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Associations of self-report measures with gait, range of motion and proprioception in patients with lumbar spinal stenosis

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ABSTRACT

Introduction: Spinal stenosis is defined as neurogenic claudication due to narrowing of the spinal canal lumen diameter. As the disease progresses, ambulation and gait may be impaired. Self-report measures are routinely used in the clinical setting to capture data related to lumbar pain symptoms, function and perceived disability. The associations between self-report measures and objective measures of physical function in patients with lumbar spinal stenosis are not well characterized. The purpose of this study was to determine the correlation between self-reported assessments of function with objective biomechanical measures of function.

Methods: 25 subjects were enrolled in this study. Subjects completed self-report questionnaires and biomechanical assessments of gait analysis, lumbar 3D ROM and lumbar proprioception. Correlations were determined between self-report measures and biomechanical data.

Results: The Oswestry Disability Index (ODI) was strongly correlated with stride length and gait velocity and weakly correlated with base of support. ODI was also weakly correlated with left lateral bending proprioception but not right lateral bending. The SF12 was not significantly correlated with any of the biomechanical measurements. Pain scores were weakly correlated with velocity, and base of support, and had no correlation any of the other biomechanical measures.

Discussion: There is a strong correlation between gait parameters and functional disability as measured with the ODI. Quantified gait analysis can be a useful tool to evaluate patients with lumbar spinal stenosis and to assess the outcomes of treatments on this group of patients.

1. Introduction

Low back pain (LBP) poses a significant burden to individuals' quality of life and to the overall health care system. Between 70% and 85% of the individuals will experience LBP at some point during their life [1,2]. In addition to pain symptoms and disability, LBP has a negative effect on physical function, including reduced gait velocity, reduced step length, increased side-to-side gait asymmetry and reduced range of spine motion [3]. Clinically, treadmill tests are often used to assess walking function by measuring the distance that can be traversed before the onset of pain.

Age-related degeneration of the spine can reduce intervertebral disk height, ossify spinal ligaments and deteriorate lumbar facet joints. These changes can reduce the spinal canal lumen diameter and induce spinal stenosis. Spinal stenosis in the lumbar region causes pain or numbness in the buttocks and/or legs. As the disease progresses, ambulation and gait may be impaired. Self-report measures such as the Oswestry Disability Index (ODI), Medical Outcomes Short Form 12 (SF12), and Numeric Rating Scale (NRS-11) are routinely used in the clinical setting to capture data related to lumbar pain symptoms, function and perceived disability. The associations between these self-report measures and objective measures of physical function in patients with lumbar spinal stenosis are not well characterized.

Within the current medical literature, there is a deficit of evidence from which clinicians can make informed decisions as to how self-reporting measures are associated with function and gait in patients with lumbar spinal stenosis. The purpose of this study was to determine the correlation between self-reported assessments of function (ODI, SF12 and NRS-11) with objective biomechanical measures of function (gait, three-dimensional lumbar range of motion (3D-ROM), and lumbar proprioception).

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2. Methods

2.1. Participants

This study was approved by the local institutional review board. Potential study participants were recruited from the Spine and Sports Medicine Intervention Clinic at Shands Rehabilitation Hospital. Candidates were patients between the ages of 18 and 90 who presented to the clinic to receive a lumbar transforaminal epidural steroid injection for symptomatic lumbar spine stenosis. Subjects were excluded if they had a BMI over 35 kg/m^2 or if they could not walk 10 m without assistance. The injection was a part of routine clinical care and was administered independently from the current investigation.

Following the informed consent process, 25 subjects were enrolled in this study (age = 62 ± 14; 14 women). All subjects had a diagnosis of lumbar radiculopathy with a median duration of symptoms of 6 months (range 1–144 months). Subjects completed each of the assessments described below during the same visit to the clinic, prior to receiving a lumbar transforaminal epidural injection.

2.1.1. Oswestry Disability Index (ODI)

The ODI is a standardized, well validated instrument to assess disability caused by low back pain. The ODI is a 10-item scale, ranging from 0% to 100%, to obtain a score for functional disability caused by LBP. A high score reflects a high rate of pain-indicated limitations. It has been shown to have excellent test, re-test reliability in patients with lumbar spinal stenosis and a minimal clinically important difference of five [4].

