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Altered spatiotemporal characteristics of gait in older adults with chronic low back pain

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ABSTRACT

Previous studies in older adults have identified that chronic low back pain (CLBP) is associated with slower gait speed. Given that slower gait speed is a predictor of greater morbidity and mortality among older adults, it is important to understand the underlying spatiotemporal characteristics of gait among older adults with CLBP. The purposes of this study were to determine (1) if there are differences in spatiotemporal parameters of gait between older adults with and without CLBP during self-selected and fast walking and (2) whether any of these gait characteristics are correlated with performance of a challenging walking task, e.g. stair negotiation. Spatiotemporal characteristics of gait were evaluated using a computerized walkway in 54 community-dwelling older adults with CLBP and 54 age- and sex-matched healthy controls. Older adults with CLBP walked slower than their pain-free peers during self-selected and fast walking. After controlling for body mass index and gait speed, step width was significantly greater in the CLBP group during the fast walking condition. Within the CLBP group, step width and double limb support time are significantly correlated with stair ascent/descent times. From a clinical perspective, these gait characteristics, which may be indicative of balance performance, may need to be addressed to improve overall gait speed, as well as stair-climbing performance. Future longitudinal studies confirming our findings are needed, as well as investigations focused on developing interventions to improve gait speed and decrease subsequent risk of mobility decline.

1. Introduction

Among older adults, low back pain is a highly prevalent condition and costs are on the rise [1–3]. Estimates from Medicare data suggest a nearly $1 billion increase in costs in recent years [3]. The majority of these costs are associated with the management of individuals who develop chronic low back pain (CLBP) [4]. Since 75% of long term care residents and more than 50% of community dwelling older adults experience some form of chronic pain [5], it is critically important to consider the direct impact of pain on daily function in older adults.

Although all older adults are at risk for mobility limitations, older adults with CLBP may be at greater risk for functional decline. In fact, several epidemiologic studies have demonstrated that low back pain is independently associated with functional decline, particularly walking performance [6–8]. In previous studies of geriatric low back pain, walking performance has primarily been assessed through evaluation of walking on level surfaces [6,9]; but, stair negotiation, which has been rated as one of the top five most difficult mobility tasks for older adults, has undergone limited evaluation in the geriatric CLBP population [10]. It is well-established in the geriatric literature that gait speed over level ground is a powerful predictor of mobility disability and mortality [11–13]. Oh-Park and colleagues have also demonstrated that stair negotiation time is associated with functional decline in the general geriatric population [14]. Further, there is a large body of literature describing the spatiotemporal characteristics of gait that underpin and explain walking performance in older adults; and these individual characteristics have also been independently linked to mobility problems [15,16]. By having a greater understanding of the underlying spatiotemporal gait characteristics seen in this group, we may be able to more effectively address mobility deficits in the geriatric CLBP population,

In this study, we examined differences in gait speed at both self-selected and fast walking paces, as well as differences in stair negotiation time, between older adults with and without CLBP. We also examined differences in spatiotemporal parameters of gait between the pain groups, with and without adjustment for walking speed. Finally, we sought to determine whether any of the spatiotemporal parameters of gait captured during overground walking on a level

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surface would be correlated with stair negotiation performance in the CLBP population.

2. Methods

2.1. Participants

This secondary analysis included baseline participant data from a sample of community-dwelling, cognitively intact (Folstein Mini-Mental State Exam score ≥24) older adults with CLBP who were enrolled in a randomized preliminary trial [17]; CLBP participants were compared to a sample of older adults without CLBP. For this study, older adults were defined using the range 60–85 years. CLBP participants met the following pain criteria: ≥3/10 pain intensity, occurring ≥4 days per week, and a minimum duration of 3 months [9]. CLBP participants were excluded if they had any of the following: a prominent component of radicular pain below the knee, known spinal pathology other than osteoarthritis (i.e. a history of recent trauma, vertebral compression fractures, ankylosing spondylitis, carcinoma metastatic to the spine), history of lumbar surgery, severely limited mobility (i.e. needed assistive device for household ambulation), progressive neurological disorders, or terminal illness. Older adults without CLBP were included if they had no LBP at enrollment and were excluded if they had any of the following: history of lumbar surgery, received treatment for CLBP in the past 6 months, severely limited mobility, progressive neurological disorders, or terminal illness. All participants were recruited from newspaper advertisements, retirement communities, and local community centers. For the CLBP group, 211 people were screened, 145 were excluded, and 66 were enrolled in the study. For the group without CLBP, 71 people were screened, 14 were excluded, and 57 were enrolled. Participants from the CLBP and non-CLBP groups were matched 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. All participants signed an informed consent form.

