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REHABILITATION SECTION

Original Research Article

Lumbar Mobility and Performance-Based Function: An Investigation in Older Adults with and without Chronic Low Back Pain

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Abstract

Objective. To explore potential differences in lumbar mobility between older adults with and without chronic low back pain, and to determine if lumbar mobility contributes to physical performance in both groups. We hypothesized that older adults with pain would have greater lumbar mobility impairments than pain-free peers, and that lumbar mobility would be associated with performance in both groups, with stronger relationships among those with pain.

Design. Matched case-control.

Setting. Research laboratory.

Patients. Community-dwelling older adults, aged 60–85 years, with (N = 54) and without (N = 54) chronic low back pain.

Methods. Inclinometer-measured maximal angles of lumbar flexion, extension, and average side-bending, as well as time to complete performance measures, Repeated Chair Rise and Timed-Up-and-Go, were measured in both groups. Analysis of variance was used to explore the difference in lumbar mobility between groups. Adjusted linear regression was used to assess the independent relationship between lumbar mobility and physical function in both groups.

Results. Those with pain had smaller angles of flexion ($P = 0.029$) and extension ($P = 0.013$). In the pain group, flexion explained 19% ($P = 0.001$) and 8.9% ($P = 0.006$) of the variance for time to complete the Repeated Chair Rise and Timed Up-and-Go tests, respectively. In the pain-free group, extension explained 12.7% ($P = 0.007$) and 10.3% ($P = 0.008$) of the variance for time to complete Repeated Chair Rise and Timed Up-and-Go tests, respectively.

Conclusion. Older adults with chronic low back pain have more lumbar mobility impairments. Lumbar mobility may be a contributing factor to decreased performance in older adults. Flexion may be most important to performance in those with pain, while extension may be vital in those without pain.

Key Words. Older Adults; Low Back Pain; Lumbar Mobility; Physical Function

Introduction

Low back pain is a highly prevalent condition in the older adult population [1]. Charges for low back pain-related costs in the Medicare population have increased three-fold in recent years, equating to almost $1 billion [2]. Generally, the majority of low back pain-related costs are linked to patients who develop chronic pain [3]. Chronic low back pain (CLBP) is more prevalent in older adults than young-to-middle aged adults, and occurrence among older adults has increased significantly over recent years [4,5]. Further, older adults with CLBP are more likely than those without pain to self-report functional limitations in activities of daily living (ADLs) [6,7].

Physical performance measures are important clinical outcomes in the geriatric population; these measures have been shown to predict difficulty and dependence with ADLs [8,9], hospitalization [10], institutionalization [11,12], and death [10–12] among community-dwelling older adults. Some performance tests significantly challenge the axial skeleton. For instance, transitioning from sit-to-stand, a common core component of many performance tests, requires sufficient lumbar mobility [13]. Although previous literature has shown that the presence [7,14] and severity [14,15] of CLBP are linked to poor performance, little is known regarding the role that clinically relevant, and potentially modifiable, factors (e.g., lumbar mobility) may have in the decline of performance.

Older adults have less lumbar flexion than younger adults [16], and CLBP worsens this deficit [7]. Thus, it is reasonable to think that the decreased lumbar mobility seen in older adults with CLBP may be a contributing factor to worse performance on tests that require sufficient lumbar mobility, such as tasks involving sit-to-stand transitions. Although previous studies have explored the relationship between lumbar mobility and self-reported disability in the CLBP population [17–20], they have not examined the relationship between this clinical impairment and performance on specific functional tasks. If proven to be linked to worse performance on standardized clinical tests of physical function, lumbar mobility would be an important modifiable factor to assess and address in geriatric patients.

The purpose of this comparative study of older adults with and without CLBP had two parts. Our first purpose was to determine if there are differences in lumbar mobility measures between older adults with and without CLBP. Our second purpose was to determine if there are differential associations between lumbar mobility measures and performance-based measures of function when comparing older adults with and without CLBP. We hypothesized that older adults with CLBP would have greater lumbar mobility impairments than older adults without pain. We also hypothesized that lumbar mobility would be associated with performance-based measures of function in both groups, but the associations would be stronger in those with CLBP.

