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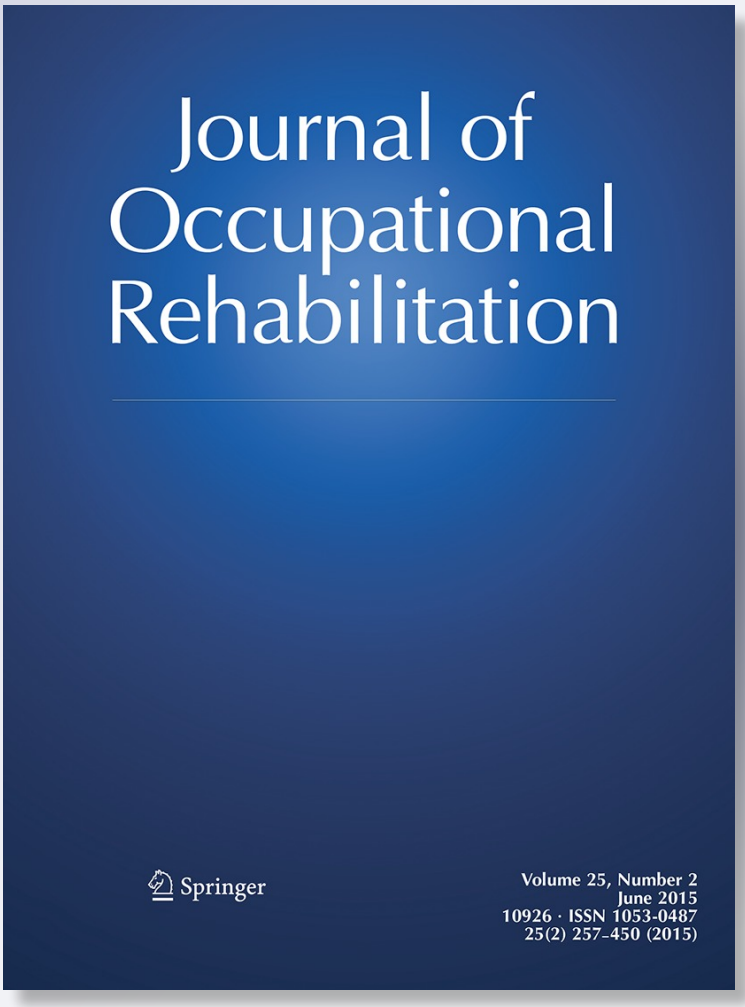
Journal of Occupational Rehabilitation

ISSN 1053-0487
Volume 25
Number 2

J Occup Rehabil (2015) 25:296-302
DOI 10.1007/s10926-014-9538-1



Springer

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Published online: 29 August 2014

Abstract *Purpose* The purpose of this study was to assess low back functional health among a group of nurses with a history of low back pain symptoms in a university hospital using a direct measure of low back functional performance and compare to traditional low back disability and pain questionnaires. *Methods* Fifty-two nurses and patient care associates volunteered for the study. The clinical lumbar motion monitor (LMM) was used to directly measure low back functional performance. The participants performed a series of standard tasks involving trunk flexion and extension at different asymmetries. The LMM measures the motion signature of the participant (range of motion, velocity and acceleration) in all three planes of the body. The clinical LMM evaluation documented objective assessment of low back function normalized for age and gender. The Oswestry Disability Index (ODI) was used to evaluate self-reported disability and the McGill Pain Questionnaire visual analog scale assessed pain symptom. *Results* The average functional performance probability was 0.49 with a standard deviation of 0.29, indicating that on average the functional performance was impaired. The average ODI score was 13.4 with a standard deviation of 11.6. The correlation between the functional performance probability and ODI was 0.046 (not statistically significant). *Conclusions* The clinical LMM functional performance measure provides a direct measure of trunk function. The low correlation between the ODI and clinical LMM functional performance probability indicates that the direct functional performance measure adds another component to our understanding of low back health or impairment that traditional questionnaires lack.

Keywords Low back injury · Nurses · Functional performance · Oswestry Disability Index

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Introduction

Low back pain is one of the most frequent reasons for lost days from work [1] and the prevalence of chronic low back pain continues to rise [2–4]. Epidemiological literature illustrates that those with low back pain are receiving an increasing number of interventional treatments [3]. This increase in treatments has resulted in an economic impact in the United States and internationally so large that an exact dollar amount was not possible [5]. Globally, low back pain has been shown to be the leading cause of disability [6]. Thus, prevention of low back pain and lost time from work associated with these injuries may be a key mechanism to decrease health care costs due to low back pain.

