Manual Therapy 20 (2015) 378–387

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Masterclass

Proprioception in musculoskeletal rehabilitation. Part 2: Clinical assessment and intervention

Nicholas C. Clark [a,*], Ulrik Röijezon [b], Julia Treleaven [c]

[a] School of Sport, Health, and Applied Science, St Mary's University, Twickenham, London, United Kingdom
[b] Department of Health Sciences, Luleå University of Technology, Luleå, Sweden
[c] CCRE Spine, Division of Physiotherapy, SHRS, University of Queensland, Brisbane, Australia

ARTICLE INFO

Article history:
Received 6 November 2014
Received in revised form
4 January 2015
Accepted 15 January 2015

Keywords:
Proprioception
Musculoskeletal rehabilitation
Assessment
Intervention

ABSTRACT

Introduction: Proprioception can be impaired in gradual-onset musculoskeletal pain disorders and following trauma. Understanding of the role of proprioception in sensorimotor dysfunction and methods for assessment and interventions is of vital importance in musculoskeletal rehabilitation. In Part 1 of this two-part Masterclass we presented a theory-based overview of the role of proprioception in sensorimotor control, causes and findings of altered proprioception in musculoskeletal conditions, and general principles of assessment and interventions.
Purpose: The aim of this second part is to present specific methods for clinical assessment and interventions to improve proprioception in the spine and extremities.
Implications: Clinical assessment of proprioception can be performed using goniometers, inclinometers, laser-pointers, and pressure sensors. Manual therapy, taping, and bracing can immediately enhance proprioception and should be used to prepare for exercise interventions. Various types of exercise (active joint repositioning, force sense, co-ordination, muscle performance, balance/unstable surface, plyometric, and vibration training) should be employed for long-term enhancement of proprioception.

1. Introduction

Proprioception is essential for well-adapted sensorimotor control. Proprioception fulfills roles in feedback and feedforward sensorimotor control and regulation of muscle stiffness, being specifically important for movement acuity, joint stability, co-ordination, and balance. Cervical proprioception is uniquely important for head-eye co-ordination and movement control. Proprioception can be disturbed in musculoskeletal disorders due to pain, effusion, trauma, and fatigue. A variety of assessment procedures and interventions have been developed to specifically test and enhance proprioception, respectively. We present an overview of clinical assessment and intervention methods for proprioception of the spine and extremities. Reference is made to research where interventions have been reported to demonstrate positive effects on proprioception. A special focus is made on exercise therapy.

* Corresponding author.
E-mail address: Nicholas.Clark@stmarys.ac.uk (N.C. Clark).

http://dx.doi.org/10.1016/j.math.2015.01.009
1356-689X/

2. Clinical assessment of proprioception

Clinical assessment of proprioception should employ tests for measuring joint position sense (JPS), kinesthesia, or force sense (Roijezon et al., 2015). In the laboratory, custom-built devices or expensive computer-interfaced equipment are frequently employed (Lephart et al., 1994; Borsa et al., 1997; Docherty et al., 1998; Waddington et al., 2000; Callaghan et al., 2002; Docherty and Arnold, 2008; Benjaminse et al., 2009; Learman et al., 2009), but are typically impracticable in the clinical setting. Researchers and clinicians have attempted to develop clinical tests for the spine and extremities, although some tests are more developed for some body parts (e.g. cervical spine) than others. Further development and refinement of clinical tests is needed.

2.1. Clinical apparatus

Goniometers, inclinometers, pressure sensors, and laser-pointers are affordable and easy-to-use in a clinical context. There is also scope for new affordable and accurate technology that includes smartphones with built-in accelerometers and gyros, camera systems such as the Kinect, the Wii Balance Board, and other video-based technology.

2.2. Specific tests

2.2.1. Joint position sense

For the cervical spine, active JPS testing can use a laser-pointer attached to a headband to determine patients' ability to relocate to the neutral starting position with the eyes closed after performing an active head movement (e.g. right rotation) (Fig. 1). The difference between the starting and end position can be measured in millimetres, and the joint position error then calculated in degrees (Roren et al., 2009; Chen and Treleaven, 2013). This method is reliable and valid when compared to sophisticated laboratory equipment (Swait et al., 2007; Roren et al., 2009; Chen and Treleaven, 2013). Errors greater than 4.5° are considered to indicate abnormal cervical active JPS. Others have used the cervical range of motion (CROM) device to measure cervical active JPS and found this to also be a reliable and valid method (Wibault et al., 2013; Treleaven et al., 2015).