Methods

Participants

This study was a secondary analysis of a sample of community-dwelling, cognitively intact (Folstein Mini-Mental State Exam score $\geq$ 24) older adults, with CLBP [21]; participants from this dataset were compared to another sample of older adults without CLBP. For the purposes of this study, older adults were defined using the age range 60–85 years. Participants with CLBP recruited for this study met the following pain criteria: $\geq$ 3/10 pain intensity, occurring $\geq$ 4 days per week, and a minimum duration of 3 months [7]. CLBP participants were excluded if they had any of the following: radicular symptoms, non-mechanical low back pain symptoms, history of lumbar surgery, severely limited mobility (i.e., needed assistive device for household ambulation), a progressive neurological disorder, or a terminal illness. Older adults without CLBP were included if they had no low back pain at the time of enrollment. These individuals were excluded if they had any of the following: a history of lumbar surgery, treatment for low back pain in the past 6 months, severely limited mobility, a progressive neurological disorder, or a terminal illness. All participants were recruited from newspaper advertisements, local senior centers, retirement communities, health fairs, and local community centers. For the CLBP group, 211 people were screened, 145 were excluded, and 66 were enrolled in the study. For the pain-free group, 71 people were screened, 14 were excluded, and 57 were enrolled in the study. Participants from the CLBP and pain-free groups were matched based on sex and age (± 2 years) and 54 participants from each group were included in the final analysis. All policies and procedures were followed in accordance with the proposal approved by the University of Delaware Institutional Review Board and the Helsinki Declaration of the World Medical Association. All participants signed an informed consent form, and consent forms are being securely stored.

Demographics and Self-Ratings

Participants reported their age and sex, and the modified Oswestry Disability Questionnaire (mODQ) was used to measure low back pain-related disability. The mODQ is a self-report instrument, which measures perceived functional limitation due to low back pain on a 0–100% scale. Higher scores indicate greater low back pain-related disability. Hicks and Manal have found the mODQ to be reliable and valid in the older adult population [22]. The numeric pain rating scale (0–10) was used to measure pain intensity with anchors from 0 ("no pain") to 10 ("worst possible pain"). Current pain intensity, worst pain intensity in the previous 24 hours, and best pain intensity in the previous 24 hours were all measured using this method, which has shown to be reliable and valid [23]. All three pain ratings were averaged for a composite pain intensity rating.

Lumbar Mobility

Lumbar mobility was assessed in the standing position using the inclinometer technique described by Waddell et al. [19]. These are single-angle measures of ROM, and are commonly used in the clinical examination of patients with low back conditions. *Lumbar flexion* was computed as the difference between thoracolumbar flexion and pelvic flexion measures. *Lumbar extension* was measured as the participant arched their trunk backward. Right and left side-bending were measured and averaged as a composite value, *average side-bending*. Measurement of lumbar range of motion (ROM) using this approach has been shown to be highly reliable (ICC = 0.86–0.98) [19], while other studies have found comparable levels of reliability using similar methodology [24–29].

Performance-Based Functional Outcome Measures

Reliable and valid performance measures of functional mobility [30–32] that stress the axial skeleton were chosen for this study. First, participants were asked to perform the Repeated Chair Rise test. From the seated position, the participant was instructed to safely complete five sit-to-stands as fast as possible while keeping their arms folded across their chest. The Timed-Up-and-Go test (TUG) was assessed using a standard chair (seat height 46 cm) with armrests on a three-meter course. Participants were instructed to stand up, walk three meters at their regular pace to a line on the floor, turn around, walk back, and sit back down with their back against the chair. The Repeated Chair Rise [30,31] and TUG [32] tests have been shown to predict future limitations in ADLs and falling among older adults.