Nurses and health care professionals are at particularly high risk of low back pain due to the patient handling demands of the job [7, 8]. Prevalence rates of low back pain amongst health care professionals range from 76 % to as high as 90 % [9–11]. In the United States, nearly 90 % of nurses are women [12, 13]. Given the high prevalence of low back pain among nurses combined with the

predominance of female nurses, low back pain in the nursing field is a women's occupational health dilemma.

Low back pain and impairment is uniquely difficult to quantitatively understand. Musculoskeletal disorders of the extremities (knee, elbow, and wrist) can be compared to the contralateral side, which is not possible with the back. Best practice guidelines suggest that rehabilitation programs include subjective questionnaires as well as direct functional assessments [14, 15]. For example, knee rehabilitation program evaluation and screening includes questionnaires as well as functional evaluations of range of motion, isokinetic strength, single leg hop test, and single leg press test that use the other limb as the criteria for deciding recovery or injury risk [16]. Furthermore, the knee isokinetic strength testing provided a quantitative functional assessment of injury risk and impairment [17–20]. Even more impressive regarding objective functional assessment the single leg hop distance test has been found to be predictive of self reported knee function 1 year post anterior cruciate ligament injury [21]. Thus, medical providers use both direct functional testing and questionnaires to determine the return to activity or work for musculoskeletal disorders of the knee, but not the low back.

For the low back there is no direct functional test that is widely used and accepted to evaluate functional impairment as has been established with other joints such as the knee. In order to fill this gap, Marras et al. [22] have developed a database quantifying how healthy subjects perform a series of low back functional tasks. The healthy database consists of both males and females in age brackets from 20 to 70 years [22]. This database provides an age and gender standard to objectively quantify an individual's low back functional performance on these tasks. This low back functional assessment provides a direct quantitative measure of low back functional performance probability where a score <0.5 indicates impairment for the individual's age and gender and a score above 0.5 indicates healthy performance [22, 23]. In addition there is a sincerity of effort score to ensure high quality performance [24].

Traditionally low back pain recovery is assessed with questionnaires. One of the most commonly used questionnaires is the Oswestry Disability Index (ODI) [25]. The McGill Pain Questionnaire has often been cited as a tool to evaluate pain symptoms in various disorders [26]. However, there is a lack of studies correlating low back functional performance measured with the LMM with subjective reports of disability and symptoms. Hence, the goal of this study is to evaluate the extent of low back problems among nurses and patient care staff in a university hospital setting using a direct low back functional performance measure and compare to traditional low back disability and pain questionnaires.

Methods

The study utilized a cross-sectional design where subjects' low back function was compared to traditional subjective responses. Inclusion criteria were employment at the University Hospital as either a nurse or patient care assistant with patient handling duties. Participants were required to have some history of back pain at some point in their lifetime. Demographic information including age, gender, height, weight, and job experience were collected. In addition history of low back pain symptoms during the subject's lifetime, in the past year, and in the past 7 days were collected. Finally, there were follow-up assessments that will not be reported here.

Questionnaires

The McGill Pain Questionnaire was used to assess symptoms at the time of testing. The visual analog scale (VAS) section will be reported which has word anchors of no pain and worst possible pain at each end [26]. The McGill Pain Questionnaire has been shown to be valid, reliable, consistent, and translated into a multitude of languages [27]. The reliability, validity and sensitivity of VAS scores have been well established in the literature [28–32], one researcher considered the VAS to be the "gold standard" for pain measures [33]. The ODI was developed, validated, and test re-test reliability established more than three decades ago [34]. Since the initial development of the ODI four versions have been developed, it has been translated into several languages, and the American Academy of Orthopeadic Surgeons uses it as their spine outcome measure [25, 35]. Thus, both questionnaires selected have been well validated and frequently used in the literature and in practice.

Functional Assessment

The clinical lumbar motion monitor (LMM) was used to quantitatively measure the "motion signature" of the subject. The LMM measures range of motion, velocity, and acceleration in three planes of the body and provides a validated measure of low back impairment [22]. The repeatability of the testing protocol has been previously established [36]. The protocol has been validated for distinguishing well between those with low back pain and healthy controls with a sensitivity of 90 % and specificity of 94 % [22]. The output from the testing protocol is a low back functional performance probability from 0.00 to 1.00 [22, 23]. The score is based on a combination of range of motion, velocity and acceleration [22, 23].

