repeated-measures ANOVA revealed that the mean number of abnormal movements per second of instrumental playing decreased significantly by approximately 80% for both pieces over the 4-year period ($F = 7.85$, $df = 8$, $P < .001$). The Tukey post hoc test revealed that statistically significant improvements occurred after 6 months of therapy (values between $P < .001$ and $P = .044$). Although the results were not significant between month 12 and follow-up at year 4, a trend revealed that the progress achieved during the first year of intensive retraining was maintained at year 4.

CONCLUSIONS AND IMPLICATIONS: A 1-year period of intensive task-specific retraining may be a successful long-term strategy for the treatment of musicians' FHD. Results suggest that retraining strategies may need to be carried out for at least 6 months before statistically significant changes are noted.

SENSORY HYPERSENSITIVITY AND NOT SENSORY HYPOESTHESIA IS CHARACTERISTIC OF NONSPECIFIC ARM PAIN

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PURPOSE: This study sought to investigate pathophysiological mechanisms underlying nonspecific arm pain (NSAP) and compare them to cervical radiculopathy and healthy controls.

RELEVANCE: NSAP is a common clinical entity with poorly understood pathophysiological mechanisms. Improving knowledge regarding pathophysiological mechanisms is important to influence clinical decision making in the management of nonspecific musculoskeletal conditions.

METHODS: Participants with NSAP ($n = 40$), cervical radiculopathy (CR) ($n = 17$), and healthy controls ($n = 40$) underwent a neurological examination and tests of nerve trunk mechanosensitivity. In addition, quantitative sensory testing (QST) was assessed using a TSA 2000 NeuroSensory Analyzer (Medoc Ltd, Ramat Yishai, Israel). Data were analyzed using descriptive statistics, Kruskal-Wallis, Mann-Whitney U , and Wilcoxon signed-rank tests. Data from the NSAP group were also analyzed using exploratory factor analysis.

RESULTS: Significant group differences were found for all QST measures. Thermal pain thresholds were significantly lower for NSAP than CR and controls ($P < .05$). Thermal detection thresholds and vibration thresholds were significantly elevated in CR compared to NSAP and controls ($P < .05$). Pressure pain thresholds were significantly lower in NSAP and CR versus controls. Factor analysis revealed that thermal pain thresholds, nerve trunk mechanosensitivity, and pressure pain thresholds were predictive of NSAP group allocation.

CONCLUSIONS: NSAP was characterized by sensory hypersensitivity involving thermal hyperalgesia, nerve trunk mechanosensitivity, and pressure pain hyperalgesia. Sensory hypoesthesia was not evident in NSAP but was found to be a key characteristic of CR.

IMPLICATIONS: Possible pathophysiological mechanisms underlying NSAP

appear to differ from those in CR. The results from this study indicate that clinical and QST findings for CR are consistent with the presence of a neuropathy, whereas those of NSAP are consistent with sensory hypersensitivity in the absence of neuropathy. These findings should influence clinical decision making in people with NSAP.

SOMATOSENSORY PROFILES IN NONSPECIFIC ARM PAIN AND MATCHED HEALTHY CONTROLS

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PURPOSE: The aim of this study was to describe the somatosensory profiles of people with nonspecific arm pain (NSAP) in terms of sensory gain and/or sensory loss.

RELEVANCE: NSAP is a common clinical entity with poorly understood pathophysiological mechanisms. A mechanism-based approach to pain classification has been advocated; however, few data exist regarding pain mechanisms in NSAP. Analysis of somatosensory profile graphs has been considered useful in identifying the presence of sensory gain or sensory loss and may be important in influencing clinical decision making.

METHODS: Participants with NSAP ($n = 40$) and matched healthy controls ($n = 40$) underwent a comprehensive quantitative sensory testing (QST) protocol using a TSA 2001 NeuroSensory Analyzer (Medoc Ltd, Ramat Yishai, Israel). QST profile graphs for individual participants were generated using z scores for QST parameters using the formula: z score = (x single participant - mean controls)/SD controls. A somatosensory profile was identified as abnormal if a QST parameter was found to be greater or less than 1.96 z scores from the mean. QST profiles were categorized as normal, sensory loss, sensory gain, or mixed gain and loss.