Statistical Analysis

Statistical analyses were performed using SPSS 23 (SPSS, Inc., Armonk, NY). Descriptive analyses were performed for both groups, including demographic characteristics, pain-related disability, and average pain intensity. Controlling for differences in body mass index (BMI), multivariate analysis of variance (MANOVA) was performed to test between-group lumbar mobility differences. Analysis of covariance (ANCOVA) was then used to further explore univariate differences in lumbar mobility variables between the groups. Separate linear regression models were computed with each performance test as a dependent variable. This approach allowed exploration of the unique contribution of lumbar mobility measures toward physical function, beyond demographic and anthropometric variables, among both groups. In the first step, age, sex, and BMI were entered, followed by flexion, extension, and average side-bending in subsequent steps. For those with CLBP, current pain intensity level (0–10) was added as a covariate to the regression models. R^2 change statistics were reported with P change values. If the data violated the assumptions of parametric testing for ANCOVA and/or linear regression, outliers were removed. Non-parametric analyses were performed if outlier removal did not improve normality. Alternate regression models were created, varying the order of entry of the lumbar mobility variables, due to the possible effect order of entry may have on the change statistics. Each model was investigated to ensure multicollinearity was not present (i.e., variance inflation factor < 4) [33].

Results

Participants

Participant demographics are provided in Table 1. The CLBP and pain-free groups were matched on age (±2 years) and sex, but those with CLBP had a higher BMI ($P = 0.044$). Mean (SD) Repeated Chair Rise times were 13.34 (6.56) and 9.22 (2.77) seconds for older adults with and without CLBP, respectively. Mean (SD) TUG times were 9.14 (3.14) and 7.38 (1.37) seconds for older adults with and without CLBP, respectively. There was one adverse event during the course of the study: one participant tripped and fell during the course of standardized performance testing, but was not injured.

Lumbar Mobility Differences Between Groups

Table 2 shows that, while controlling for between-group differences in BMI, MANOVA showed a difference in lumbar ROM between the CLBP and the pain-free groups ($P = 0.047$). Univariate ANCOVA indicated that older adults with CLBP had less lumbar flexion (mean difference = 5.91 degrees; $P = 0.029$) and extension (mean difference = 4.59 degrees; $P = 0.013$). However, the extension data in the CLBP group were not normally distributed. Mann-Whitney U non-parametric tests revealed significant differences between groups ($P = 0.006$). Although normally distributed, average side-bending was not significantly different between groups.

Table 1 Participant characteristics

Characteristics	CLBP (N = 54)	No CLBP (N = 54)
	N (%)	
Female	37 (68%)	37 (68%)
	Mean (SD)	
Age (y)	69.31 (6.65)	71.15 (6.76)
BMI	29.05 (5.57)*	27.01 (4.80)*
mODQ	33.93 (10.88)	–
Average pain intensity (0–10)	3.37 (1.64)	–

CLBP = chronic low back pain; SD = standard deviation; BMI = body mass index; mODQ = modified Oswestry disability questionnaire.

*$P < 0.05$.

Lumbar Mobility Associations with Physical Performance

Table 3 shows that, in the CLBP group, the demographic variables and current pain intensity in model 1 accounted for 19.7% ($P = 0.046$) of the variance in Repeated Chair Rise time. The addition of flexion in model 2 accounted for an additional 19.0% ($P = 0.001$) of the variance. However, the addition of lumbar extension in model 3 and average side-bending in model 4 did not significantly improve the predictive ability of the model. Removal of four outliers was necessary to satisfy the assumption of normality of residuals.

Table 2 Differences in maximal angle of lumbar mobility measures (in degrees) controlling for BMI

Lumbar mobility measures	CLBP (N = 54) Mean (SD)	No CLBP (N = 54)	*P* value
Flexion	33.76 (13.99)	39.67 (11.91)	0.029*
Extension	19.41 (9.85)	24.00 (8.10)	0.013*
Average side-bending	16.64 (7.15)	19.04 (6.36)	0.154

BMI = body mass index; CLBP = chronic low back pain; SD = standard deviation.
$^{*}P < 0.05$.