Procedure

Upon arrival in the testing area the subjects signed a consent form approved by the University's Institutional Review Board (IRB). The subject then completed the questionnaire. The LMM was then placed on the subject's back with a waist belt and shoulder harness. The subject was then instructed to "flex and extend to upright as fast as the subject could comfortably while maintaining the twist position on the display in the control zone". If the subject was experiencing persistent pain symptoms during the testing the subject was instructed that the test was to evaluate the subject's back function and not to make the symptoms worse so "do whatever the subject felt comfortable doing". After the initial zero control zone task was completed the subject was instructed to twist in each direction as far as possible. Depending on the subject's performance four additional control tasks at 15 and 30 degrees clockwise and counter-clockwise were performed. In addition to the control tasks the subjects were instructed to bend forward and back, side to side and twist as fast as the subject could comfortably. Typically these sessions were completed in the 30 min just prior to the beginning of the nurses' shift at the hospital.

Data Analysis

Preliminary analysis included scoring the McGill Pain Questionnaire. The VAS was scored from 0 to 10 [26]. The ODI was scored according to Fairbank et al. [25] and then scores were categorized 0–20 % minimal disability, 20–40 % moderate disability, 40–60 % severe disability, 60–80 % crippling and 80–100 % exaggerated [25, 34, 37]. The low back functional assessment range of motion, velocity and acceleration were processed using custom software and a functional performance probability for each subject was output [36].

Statistical Analysis

Descriptive statistics were calculated for each measure. SAS 9.2 (Cary, NC, 2008) was used to evaluate the Pearson correlation among the three screening tools. In addition, two sample t tests were performed to evaluate differences between those with impaired low back function and those without.

Results

Fifty-two nurse/patient care assistants enrolled in the study. Forty-six (88 %) were female with an average of 15.1 (standard deviation 13.6) years experience. The 12-month prevalence of low back pain was 90 % and the 1-week prevalence was 58 %. The point-prevalence at the time of testing based on the McGill Pain Questionnaire responses was 50 %. The results show a high prevalence of low back pain symptoms amongst the population of nurses/patient care assistants.

The average ODI score was 13.4 with a standard deviation 11.6. Forty-one of the 52 (79 %) participants had an ODI score from 0 to 20 % indicating minimal disability and 11 of the 52 (21 %) had an ODI from 20 to 40 % indicating moderate disability. None of the participants had a score >40 %. The average functional performance probability was 0.49 with a standard deviation of 0.29, indicating that on average the subjects' back health was impaired. The average sincerity of effort score was 0.91 with standard deviation 0.09 indicating very good sincerity. No subjects had a score <0.6, which is the cut-off point for good quality performance [38]. Table 1 lists the correlations between each of the screening tools. There was not a significant correlation between either the McGill Pain Questionnaire VAS or ODI and the functional performance probability as indicated in the table. The correlation between the McGill Pain Questionnaire and ODI was significant and indicated a moderate association [39].

A low back functional performance score of <0.5 indicates impaired low back function for that individual's age and gender whereas a score above 0.5 indicates healthy performance. There were 29 of the 52 (56 %) participants with impaired performance for their age and gender. Table 2 lists means, standard deviations and p values for demographic data, pain symptoms and ODI for those with and without low back functional impairment. The table indicates no statistical differences in age, years of

Table 1 Pearson correlation coefficients between screening measures at baseline

	Functional performance probability	McGill Pain Questionnaire visual analog score	Oswestry Disability Index
Functional performance probability	1		
McGill Pain Questionnaire visual analog score	0.0288	1	
Oswestry Disability Index	0.0464	0.6537**	1

** $p < 0.001$

Table 2 Demographic, pain and disability scores for those with healthy and impaired low back function

Measure	Healthy low back function	Impaired low back function	*p* value
Oswestry	13.3 (11.8)	13.6 (11.7)	0.9127
Pain visual analog	2.04 (2.1)	2.07 (2.0)	0.9650
Age (years)	39.7 (12.3)	42.9 (11.9)	0.3477
Experience (years)	14.3 (13.5)	15.7 (14.1)	0.7922
Height (inches)	66.6 (4.1)	64.8 (3.2)	0.1385
Weight (lbs)	160.8 (54.4)	164.2 (32.3)	0.8071
Body Mass Index	25.7 (7.4)	27.5 (5.0)	0.3763

experience, height, weight, or Body Mass Index. Furthermore, there were no differences in pain or ODI measures between those with a low back functional impairment and those without.

Discussion

The results of the current study had a 90 % 1 year prevalence rate for low back pain in nurses and patient care associates. Similarly, June and Cho [11] also found a 90 % 1 year prevalence rate in a comparable population. These high prevalence rates among nurses illustrate that the occupational demands of patient handling put these workers at increased risk of low back injury [7, 8]. Hignett [40] has shown that nurses are at greater risk of low back injury than other occupations. Furthermore, all the workers that participated in the study were working full duty even though 56 % had impaired low back functional performance for their age and gender. It is hypothesized that this impaired low back function combined with the high level physical demands required in the nursing field may put those individuals at even greater risk of future episodes of the low back pain.