RESULTS: Sensory abnormalities were identified in 95% of the NSAP group and 55% of controls. Mixed sensory gain and loss affected 40% of NSAP and 17% of controls. Sensory gain was identified in 30% of NSAP and 22% of controls. Sensory loss affected 25% of NSAP and 15% of controls.

CONCLUSIONS: The finding of at least 1 sensory abnormality was prevalent in participants with NSAP, with sensory gain or mixed sensory gain and loss being the most common classifications.

IMPLICATIONS: The level of sensory "abnormalities" identified in healthy controls as well as the presence of bilateral sensory abnormalities in people with unilateral NSAP suggests that caution should be exerted in interpreting individual QST data.

VELOCITY OF ISOKINETIC TRUNK EXERCISES INFLUENCES BACK MUSCLE RECRUITMENT PATTERNS IN HEALTHY SUBJECTS

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PURPOSE: To investigate both relative trunk muscle activity and ratios of local to global trunk muscle activity at different velocities (30°/s, 60°/s, 90°/s, and 120°/s) of isokinetic movements on a Cybex dynamometer.

RELEVANCE: Although isokinetic exercises at different angular velocities are often used for assessment and therapy in patients with chronic low back pain, little is known about the effect of velocity on the muscle activity.

METHODS: Fifty-three healthy employees of Belgian Defence (26 men and 27 women) aged between 20 and 57 years voluntarily performed isometric and isokinetic exercises at 4 different velocities on a Cybex NORM dynamometer (standing position). Surface electromyographic signals of the internal and external obliques (IO and EO), the lumbar multifidus (MF), and the thoracic part of iliocostalis lumborum (ICLT) were recorded on both sides.

RESULTS: The relative muscle activity of the back muscles was significantly lower for 120°/s. The ratio MF/ICLT during extension was significant-

ly lower for the velocities 30°/s and 90°/s, compared to the ratio at 120°/s ($P \leq .027$). Independent of the age of the subjects and the velocity of the isokinetic exercise, the ratio MF/ICLT was significantly higher for the men ($P < .001$) in comparison to the women. The ratio IO/EO was significantly higher for the women ($P = .051$) in comparison to the men.

CONCLUSIONS: Both the relative muscle activity and the local-to-global muscle activity ratio of the back muscles, but not of the abdominal muscles, were affected by changes in velocities of isokinetic exercises. The global muscle system was more influenced by changes in velocity than the local muscle system.

IMPLICATIONS: This study emphasizes the need to test and train at different velocities in function of the aim. In accordance with the gender differences demonstrated in the back and abdominal muscle activity ratios, the training programs of men and women should be different.

EFFECTS OF LOW- AND HIGH-LOAD MOTOR CONTROL EXERCISES ON LUMBAR CURVATURE DURING STANCE IN PATIENTS WITH LOW BACK PAIN

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Research guidelines recommend evaluating different treatments in defined subgroups of patients with low back pain. The aim of the present study was to compare the effects of 2 training regimes, low- versus high-load motor control training, on the lumbar curvature during stance in patients with peripherally mediated mechanical low back pain. As a measure of the curvature, we used the angle of the sacrum (SA) and the posterior projection (PP), calculated from X-rays. The study intended to contribute to the knowledge about whether loading intensity of the exercise regime influences the curvature. Seventy patients with movement control impairments were randomized into one of two 12-session exercise groups. All physiotherapists in charge of the training emphasized movement quality. Those conducting the low-load group focused on posture, teaching the patients to avoid provocative movement patterns, to reduce activity in overactive 2-joint mobility muscles, and to increase activity in local and global stabilizers. The physiotherapists of the high-load group taught the patients the deadlift exercise that, after a period of technique training and neural adaptation, was progressed by increasing the weights. A paired-samples *t* test showed that training regime did not influence the SA but had an effect on PP. However, an independent-samples *t* test showed that this effect did not significantly differ between the groups. It was concluded that the instruction to maintain a neutral lumbar posture during training might influence the PP but not the SA regardless of the load of the exercises. This study provides insights into the contribution of the rehabilitation approach to changes in spinal alignment. Stringency of movement quality when performing the exercise may have crucial importance, but it is still unclear whether high- or low-load exercises should be preferred. Furthermore, the clinical importance of changes in spinal curvature requires testing in future studies.