When exploring alternate regression models, which varied the order of entry of lumbar mobility variables, an order effect was found for Repeated Chair Rise time in both of the alternate models, as depicted in Table 3 models A and B. In model 2_A, extension became a significant ($P = 0.012$) contributor for Repeated Chair Rise performance, and flexion remained a significant ($P = 0.011$) contributor in the next step. In model 2_B, average side-bending became a significant ($P = 0.033$) contributor, while the addition of flexion remained significant ($P = 0.008$), for Repeated Chair Rise time.

Table 4 shows that, for TUG performance in the CLBP group, the demographic variables and current pain intensity in model 1 accounted for 39.0% ($P < 0.001$) of the variance. The addition of flexion in model 2 accounted for an additional 8.9% ($P = 0.006$) of the variance. However, the addition of extension and average side-bending did not significantly contribute to the variance explained in the model. Assumptions of parametric testing were satisfied, so no further analysis was needed.

Using the same alternate regression method as before, the order of entry for lumbar mobility measures was varied; an order effect was found in both of these models, as depicted in Table 4 models A and B. In model 2_A, extension became a significant ($P = 0.004$) contributor to TUG time; however, flexion was no longer a contributor to TUG time when entered in model 3_A. In model 2_B, average side-bending became a significant ($P = 0.022$) contributor to TUG time when it was the first lumbar mobility measure added to the model. Interestingly,

Table 3 Linear regression model for repeated chair rise performance and alternative models to explore order effect, in older adults with CLBP (N = 50)*

Model	Independent variables	R^2 change	Adjusted R^2	*P* change
Regression model: Lumbar flexion entered first into regression analysis				
1	Age, sex, BMI, current pain level	0.197	0.123	0.046**
2	Model 1 + **flexion**	0.190	0.315	0.001**
3	Model 2 + extension	0.027	0.329	0.179
4	Model 3 + average side-bending	0.001	0.313	0.777
Standardized $\beta(P)$ for flexion, extension, & average side-bending = −0.385 (0.012),** −0.228 (0.253), & −0.058 (0.777)				
Alternative model A: Altered order of trunk mobility variables with lumbar extension entered first				
1_A	Age, sex, BMI, current pain level	0.197	0.123	0.046**
2_A	Model 1_A + **extension**	0.114	0.230	0.012**
3_A	Model 2_A + flexion	0.103	0.329	0.011**
4_A	Model 3_A + average side-bending	0.001	0.313	0.777
Alternative model B: Altered order of trunk mobility variables with average side-bending entered first				
1_B	Age, sex, BMI, current pain level	0.197	0.123	0.046**
2_B	Model 1_B + **average side-bending**	0.083	0.195	0.033**
3_B	Model 2_B + flexion	0.115	0.307	0.008**
4_B	Model 3_B + extension	0.020	0.313	0.253

BMI = body mass index.
*Four outliers removed.
$^{**}P < 0.05$.

when flexion and extension were added in subsequent steps, neither were significant contributors to TUG performance.

Table 5 shows that, in the pain-free group, demographic variables and flexion did not contribute significantly to Repeated Chair Rise time variance. However, the addition of extension in model 3 explained an additional 12.7% ($P = 0.007$) of the variance in Repeated Chair Rise time. Average side-bending was not a contributor of Repeated Chair Rise time variance among older adults without CLBP. Using alternate regression models, no order effect was found for lumbar mobility variables; extension continued to be the only significant contributor to Repeated Chair Rise time. No further analysis was needed, because all assumptions of parametric testing were met.