Eighty-eight percent of the participants in the current study were female, illustrating the high percentage of women in the nursing work environment. Our results were similar to those of Dulon et al. [13] who studied geriatric care nurses with a sample of 88 % women. According to Shields et al. [12] more than 90 % of nurses in the United States were female in 2008 and 2009. In addition, other health care fields including occupational and physical therapy have been shown to be predominately comprised of female workers and have high rates of low back injuries [41, 42]. The fact that the nursing and other health care fields dominated by women coupled with the high prevalence of low back injury in these environments creates a women's occupational health problem.

The average ODI was 13.1 indicating minimal disability and no subject had a score >40 indicating moderate disability. These scores indicated that study participants had a relatively low perception of their disability. Physical therapists have also been shown to have a low perception of their own disability for low back disorders and other musculoskeletal disorders [43, 44]. Interestingly, researchers have shown that an ODI >6 in a group of athletes was found to increase the risk of back or lower extremity injury by more than 4 times [45]. This may suggest that in physically demanding occupations and sports those with low ODI scores may still be at increased risk of low back injury. The results of this study show that participants had impaired low back function when measured directly with a low perception of disability, which may explain the increased level of injury risk with low ODI scores.

This study examined three low back health screening tools including McGill Pain Questionnaire, ODI and low back functional performance probability. There was a moderate correlation between the McGill Pain Questionnaire and ODI. Previous researchers have also found a moderate correlation between these two scales [46]. The LMM functional performance probability score was not correlated to either pain symptoms or ODI indicating that it measures function in a very different manner than the ODI. It is theorized that the ODI measures the subject's perception of how his or her low back pain has been interfering with activities of daily living (personal care, lifting, walking, sitting, standing etc.). In performing daily activity individuals may have learned to perform these tasks by trading off motion to the hips, knees, ankles or shoulders to perform these tasks with minimum back motion thereby reducing back pain symptoms resulting in a reduced ODI score. The LMM functional performance on the other hand directly measures low back motion on a standard series of tasks and compares that to a database of healthy controls. Thus the LMM provides a direct measurement of low back functional health normalized for age and gender whereas the ODI measures the individual's perception of how pain symptoms affected their performance of daily activities that may or may not be performed with back motion. It is thought that the low correlation between functional performance probability and ODI is due to the difference of measuring an individual's perception and direct measurement of trunk motion. Furthermore, previous research has shown that in acute muscular low back pain cases at 12 weeks there is a lag in functional performance probability recovery compared to symptom and subjective questionnaire recovery [47]. It is thought that this delayed recovery in functional performance probability may vary due to length of low back pain episode, type of disorders, treatment and psychosocial factors.

Musculoskeletal disorders of the extremities (e.g. knee and shoulder) have several contralateral functional

assessment evaluation tools in addition to questionnaire to assess impairment and recovery. Unfortunately contralateral comparisons are not feasible for the low back. However, the LMM functional performance measure can provide quantitative assessments of low back function based upon the patient's motion signature without loading the spine. Pryce et al. [48] also found that subjective pain and disability measures were limited in their ability to account for accelerometer performance measures in lumbar spinal stenosis patients. This emphasizes the need for a dynamic functional assessment tool for the low back in addition to questionnaire to evaluate severity of impairment and recovery.

Our nursing low back health study also involved a follow-up session at 6 month after various interventions. However, there was not enough follow-up compliance by the participants to report changes by intervention group. As an example of how the ODI and LMM functional performance measures document very different parameters, one subject provides an interesting case study. Subject X participated at baseline, followed up 6 months later after being in the educational program and then over 18 months later had a major back problem seeking medical care in the clinic. The educational program was a pamphlet with spine anatomy, proper body mechanics to reduce spine load, and an exercise program to stretch and strengthen the muscles. Figure 1 illustrates the changes in ODI and functional performance probability over the course of four visits for this subject (case study). At baseline her functional performance probability was 0.67 for her age, and her ODI was 38. At the follow-up session she reported following through on the exercise program "just a little" and implementing the proper body mechanics "a great deal". As illustrated in the figure her functional performance probability improved to 0.95 for age and gender, and her ODI score dropped slightly. Interestingly, this particular subject was then seen in clinic over 18 months later with back pain and leg numbness. She reported that there was no specific incident that precipitated the symptoms but at the end of a busy shift she noticed the symptoms. The only two activities that she specifically recalled that may have contributed were pushing a larger than average patient in a wheel chair and one patient needing extra assistance returning to bed. Subject X was seeking surgical intervention for not only back pain but also leg numbness. Her ODI went up to 52 and functional performance probability went down to 0.01 for her age and gender. The figure illustrates that 6 weeks after surgery (3/2014) subject X functional performance probability had a clinically meaningful improvement [23] to 0.54 for her age and gender and her ODI dropped to 6. Thus, the functional performance probability provides a direct quantitative assessment of how the individual's low back function changes over time.