THE EFFICACY OF DIRECTIONAL PREFERENCE MANAGEMENT FOR LOW BACK PAIN: A SYSTEMATIC REVIEW

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PURPOSE: To determine the efficacy of treatment using the principles of directional preference management (DPM) for people with low back pain (LBP) and a directional preference (DP).

RELEVANCE: Providing specific treatment based on symptom response for people with LBP and a DP is a widely used treatment approach. The efficacy of treatment using the principles of DPM for LBP is unclear.

METHODS: This study was an update of a published systematic review by the same author group. Computer databases were searched for randomized controlled trials (RCTs) published in English up to October 2011.

Only RCTs investigating DPM for people with LBP and a DP were included. Outcomes for pain, back-specific function, and work participation were extracted. A qualitative analysis using the GRADE approach was performed.

RESULTS: Seven RCTs (with a total of 781 participants) were included in this review. Six trials were considered high quality. Clinical heterogeneity of the included trials prevented meta-analysis. GRADE quality assessment revealed mixed results; however, moderate evidence was identified that DPM was significantly more effective than a number of comparison treatments for pain, function, and work participation at short, intermediate, and long-term follow-up. No trials found that DPM was significantly less effective than comparison treatments.

CONCLUSIONS: Some evidence was found supporting the effectiveness of DPM when applied to participants with a DP, particularly at short-term and intermediate-term follow-up. However, the evidence was in general mixed, with a number of trials revealing conflicting results or showing no effect.

IMPLICATIONS: Further high-quality RCTs are warranted to evaluate the effect of DPM applied to people with LBP and a DP. Future research should consider replication of existing trials that showed large effects and detailed operational definitions of classification and treatment protocols.

RELIABILITY AND VALIDITY OF A KINEMATIC SPINE MODEL DURING ACTIVE TRUNK MOVEMENTS IN HEALTHY SUBJECTS AND NONSPECIFIC LBP

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PURPOSE: Develop a standardized, reliable, and valid spine model of active trunk movements to discriminate kinematic patterns of patients with NSCLBP from those of healthy subjects.

RELEVANCE: Quantitative outcome measures for clinical trials in manual therapy.

METHODS: Two groups (30-65 years): healthy ($n = 25$) and NSCLBP ($n = 25$). Subjects performed 7 different tasks of trunk movements from a sitting position at nonimposed speed during 2 sessions. Nine markers were placed on bony landmarks to measure the range of motion (ROM) and the speed of 5 spinal segments, recorded by 8 optoelectronic cameras.

RESULTS: Both groups showed good to excellent reliability in all tasks for the kinematic variables (ROM and speed) of all the spinal segments (ICCs = 0.70-0.96; SEM, 19.4%-3.3%). The minimal detectable change (MDC) in the NSCLBP group ranged from 16.7% to 53.7%. Comparison between groups showed significant ($P < .05$) to highly significant *P* values ($P < .001$), with large to very large effect sizes (Cohen $d = 0.6-2$) for ROM and speed of all spinal segments in trunk flexion, rotation, and flexion-with-rotation tasks. In these tasks, the best sensitivity values were found for speed variables (80%-92%), and the best specificity values for ROM variables (72%-100%). The best compromise between sensitivity and specificity was found for speed variables. On the contrary, comparison between groups for lateral sidebending tasks revealed inconsistent results between spinal segments.

CONCLUSION: Kinematic variables are valid and reliable measures.

IMPLICATIONS: These tasks can be used to assess NSCLBP patients in clinical practice to help in diagnosis and for the evaluation of treatment management, as well as quantitative outcome measures for interventions in clinical trials.

RADIOLOGICAL AND CLINICAL ANALYSIS OF THORACIC SPINE EXTENSION MOTION ASSOCIATED WITH BILATERAL ARM ELEVATION

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PURPOSE: To measure thoracic spine extension motion during bilateral arm elevation using functional radiography and photographic image

analysis in young, asymptomatic men.

RELEVANCE: Extension motion of the thoracic spine is considered important in achieving normal shoulder girdle function. However, thoracic motion during arm elevation has not been examined in men and has not been directly measured using functional radiographic analysis.

