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Full Length Article

Gender differences in asymmetrical limb support patterns between subjects with and without recurrent low back pain

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ABSTRACT

New insight regarding limb-dominance effects on temporal-spatial gait parameters is needed to further investigate subjects with recurrent low back pain (LBP). Although an asymmetrical gait pattern was found to reflect natural functional differences, there is a lack of information regarding gender differences on dominant limb support patterns in subjects with LBP. The purpose of this study was to investigate temporal-spatial gait parameters based on limb dominance and gender between subjects with and without LBP. One hundred and ten right limb dominant older adults (51 subjects with LBP and 59 control subjects) participated in the study. A three-dimensional motion capture system was utilized to measure temporal-spatial gait parameters, including initial double, single, and terminal double limb support times and walking speed. The gender differences between subjects with and without LBP were analyzed based on dominance for those parameters. Overall, limb dominance demonstrated significant differences on single and terminal double limb support times as well as walking speed. Limb dominance also demonstrated interactions on group x gender for single limb support time and walking speed. The male subjects with LBP demonstrated significantly increased single limb support times on the non-dominant limb. The significant gender and group interactions based on limb dominance account for a possible pain avoidance, asymmetrical limb support pattern. The causal pathway in dominance dependency gait by unweighted ambulation might be considered as an intervention for correcting these gait deviations in subjects with LBP. The specific modification recovery profiles of the subjects with LBP could shed light on variability of current LBP experiences of the subjects and reasons for gait deviations. Clinicians need to consider the mechanism of dominant limb dependency, which requires postural control strategies in male subjects with recurrent LBP.

1. Introduction

Low back pain (LBP) is a common musculoskeletal dysfunction, and an approximate 24% to 87% rate of recurrence has been reported in those who have recovered from an episode of LBP (Pengel, Herbert, Maher, & Refshauge, 2003; Stanton et al., 2008). One study indicated that after the resolution of an episode of acute LBP, about 25% of subjects will have a

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recurrence in the next year (Stanton et al., 2008). Individuals with LBP tend to walk slowly due to a possible "guarding strategy" to further limit spine motion (Lamoth, Meijer, Daffertshofer, Wuisman, & Beek, 2006; van der Hulst, Vollenbroek-Hutten, Rietman, & Hermens, 2010).

As the body moves forward, one limb typically provides support while the other limb advances in preparation to shift the center of mass onto the supporting limb. A functional demand is placed on each limb in carrying out the tasks of propulsion and controlling bilateral asymmetry during walking (Sadeghi, Allard, Prince, & Labelle, 2000). The stance phase of gait is subdivided into initial double stance, single limb stance, and terminal double limb stance. During double stance periods, both limbs typically do not share the load equally as asymmetry on the dominant limb contributes disproportionately to increase support during walking (Zahraee, Karimi, Mostamand, & Fatoye, 2014). The increased activity level, such as gait training, is an effective way of managing LBP (Gordon & Bloxham, 2016; Liddle, Baxter, & Gracey, 2004; Monticone et al., 2014); however, there is a lack of understanding on gait asymmetry in spatial and temporal parameters in subjects with LBP. The temporal-spatial characteristics were utilized to estimate asymmetry characteristics based on walking speed and age (Del Din et al., 2016). Altered trunk coordination is often reduced or absent in subjects with LBP (Lamoth et al., 2006; Pakzad, Fung, & Preuss, 2016); however, it is still unclear if these differences are related to a specific limb support pattern to avoid pain during the stance phase of the gait cycle.

Gait asymmetry is greater during perturbed walking and increases during double-limb support in order to reduce the risk of tripping and falling (Bautmans, Jansen, Van Keymolen, & Mets, 2011; Benedetti, Berti, Maselli, Mariani, & Giannini, 2007; Stacoff, Diezi, Luder, Stussi, & Kramers-de Quervain, 2005). During walking, limb dominance, leg length discrepancies, and/or strength imbalances or muscle activation patterns might be related to asymmetry of the limbs (Laroche, Cook, & Mackala, 2012; Sadeghi, Prince, Zabjek, & Labelle, 2004; Sadeghi et al., 2000). In addition, gender differences on temporal-spatial gait parameters also contribute to asymmetrical loading patterns in subjects with LBP (Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley, 2009; Frimenko, Goodyear, & Bruening, 2015; Gombatto, Collins, Sahrmann, Engsberg, & Van Dillen, 2006). While several studies have suggested that these temporal-spatial metrics deteriorate more rapidly with increasing age for women than men (Callisaya, Blizzard, Schmidt, McGinley, & Srikanth, 2008; Doyo, Kozakai, Kim, Ando, & Shimokata, 2011; Himann, Cunningham, Rechnitzer, & Paterson, 1988), others have found no gender interactions with ageing (Steffen, Hacker, & Mollinger, 2002; Verlinden et al., 2013).

Some studies have supported a growing body of evidence in substantial gender differences to pain responses. Specifically, males were shown to walk at higher preferred speeds with longer step lengths, but reduced cadence, compared with women (Bohannon & Williams Andrews, 2011; Frimenko et al., 2015). Another study indicated that gait asymmetry might be greater in older women with strength asymmetry, which increases when they walk near their maximal capacities (Laroche et al., 2012). However, older adults exhibit strength asymmetries of approximately 15% to 20% (Perry, Carville, Smith, Rutherford, & Newham, 2007; Skelton, Kennedy, & Rutherford, 2002) compared with an asymmetry between 5% and 15% in young adults. These studies found natural functional differences with asymmetrical patterns of the lower limbs during ambulation.

The deficiencies in motor control during gait may also produce excessive asymmetrical loading patterns and postural fluctuations in subjects with LBP (Roffey, Wai, Bishop, Kwon, & Dagenais, 2010; Vogt, Pfeifer, Portscher, & Banzer, 2001; Zahraee et al., 2014). For example, the loss of discrete control of the spinal muscles may be due to motor cortical organization changes and neurophysiological mechanisms in subjects with LBP (Tsao, Danneels, & Hodges, 2011). This asymmetry might be related to increased compensatory patterns through increased lumbar rotation to the dominant side in subjects with recurrent LBP (Sung, Danial, & Lee, 2016). Gait asymmetry is important for early detection, development of therapeutic strategies, and insight into underlying mechanisms. Few studies explicitly consider limb dominance for postural control, and it is important to investigate the characteristics of the limbs and the factors mediating neuromuscular differences (Sung, Spratt, & Wilder, 2004a,b).

Therefore, the purpose of this study was to compare limb support times in the gait cycle as well as walking speeds between subjects with and without LBP based on limb dominance and gender. We hypothesized that those gait parameters (e.g., initial double, single, and terminal double limb support times and walking speed) in subjects with LBP would be different between genders.

2. Methods

2.1. Target population

Subjects were recruited from the University community; and the procedures, goals, and potential risks of the study were explained to them. Those subjects who expressed interest in the study became eligible, and the subjects who met study inclusionary criteria signed a copy of the Institutional Review Board approved consent form.

Subjects were eligible to participate if they: 1) were able to walk without pain referral into the lower extremities, 2) were free from lower limb injury and a history of a neurological disorder, 3) recently recovered from recurrent LBP as defined by de Vet et al. (2002) and reported one year incidence of recurrence of acute nonspecific LBP (Stanton et al., 2008), 4) had no risks associated with participation in the study as confirmed by the subjects' family physicians, and 5) possessed less than a 2 cm leg length discrepancy (measured from the anterior superior iliac spine (ASIS) to the medial malleolus).