2.1.2. Medical Outcomes Short Form 12 (SF-12)

The SF-12 is a global health assessment questionnaire ranging from 0 to 100 points, to score self-experienced health related to quality of life [5]. Items are grouped into two domains from which an overall summary score, a physical component score and a mental component score can be derived. A high score on each of the scales reflects a high level of self-experienced health. The SF-12 has demonstrated validity and reliability in populations with back pain [6].

2.1.3. Chair rise time

Chair rise time was measured as the participant moves from a sitting to a full standing position. Chair rise time provides an indication of leg power and leg strength, both of which have been shown to be important factors in mobility [7]. Participants were asked to stand with as little assistance from the arms as possible (preferably with arms folded across the chest) – use of the arms was permitted if the participant felt unstable. Three trials were performed with approximately 10 s rest between each trial. A stopwatch was used to measure the time and the fastest time was used for statistical analysis. The same investigator administered all chair rise tests. Intraclass correlation for test, re-test of the chair rise measure is 0.84–0.94 in patients with back pain [8].

2.1.4. Pain ratings

Back pain intensity was measured using an 11 point Numeric Rating Scale (NRS-11), with 0 being no pain and 10 being the worst possible pain. The NRS-11 is an accepted outcome measure for pain conditions [9]. Such measurement has demonstrated reliability and validity [10] for assessment of pain intensity.

2.1.5. Gait analysis

Gait analysis was performed on a 26 in. long instrumented walkway (GaitRite®; CIR Systems, Inc., Havertown, PA). The walkway contains an array of pressure sensors that enable temporalspatial parameters to be accurately calculated. During the assessment, the subject walked at a self-selected, comfortable pace across the walkway. Gait analysis trials were repeated three times and the gait parameters were averaged across all three trials. The values of specific parameters were evaluated: walking velocity, stride length, step width, double support and single support times, and base of support. The interclass correlation values for these parameters listed above range from 0.66 to 0.94 in older adults during tests performed on separate visits to the lab [11–14].

2.1.6. Lumbar three-dimensional range of motion (3D-ROM)

Lumbar 3D-ROM was measured using an electromagnetic tracking system (Liberty, Polhemus Inc., Colchester, VT). Sensors were placed on L1 and L5 locations and relative joint angles were calculated for each of the three anatomical planes using a custom developed LabView (National Instruments, Austin, TX) computer program. Relative angulation between L1 and L5 was calculated so that any motion of the lower extremity or pelvis would not affect the measurement. The maximum envelope of motion in each plane was reported. 3D-ROM is a simple, noninvasive measurement of the flexibility of the spine in each of the three anatomic planes. During flexion/extension, subjects were instructed to cross their arms on their chest and to keep their eyes directed to a spot on the wall in front of them in order to minimize neck motion. During lateral bending, subjects were instructed to keep their arms at their side and in light contact with their thigh as they bent laterally to the left and right. This was done to minimize rotation during lateral bending trials. During axial rotation, subjects were instructed to cross their arms on their chest and to keep their eyes level as they rotated (“as if you were scanning the horizon at the beach”). Previous studies have shown that 3D ROM using the polhemus system is reliable and consistent with radiographic measures of lumbar motion [15,16]. In studies of other computerized devices for measuring lumbar ROM, ICCs of 0.89 have been reported for intraobserver measures and 0.85 for interobserver measurements [17,18].

2.1.7. Lumbar proprioception

Joint proprioceptive sense can be impaired following injury. This phenomenon has been observed in several joints in the body, including the spine. Several previous studies have identified a relationship between decreased lumbar proprioception and LBP [19–21]. Lumbar proprioception was measured by requiring a subject to attempt to reproduce a position of the spine that has been previously set by the experimenter (target position). After the subject repositioned their spine, the lumbar angulation is measured and compared to the target position. The difference between the target position and the subjects attempted repositioning is the repositioning error (RE). Lumbar motion during the proprioception protocol was measured using the same hardware and software described for the 3D-ROM test. The lumbar proprioception test has previously been reported to have an ICC between 0.61 and 0.76 [22,23].

2.2. Data analysis

To analyze the correlation between self-report scores and biomechanical parameters (velocity, stride length, cadence, base of support, ROM and proprioception), a linear regression model was fit between each pair of parameters. The *F*-test was performed to determine whether the relationship between two variables was statistically significant. The *p* value was set a priori to 0.05. All statistical analyses were performed using the open-source R statistical package (Version 2.13).