METHODS: In 21 asymptomatic male participants (mean \pm SD age, 22.6 \pm 3.2 years), the thoracic kyphosis was measured in neutral standing and in end-range bilateral arm elevation. The difference between positions was used to define the range of thoracic extension motion. Clinical measurements were obtained from digital photographs, and radiographic analysis was performed using a vertebral centroid technique. Bland-Altman plots were used to examine the agreement between measurement techniques. The relationship between the thoracic kyphosis in neutral and in full arm elevation was examined using linear regression analysis.

RESULTS: The mean \pm SD range of thoracic extension motion was 12.8° \pm 7.6° (range, 0°-26°) and 10.5° \pm 4.4° (range, 3°-17°) when measured from the radiographs and photographs, respectively. The radiographic and photographic measurements were significantly correlated in neutral ($r = 0.71$) and arm elevation ($r = 0.82$). The mean difference between techniques was 2.1° in neutral and 0.5° in arm elevation. The neutral thoracic kyphosis angle was significantly correlated with the thoracic kyphosis in end-range arm elevation (radiographs: $r = 0.78$; photographs: $r = 0.84$).

CONCLUSIONS: In asymptomatic men, bilateral arm elevation is associated with movement of the thoracic spine toward extension, but the amount of movement is variable between individuals. The kyphosis in arm elevation may be influenced by the neutral spine posture.

IMPLICATIONS: Clinical examination of patients with shoulder pain should include an evaluation of thoracic spine posture and extension motion. Photographic analysis provides a good representation of the thoracic kyphosis and change in thoracic spine posture during arm elevation.

MANUAL THERAPY APPLIED TO THE FASCIA SYSTEM

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PURPOSE: To describe a practice-based evidence approach to fascial manual therapy where clinical hypothesis generation is supported by current research.

RELEVANCE: Joint mobilization/manipulation and exercise are excellent tools in the treatment of biomechanical dysfunction, yet there are many patients who still have pain and functional limitation despite having been exposed to what evidence suggests is the best available treatment. Applying manual therapy techniques to the fascial system appears to offer further benefit to patients with orthopaedic complaints.

EVALUATION: Recognizing the continuity of fascia, movement was retested once fascial planes were engaged, uncovering restriction that, when mobilized, seemed to consistently decrease pain, increase range, and improve function. (Case examples will be presented along with anatomical dissection photos.) These clinical observations led to hypothesis generation about fascial properties that were then searched in the literature. Historically, fascia has been largely ignored by the traditional healthcare community as the body has been compartmentalized, de-emphasizing its continuity. Fascia is also considered difficult to research due to its ubiquitous nature. However, recent international scientific conferences dedicated to fascia research indicate a shift to mainstream science. A brief review of current fascia research will be presented illustrating that fascia is continuous throughout the body, innervated with mechanoreceptors and nociceptors as well as distributing force, thus playing a large mechanical role. Manual therapy-type forces applied to fascia in laboratory settings have been shown to have beneficial effects at the cellular level.

CONCLUSIONS: The fascial system is an ubiquitous, innervated force distributor that can restrict movement and generate pain. Clinical observation and laboratory findings suggest a beneficial effect of manual therapy on fascial tissues. Current research is consistent with the clinical hypotheses.

IMPLICATIONS: Adding fascial evaluation and management may supple-

ment the clinician's toolkit and improve patient outcomes.

WHAT DO PHYSIOTHERAPISTS CONSIDER TO BE THE BEST SITTING SPINAL POSTURE?

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PURPOSE: To investigate the perceptions of physiotherapists on the best seated spinal posture, how this perception varies between countries, and what factors may influence these perceptions.

RELEVANCE: Prolonged sitting commonly aggravates low back pain (LBP), and postural advice is a mainstay of physiotherapy clinical practice. However, it is unclear what physiotherapists consider to be the best sitting posture.

METHODS: Two hundred ninety-five physiotherapists attending clinical workshops on LBP in 4 European countries selected their best sitting posture from a series of photographs. Physiotherapists also completed the Back Beliefs Questionnaire (BBQ). Chi-square analysis was used to examine if specific postures were selected more frequently, and how this varied between countries. Differences between physiotherapists selecting various postures were examined using Mann-Whitney *U* tests. Qualitative comments on each posture were categorized into common themes.