Table 5 also shows that, for TUG time in the pain-free group, the demographic variables in model 1 explained

Table 4 Linear regression model for TUG performance and alternative models to explore order effect, in older adults with CLBP (N = 54)

Model	Independent variables	R^2 change	Adjusted R^2	*P* change
Regression model: Lumbar flexion entered first into regression analysis				
1	Age, sex, BMI, current pain level	0.390	0.340	< 0.001*
2	Model 1 + **flexion**	0.089	0.425	0.006*
3	Model 2 + extension	0.039	0.456	0.057
4	Model 3 + average side-bending	0.001	0.446	0.769
Standardized β(*P*) for flexion, extension, & average side-bending = −0.230 (0.085), −0.259 (0.112), & 0.051 (0.769)				
Alternative model A: Altered order of trunk mobility variables with lumbar extension entered first				
1_A	Age, sex, BMI, current pain level	0.390	0.340	< 0.001*
2_A	Model 1_A + **extension**	0.096	0.432	0.004*
3_A	Model 2_A + flexion	0.033	0.456	0.081
4_A	Model 3_A + average side-bending	0.001	0.446	0.769
Alternative model B: Altered order of trunk mobility variables with average side-bending entered first				
1_B	Age, sex, BMI, current pain level	0.390	0.340	< 0.001*
2_B	Model 1_B + **average side-bending**	0.064	0.397	0.022*
3_B	Model 2_B + flexion	0.038	0.426	0.069
4_B	Model 3_B + extension	0.028	0.446	0.112

TUG = timed up-and-go test; CLBP = chronic low back pain; BMI = body mass index.
*$P < 0.05$.

Table 5 Linear regression models for repeated chair rise and TUG performance in older adults without pain (N = 54)

Model	Independent variables	R^2 change	Adjusted R^2	*P* change
Dependent variable = Repeated chair rise performance				
1	Age, sex, BMI	0.109	0.056	0.119
2	Model 1 + flexion	0.012	0.049	0.423
3	Model 2 + extension	0.127	0.169	0.007*
4	Model 3 + average side-bending	0.014	0.168	0.347
Standardized β(*P*) for flexion, extension, & average side-bending = 0.055 (0.719), −0.353 (0.013),* & −0.145 (0.347)				
Dependent variable = TUG performance				
1	Age, sex, BMI	0.232	0.186	0.004*
2	Model 1 + flexion	0.029	0.201	0.171
3	Model 2 + extension	0.103	0.298	0.008*
4	Model 3 + average side-bending	0.003	0.286	0.660
Standardized β(*P*) for flexion, extension, & average side-bending = −0.052 (0.714), −0.331 (0.012),* & −0.063 (0.660)				

TUG = timed up-and-go test; BMI = body mass index.
*$P < 0.05$.

22.4% ($P = 0.004$) of the variance. The addition of flexion in model 2 did not significantly contribute to the variance of TUG performance. Similar to Repeated Chair Rise time in this group, the addition of extension in model 3 explained an additional 11.3% ($P = 0.004$) of TUG time; neither flexion nor average side-bending contributed to the explanation of TUG time variance. Furthermore, alternate regression models for TUG time revealed no order effect for lumbar mobility variables. Assumptions of parametric testing were satisfied, so no further analysis was needed.

Discussion

Our results supported both of our hypotheses: Older adults with CLBP had limited lumbar mobility compared to those without pain, and lumbar mobility was related to functional performance. However, the relationships between lumbar mobility and functional performance differ between those with and without CLBP.

This comparative analysis expands on previous work that shows older adults with CLBP have less lumbar flexion than those without pain [7]. We have demonstrated that lumbar mobility deficits are not limited to only flexion, but also, extension. It is important to note that while the absolute differences in flexion and extension are similar in magnitude (approximately 5 degrees), total extension is much less than flexion in a normal population. Therefore, the relative deficit in extension is clearly a larger proportion of total possible extension, in comparison to flexion. While it has been established that there are deficits in both flexion and functional performance in the CLBP population [7], to our knowledge, this if the first time the *relationship* between these two variables has been examined.