Figure 1 illustrates the relationship of LMM functional performance probability and the ODI for one individual over time. This figure illustrates that as functional performance probability increases there is a decrease in ODI score, which some may believe illustrates a correction between measures. Table 1 indicates that the correlation between these measures is quite low at 0.0464. In examining the study population 41 of the 52 participants had an ODI 0–20 % score indicating minimal disability compared to the functional performance probabilities that ranged from 0.14 to 0.99 for those subjects. The wide range of functional performance probabilities for the minimal ODI disability scores results in a low correlation for the population. This illustrates the need for population based studies and not case studies, therefore more research is needed to generate a population based prospective evaluation of the measures.

Low back pain recovery is a complex process and the combination of questionnaires and low back functional

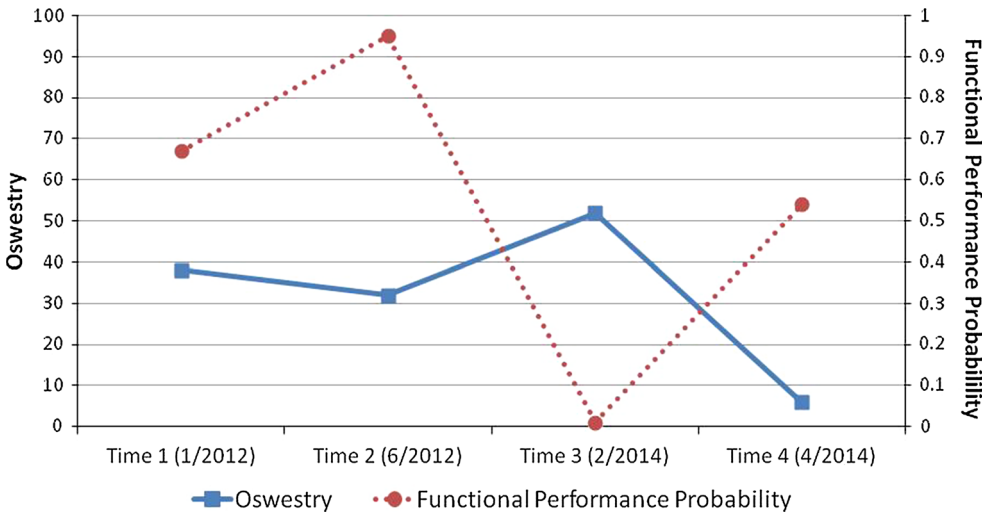

Fig. 1 Case study nursing subject ODI and functional performance probability over time

measures may provide insights that have not been uncovered in the past leading to better treatment outcomes and prevention of chronic low back pain. Friedly et al. [3] suggested that there is an ever-expanding array of treatment options for low back pain patients the combination of questionnaire and direct dynamic functional measure may provide a quantitative assessment of the effectiveness of different types of treatments. Previous research using the functional performance probability has shown that workers with a low back injury in manufacturing jobs who sought medical attention for their back pain returned to work full duty even though their low back functional performance probability was still impaired in 88 % of cases [49]. In addition Hush et al. [50] stated that our understanding of low back pain recovery process appears to be deficient and that further investigations were necessary. The current study reveals a complex concept of recovery which may suggest a multitude of recovery measures that not only include pain symptoms and self reported perception of recovery, but also direct quantitative functional performance probability measures to provide a more complete analysis of the recovery process. The combination of functional measures and questionnaires has been used for knee musculoskeletal disorders for years however the development of low back functional assessment measures lags behind that of standard practice knee measurements. Thus, the clinical LMM may provide a direct measure of low back functional performance and a good low back health screening tool as well as provide quantitative information that can not be derived from existing "subjective" indices.

Limitations

One of the limitations of the study was small sample size. A second limitation was that subjects had either minimal or moderate levels of disability measured by the ODI. Additional research to quantify functional performance probability with greater levels of disability measured by the ODI may provide further insights into the relationship between the two scales.

Acknowledgments This study was funded by The Ohio State University.

Conflict of interest None.

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