RESULTS: Eighty-five percent of physiotherapists selected 1 of 2 lordotic postures as their best sitting posture, with 1 posture being selected significantly more frequently ($P < .05$). Interestingly, these 2 most frequently selected postures differed greatly in their thoracic spine curvature. The choice of best sitting posture also varied between countries ($P < .05$). Those who selected more upright sitting postures had more negative LBP beliefs ($P < .05$).

CONCLUSIONS: Overall, disagreement remains on what constitutes the best sitting posture. Lordotic sitting postures were most commonly selected, with thoracic posture varying considerably. Seated postures that matched the natural spinal curve and appeared relaxed were often deemed advantageous. More negative beliefs about LBP may be linked to selecting upright seated postures due to physiotherapists' fears about spinal vulnerability in LBP.

IMPLICATIONS: Considering the disagreement among physiotherapists on what constitutes the best sitting posture, it is likely that people with LBP receive inconsistent postural advice. Further research on the perceptions of people with LBP on the best sitting posture is ongoing.

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THE SLUMP TEST: A SCREENING TOOL FOR NEUROPATHIC PAIN

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The early detection of neuropathic pain plays a key role in directing appropriate referrals to specialists as well as treatment. The purpose of this study was to assess the suitability of the slump test as a screening tool for neuropathic pain. A concurrent validity design was used to compare the diagnostic outcome of a thorough clinical examination to that of the slump test. Subjects with subacute or chronic low back pain were categorized as having neuropathic pain (NeP) or nonneuropathic pain (NNP) by an experienced clinician using an established diagnostic algorithm. All subjects were then independently assessed for the presence of NeP using the slump test. A conventional slump test was performed and the outcome designated positive if knee extension differed by 10° or more from the unaffected side, unilateral leg pain was reproduced by the test, and/or the pain was reduced with cervical extension. Novel qualifiers, including pain reproduced below the knee and verbal pain descriptors associated with neuropathic pain, were also recorded during the slump test. The outcome of the slump test, with and without qualifiers, was compared to the reference diagnosis from the clinical examination. The convention-

al slump test displayed high sensitivity (0.91) and moderate specificity (0.70; +LR = 3.03; -LR = 0.13) for NeP. When the requirement for pain extending below the knee was added to the criteria for a positive slump test, sensitivity was reduced (0.59) but specificity dramatically increased (0.95; +LR = 11.8; -LR = 0.43). Combining the results, a negative outcome from the conventional slump test would effectively rule out NeP (-LR = 0.13), whereas a positive outcome from the modified slump test (pain reproduced below the knee) would rule in NeP (+LR = 11.8), indicating potential for the slump test to provide a simple and highly effective screening tool for NeP.

ARE CHILD-BEARING HIPs A RISK FACTOR FOR GREATER TROCHANTERIC PAIN SYNDROME? A CASE-CONTROL STUDY

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PURPOSE: To determine if pelvic or hip width predisposed women to greater trochanteric pain syndrome (GTPS).

METHODS: A prospective case-control study: 32 women with GTPS, 20 women having gluteal tendon reconstructions (GTR), 20 women with severe hip osteoarthritis (OA), and 21 asymptomatic (ASC) women were recruited. Anatomical landmarks from anterior/posterior pelvic X-rays were measured, providing the femoral neck shaft angle (NSA), acetabular index, and the following ratios: anterior inferior iliac spine (AIIS)-lateral acetabulum, AIIS-superior greater trochanter, AIIS-lateral greater trochanter, and superior greater trochanter-lateral greater trochanter. Measures of BMI, waist, hip, and greater trochanter girth were taken, with waist-hip and waist-greater trochanter ratios calculated. Data were analyzed via 1-way ANOVA with post hoc Scheffé analysis, and multivariate analysis.