Our regression results suggest that relationships between lumbar mobility and performance exist beyond suspected covariates of demographic characteristics and pain intensity (for those with CLBP); past studies did not control for these variable. For older adults with CLBP, the negative regression coefficient suggests that individuals with less flexion perform worse on these functional tests. In contrast, extension's negative regression coefficient suggests that, for older adults *without* pain, less extension is linked to worse performance on these tests.

Waddell et al. found similar lumbar mobility differences in younger adults with and without CLBP with the exception of flexion, which was actually greater in their CLBP sample [19]. Comparable to our findings, Waddell et al. found that flexion shared the strongest relationship with dysfunction; however, they measured dysfunction using a self-report instrument and included a younger sample [19]. In studies similar to Waddell's, flexion [18,20] and extension [20] had comparable relationships with self-reported disability. In contrast, Grönblad et al. found no relationship between lumbar mobility and disability survey scores, but their significance levels were much more stringent, despite similar sample sizes [17]. Our investigation provides a unique insight into dysfunction, as functional performance captures a different construct from self-report measures. Future prospective investigations should be conducted, exploring the role of lumbar mobility limitations as causal factors for future reductions in performance.

It is important to note that these performance-based tests occur largerly in the sagittal plane; therefore, flexion and extension would reasonably be the most consistent factors linked to performance on these tests. Furthermore, with age, knee extensor strength decreases [34], and a common compensatory pattern to transition to standing is to increase lumbar flexion [35]. Thus, it is not surprising that if flexion is limited, as is the case in those with CLBP, an older adult may require more time to transition from sit to stand. Also, if extension mobility is lacking, it may be more difficult to reach an upright position from sitting, regardless of pain status.

In alternate modeling, flexion, extension, and average side-bending significantly explained test time variance beyond demographic and current pain intensity variables for older adults with CLBP; however, these relationships were dependent upon the order of entry. This indicates that these lumbar mobility measures correlate with one another to some degree, although not enough to cause multicollinearity. Conceptually, when a lumbar mobility measure is entered earlier in the model, more performance test time variance is available for explanation. This suggests that all mobility measures may be important to some degree in the context of performance in older adults with CLBP; despite entry order, flexion is the most consistent contributor to performance-based function, as it remains significant in each of the dependent variables' full models.

Study Limitations

In addition to the cross-sectional design, which does not allow us to draw conclusions about causality, our study has other limitations. First, we are unable to explore the determinants of limited, clinically-measured lumbar mobility, such as specific biomechanical movement strategies, which may help to better target our treament interventions. Second, lordosis may vary with age; however, it is difficult to take this into account with lumbar mobility measurements, and its clinical importance relative to lumbar mobility is unknown. Third, it is difficult to extrapolate what "normal" lumbar mobility is in the older adult population, because of the heterogeneity of methods used to measure lumbar mobility in previous literature. However, the data from our pain-free group provide a reasonable representation of normal lumbar mobility, which clinicians can use in the treatment of the geriatric CLBP population. Fourth, it is possible that we did not see greater contributions from average side-bending, because of the nature of our performance-based measures; all performance tasks occurred primarily in the sagittal plane. Fifth, sample size estimates were not calculated *a priori*, but the risk of a type II error is likely low, given our statistically significant results. Finally, there are many factors, physical and psychological, that may contribute to performance-based physical function tests in older adults with CLBP, such as strength or fear-avoidance; however, the focus of this study was to identify one such factor (e.g., lumbar mobility) that may contribute to disability in this multifactorial geriatric condition.

Conclusion

Our results suggest that impaired lumbar mobility is more common among older adults with CLBP, and these impairments contribute to sit-to-stand task performance in both those with and without CLBP. Clinically, all of these lumbar mobility measures may need to be assessed, and intervened upon, in order to improve performance on these tests in the older adult CLBP population; but, lumbar flexion may be the most important lumbar mobility measure. In contrast, lumbar extension may be the only important lumbar mobility measure for a clinician to consider, relative to poor performance on these tests, for older adults without pain. However, future prospective analyses are needed to further substantiate these claims.

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