For the extremity joints, goniometers (universal, bubble, digital) can also be used to measure active JPS. The sequence of events is the same as that described for laboratory measurement of active JPS (see Masterclass Part 1) (Roijezon et al., 2015). Depending on the device used and the extremity joint measured, reliability and measurement error of active movement goniometry can range widely (Gabbe et al., 2004; Lephart et al., 2007; Dickson et al., 2012; Kolber and Hanney, 2012; Hamid et al., 2013), and this should be carefully considered if goniometry is used to measure active JPS of extremity joints. For the shoulder joint, laser-pointer active JPS tests have also been developed and show promise in those with and without shoulder injury (Balke et al., 2011). There is potential for using the laser-pointer to measure JPS in other joints but, to date, there is limited research.

2.2.2. Kinesthesia

For the cervical spine, kinesthesia can be assessed by following a trace or intricate pattern as accurately as possible. This can be a visual trace (e.g. figure-of-eight, zig-zag pattern) (Woodhouse et al., 2010) or by following a computer generated marker that is moving in a more unpredictable pattern (e.g. "the fly") (Kristjansson et al., 2004). Outcome variables usually used here are the mean displacement or time on target. Advances in smart phone sensors have made "the fly" technology more readily accessible to clinicians (Kristjannson, 2014), although recent work has also been conducted to investigate the feasibility of a low cost quantitative method using video analysis of the patient tracing a pattern with a head-mounted laser (Pereira et al., 2015).

Fig. 1. Cervical Joint Position Sense Assessment. The patient is seated with the laser pointer attached to a headband, 90 cm from the target. The target is adjusted so that the laser projects to the centre of the target. They are asked to concentrate on this resting head position and then close the eyes. They then perform an active movement to comfortable limits and return to the resting head position as accurately as possible. The difference between the initial and end position can be measured in millimetres and then converted to degrees.

2.2.3. Force sense

Force sense can be measured by the accuracy of reproducing a specific target force. For example, the pressure biofeedback device used for assessing the cranio-cervical flexion test could be considered a method of assessing force sense in the cervical spine (Jull, 2000). The ability to hold steadily or the accuracy in achieving and maintaining a desired pressure can be used. Others have also used custom-made dynamometry placed at the mandible to measure precision and accuracy of maintaining low load upper cervical flexor force levels (O'Leary et al., 2005).

2.3. Non-specific tests

2.3.1. Balance tests

Balance tests, such as timed single-leg stance tests, have historically been used to measure lower extremity (e.g. ankle) proprioception. As discussed previously (see Masterclass Part 1) (Roijezon et al., 2015), these tests are not specific tests of proprioception since balance is a product of integrating sensory, central nervous system (CNS), and motor functions (Macpherson and Horak, 2013). Nevertheless, balance tests could potentially give an indication of improvement following proprioceptive training. Balance tests can be modified to try to bias proprioception by, for example, closing the eyes, adding neck torsion, or using unstable surfaces (Roijezon et al., 2015).

2.3.2. Oculomotor and eye-head coordination tests

Oculomotor and eye-head co-ordination assessment in people with neck pain is important as cervical spine afferents have a unique and important role in maintaining eye and head movement control (Corneil et al., 2002; Peterson, 2004). At present, clinical tests incorporate qualitative assessment of the ability to: 1) maintain gaze while moving the head; 2) co-ordinate eye and head movement; 3) eye follow while keeping the head still in neck torsion compared to neck neutral positions (Fig. 2). Recent research has found these clinical tests to be reliable and able to discriminate between chronic neck pain and asymptomatic individuals (Della Casa et al., 2014), and are described in detail elsewhere (Treleaven, 2008; Grip et al., 2009; Treleaven et al., 2011).

3. Clinical interventions to improve proprioception

In Part 1 of this Masterclass (Roijezon et al., 2015), the importance of addressing causes of altered proprioception and rehabilitation techniques intended to enhance proprioception were introduced. Pain, effusion, and fatigue can be common after musculoskeletal injury, result in impaired proprioception (Treleaven et al., 2003; Anderson and Wee, 2011; Cho et al., 2011), and, consequently, are barriers against effective interventions for enhancing proprioception and sensorimotor control. Therefore, it is important to administer techniques to reduce pain, effusion, and fatigue in order to facilitate the implementation of effective interventions to enhance proprioception. Augmentation of somatosensory information via passive techniques such as manual therapy, soft tissue techniques, and taping or bracing can be