RESULTS: The GTR group had a lower NSA than the other groups ($P = .007$). The odds ratio (95% CI) of having an NSA of less than 134° , relative to the ASC group, was: 3.33 (1.26, 8.85) for GTR, 1.4 (0.52, 3.75) for GTPS, and 0.85 (0.28, 2.61) for OA participants. No group difference was found for the pelvic or hip ratios, BMI, or girth measures other than at the greater trochanter (mean ASC, 99.1 cm; 95% CI: 94.7, 103.5; mean GTPS, 105.9 cm; 95% CI: 100.2, 111.6; mean GTR, 103.8 cm; 95% CI: 100.3, 107.3; mean OA, 100.3 cm; 95% CI: 97.7, 103.9) (ANOVA: $P = .036$). Multivariate analysis found that GTPS and GTR participants had a positive association with higher adiposity.

CONCLUSION: The risk of GTPS associated with female anthropometry lies in the NSA, increased adiposity, and adipose distribution.

IMPLICATIONS: A lower NSA probably increases the compression of the gluteus medius tendon on the greater trochanter. Further, higher levels of adiposity are a likely contributor to developing gluteal tendinopathy.

GLUTEUS MINIMUS ACTIVATION IS EARLIER IN SUBJECTS WITH HIP PAIN: A NONINVASIVE STUDY BY M-MODE ULTRASOUND IMAGING

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PURPOSE: To measure the timing of gluteus medius (Gmed) and minimus (Gmin) activation during step-down in subjects with hip pain and controls using M-mode ultrasound.

RELEVANCE: The noninvasive measurement of both superficial and deep muscle activity is required for assessing muscle activation patterns within the hip abductors. A redistribution of abductor activity has been suggested in early hip joint degeneration.

METHODS: Thirty-five subjects with anterior, nontraumatic hip pain (mean \pm SD age, 54 ± 8.6 years; 20 women) and 35 controls (mean \pm SD age,

57 ± 6.6 years; 23 women) were scanned on the lateral hip of the leading leg during 6 repetitions of step-down onto a force platform using M-mode ultrasound. In 3 depth levels of the abductors, superficial Gmed, deep Gmed, and Gmin, onset of initial foot contact, timing of peak ground reaction force, and, in M-mode, onset of 3 intensities of muscle tissue motion were measured using computerized detection. The time lag between onsets of muscle motion and force was normalized to loading velocity, averaged per subject, and compared by ANOVA between groups.

RESULTS: Subjects with pain demonstrated earlier activation of the 3 abductor levels. The mean difference of high-intensity motion onset was most marked in Gmin, with 81 milliseconds ($P = .01$); superficial Gmed was 62 milliseconds earlier ($P = .03$), and the deep Gmed was 31 milliseconds ($P = .32$).

CONCLUSIONS: M-mode ultrasound enables clinically relevant, noninvasive measurements of deep muscle activity. Hip pain affects motor performance of the hip abductors in a depth-dependent pattern, with the strongest effect on Gmin.

IMPLICATIONS: The M-mode assessment of muscle activation needs further scientific exploration regarding interpretation and applicability. Therapy to address selective Gmin activation needs to be developed.

THE EFFECT OF MANUAL THERAPY APPLIED TO PATIENTS WITH MENISCUS TEAR: A CASE SERIES WITH A MINIMUM OF 6 MONTHS OF FOLLOW-UP

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PURPOSE: To present the effects of using manual therapy in patients who had knee pain related to degenerative meniscus tear.

RELEVANCE: Eight weeks of (twice per week) physical therapy were reported in 2 studies to have resulted in 16% to 25% improved Lysholm knee scores in patients with degenerative meniscus tear. However, only therapeutic exercises (not manual therapy) were incorporated in the conservative management, as disseminated by the published reports.

CASE DESCRIPTION: A series of 5 patients with a mean \pm SD age of 58 ± 7.8 years (90% CI) had an initial Lower Extremity Functional Scale (LEFS) average \pm SD of 35.8 ± 11.4 (90% CI) out of 80. The patients presented with knee pain and MRI evidence of degenerative meniscus tear. Decreased knee varus mobility was noted in all patients. Therefore, knee varus mobilization was utilized as a specific manual therapy technique in these patients.