2.2. Demographics and self-ratings

Participants reported their age and sex, while 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 disability. Hicks & Manal have found the mODQ to be reliable and valid among older adults [18]. 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, as well as best and worst pain intensity in the previous 24 h, were measured using this method, which has shown to be reliable and valid [19]. All three pain ratings were averaged for a composite pain intensity rating.

2.3. Gait assessment

The GaitMat II™ system (E.Q. Inc., Chalfont, PA), a computerized 4-m walkway, was used to collect and analyze gait data. At either end of the walkway, there are inactive segments (1 m) which allow for walking acceleration and deceleration. After two practice trials, each participant walked on the GaitMat II™ three times at their self-selected walking speed and three times at their fastest, safe walking speed. The following gait characteristics were measured: gait speed, stride length, step width, swing time, stance time and double limb support time.

2.4. Stair negotiation

The stair climbing test (SCT) was used to assess stair negotiation as older adults have rated stairs as one of the top 5 tasks “most difficult” due to “old-age” [10,20,21]. Participants were timed as they ascended and descended 12 standard steps. A hand rail was available for participants during testing if needed; but, they were encouraged to ascend and descend the stairs with their legs only if able to do so safely. Ascent and descent were performed at each person’s self-selected speed and timed to the nearest hundredth of a second with a standard stopwatch. Given the challenge of stair-climbing, the SCT is able to measure higher levels of function than other performance tests and reduces possible ceiling effects [22].

2.5. 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 overall between-group differences in gait speed and stair negotiation time. Analysis of covariance (ANCOVA) was then used to further explore univariate differences in performance. For the analysis of spatiotemporal parameters, the same approach of using MANOVA followed by ANCOVA was used for each walking pace condition (self-selected and fast); but, initially, the analyses were adjusted for BMI alone followed by an additional adjustment for gait speed to explore whether between-group differences were independent of speed. To better understand the magnitude of differences between pain groups, standardized effect sizes were calculated for all gait outcomes. Standardized effect size was calculated by subtracting the mean gait value of the CLBP group from the mean value of the group without CLBP and then dividing the difference by the pooled standard deviation of the 2 scores [23].

For the CLBP group, separate linear regression models were computed with stair ascent and descent times as the dependent variables. This approach allowed exploration of the unique correlation between spatiotemporal gait measures and stair negotiation, beyond age, sex, BMI and pain. Multicollinearity was found between stance time and double limb support time (i.e. variance inflation factor > 4) [24]; therefore stance time was not included in regression modeling. In the first step, age, sex, BMI and pain were entered, followed by addition of stride length, step width, swing time and double support time from the self-selected walking speed assessment. Finally, for each dependent variable, a reduced, final regression model was constructed that only included those independent variables that were significantly associated with the dependent variable of interest. Standardized beta (ß) coefficients are reported for each independent variable included in the final reduced models to allow for direct comparison between independent variables in the model as they relate to the dependent variable being studied.

3. Results

3.1. Participants

Participant demographics are provided in Table 1. Groups were matched on age (± 2 years) and sex, but those with CLBP had a higher BMI (p = .044). The average pain rating, pain duration and mODQ scores indicate that our CLBP group met the inclusion criteria of longstanding, moderately severe pain.

Gait speed and stair negotiation time between older adults with and without CLBP

After controlling for BMI, MANOVA indicated a significant overall difference between groups for gait speed and stair negotiation time (p = .003). Follow-up univariate ANCOVAs, as seen in Table 2, in-