RESULTS: Patients were seen for 3.0 ± 0.9 (90% CI) visits, resulting in a final LEFS average of 59.4 ± 10.6 (90% CI). Other impairments were addressed after the final LEFS was collected to isolate the effect of manual therapy. The change from initial to final LEFS score was 66%, and this was achieved within 1 month. Finally, the follow-up (6-month minimum) LEFS score collected had an average of 57.6 ± 6.53 (90% CI). In summary, manual therapy compared favorably with conventional exercises (based on percent improvement in function, cumulative total number of visits, and treatment duration).

CONCLUSIONS: Manual therapy as applied to patients who presented with (MRI evidence of) degenerative meniscus tear resulted in positive outcome. However, care must be taken not to extrapolate these results in similar patients until more study is done to determine cause and effect.

IMPLICATION: Manual therapy offers a promising and viable alternative to traditional exercises for nonoperative intervention of degenerative meniscus tear.

PREDICTORS OF GROIN AND LOWER-LIMB INJURY ACROSS FOUR CODES OF FOOTBALL

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PURPOSE: Identifying predictors of lower-limb injury across codes of football may assist in the development of programs to prevent injury, reducing the associated costs to the player and team.

RELEVANCE: Lower-limb and groin pain results in considerable lost time from sporting participation, threatens continued participation, and incurs significant social and economic costs for individuals and institutions/clubs.

METHODS: Three hundred thirty-one male semi-professional Australian Rules Football (n = 91), Rugby League (n = 87), Rugby Union (n = 96), and soccer (n = 53) players who were injury free at inception, having never experienced groin injury, participated in the study. Preseason screening quantified 14 possible predictor variables, and all participants were followed weekly for a full competition season to determine injury (defined as loss of game and training time and inability to participate fully in training). Four participants were lost to the study. Univariate analysis determined which predictors were intercorrelated and could be excluded from the analysis, followed by stepwise linear regression to determine predictors.

RESULTS: Twenty participants incurred groin injuries over the season, 8 of which occurred in Australian Rules Football. Poor preseason preparation, poor single-leg dynamic balance, excessive hip rotation, and poor hip abduction range predicted groin injury in this code. Predictors of non-groin injury varied widely across the 4 codes, with anthropometric variables (BMI and pelvic width) and performance variables (single-leg dynamic balance and hip range of movement) figuring strongly.

CONCLUSIONS: Predictors for both groin and general lower-limb injury vary widely across the 4 codes of football commonly played in Australia. Increased hip internal rotation appears to be a consistent predictive factor for injury in this cohort.

IMPLICATIONS: No single set of predictors explains the time lost to training and competition across the codes, and team medical staff would be wise to address code-specific predictors as outlined in the study.

CLASSIFICATION OF SAGITTAL STANDING ALIGNMENT AND ITS RELATIONSHIP TO SPINAL PAIN: A STUDY AMONG PRE-PEAK HEIGHT VELOCITY SUBJECTS

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PURPOSE: To construct a sagittal standing alignment classification system in which the clinical significance of identified subgroups was considered with spinal pain measures.

RELEVANCE: Although postural classification appears to be part of routine practice, no universal consensus exists about which typology should be adopted. Limited epidemiological data support the belief that posture is associated with spinal pain.

METHODS: The study population consisted of 639 pre-peak height velocity (pre-PHV) boys (mean ± SD age, 12.6 ± 0.54 years) and 557 pre-PHV girls (mean ± SD age, 10.6 ± 0.47 years). Using quantitative posture data, participants were classified in postural categories (cluster analyses) both on a gross body segment and lumbopelvic level. Prevalence rates of spinal pain measures (pain and seeking care) were compared between postural subgroups (logistic regression).

RESULTS: A 2-level subject typology was obtained with 3 major global alignment categories (neutral, swayback, and leaning forward), and 12 lumbopelvic subcategories. In pre-PHV boys, higher odds (1.722-3.244)

were found for low back pain and neck pain prevalence (lifetime and 1 month) in those classified as having a swayback posture when compared with those having neutral global alignment. The study's effect size, however, was small (Nagelkerke $R^2 \leq 0.044$). On a lumbopelvic level, no associations between posture subtypes and spinal pain measures were significant. In pre-PHV girls, spinal pain measures did not differ between posture types.

CONCLUSIONS: Clinically meaningful posture clusters of pre-PHV subjects exist based on their individual standing profile. In pre-PHV boys, an association was found between global alignment categorization and pain prevalence in the more mobile areas of the spine (namely, the lumbar and cervical areas). In contrast, this study provides no evidence to suggest that posture is a short-term risk factor for spinal pain in pre-PHV girls.

IMPLICATIONS: Long-term multifactorial follow-up will be necessary to assess the importance of habitual posture as a potential risk factor for developing spinal pain up to adulthood.

EFFECT OF DIFFERENT COGNITIVE DUAL TASKS ON POSTURAL SWAY AND TRUNK STIFFNESS IN CHRONIC LOW BACK PAIN PATIENTS COMPARED TO HEALTHY CONTROLS

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PURPOSE: Low back pain patients often show larger postural sway compared to healthy control subjects, which indicates impairments in sensorimotor control. The purpose of this study is to investigate the effect of different cognitive dual tasks on sitting postural sway and trunk stiffness in chronic low back pain (CLBP) patients compared to healthy control subjects.

RELEVANCE: Cognitive dual tasks are used to investigate the role of the cognitive systems and the amount of attention demand in postural control. Numerous types of dual tasks are used to investigate the effect on postural control. The type of dual task might influence the outcome.

METHODS: A total of 20 CLBP patients and 20 control subjects were included based on clinical criteria. The postural control tests were performed with and without cognitive dual tasks. Three different types (counting, memory, and spatial memory) of cognitive tasks were utilized. A 3-D motion analysis system was used to measure postural sway of trunk and pelvis in 3 cardinal planes. These data were used to evaluate motor control by means of postural sway and trunk stiffness.

RESULTS: The counting dual task had a significantly different effect from the memory and spatial memory tasks within the control group. The counting dual task also had a significantly different effect between both test groups. In the CLBP group, the counting task led to increase in postural sway and increase in trunk stiffness. The control group showed decreased postural sway and decreased trunk stiffness.

CONCLUSION: Different cognitive dual tasks led to different effects on postural control within the control group. Depending on the type of dual task, the effect was also different between CLBP patients and healthy controls.

IMPLICATIONS: Interpretation of the influence of cognitive dual tasks on postural control must be made carefully and situated under the specific conditions that were used.

PHASE ANALYSIS OF MULTISEGMENTAL SPINE KINEMATICS AT 2 GAIT SPEEDS

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PURPOSE: To track the kinematic behavior of the spine, at multiple segmental levels, at 2 gait speeds.

RELEVANCE: Intersegmental kinematic data from the spine will allow us to increase our understanding of the relationship between spinal motions

during gait and low back pain (LBP).

METHODS: A 29-year-old male, with a history of recurrent LBP, walked on a treadmill at 2 speeds: 0.75 m/s and 1.50 m/s. Ten consecutive gait cycles were collected at each speed. Electromagnetic 3-D motion sensors were mounted over the thighs, the sacrum (S1), and the spinous processes of L3, T12, T9, T6, T3, and C7. Mean angular position and phase offset relative to S1 were determined for each spine segment.

RESULTS: Segment motions in the sagittal and frontal planes were biphasic at all levels, corresponding to the step cycles of the lower limbs, with increased amplitudes of movement at 1.50 m/s. In the transverse plane, movements at 0.75 m/s were largely monophasic, but tended toward a more biphasic pattern, particularly at S1 at 1.50 m/s. Segmental phase offsets showed a general trend toward increasing out-of-phase behavior

relative to S1, in the caudocranial direction, although this pattern was reversed in the sagittal plane at 1.50 m/s. The most notable findings, however, were in the transverse plane. Phase offsets were greater at 1.50 m/s (90° or greater) compared with 0.75 m/s (less than 45°). A deviation from the caudocranial progression was also noted at 0.75 m/s, related to a brief deviation from the otherwise sinusoidal trajectories of S1 and L3 near the start of left stance. This occurred in 9 of 10 gait cycles, and may be indicative of a clinical instability.

CONCLUSIONS: The results demonstrate measurable intersegmental motions, distinctive phase offsets during gait, and a potentially pathological movement pattern between L3 and S1.

IMPLICATIONS: Detailed, segmental analysis of spine motion may have clinical applications for the identification of pathology.