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A compensation of angular displacements of the hip joints and lumbosacral spine between subjects with and without idiopathic low back pain during squatting

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ABSTRACT

Low back pain (LBP) is one of the most common symptoms reported in adults. However, the contribution of postural control on the lumbar spine and hips during squatting has not been carefully investigated in individuals with LBP. The aim of this study was to compare three-dimensional kinematic changes of the lumbar spine and hips between subjects with and without idiopathic chronic LBP during squatting activities. In total, 30 subjects enrolled in the study (15 control subjects and 15 subjects with idiopathic chronic LBP). All participants were asked to perform squatting activities five times repeatedly while holding a load of 2 kg in a basket. The outcome measures included the Oswestry Disability Index (ODI) and kinematic angular displacement for the hips and lumbar spine. The LBP group demonstrated increased range of motion (ROM) in flexion of the dominant ($T = -2.14$, $p = 0.03$) and non-dominant ($T = -2.11$, $p = 0.03$) hips during squatting. The lumbar spine flexion ROM significantly decreased ($T = 2.20$, $p = 0.03$). The kinematic changes demonstrated interactions with region × group ($F = 5.56$, $p = 0.02$), plane × group ($F = 4.36$, $p = 0.04$), and region × plane ($F = 2292.47$, $p = 0.001$). The ODI level demonstrated significant interaction on combined effects of body region and plane ($F = 4.91$, $p = 0.03$). Therefore, the LBP group utilized a compensation strategy to increase hip flexion with a stiffened lumbar spine in the sagittal plane during squatting. This compensatory kinematic strategy could apply to clinical management used to enhance lumbar spine flexibility in subjects with idiopathic chronic LBP.

1. Introduction

Chronic idiopathic low back pain (LBP) is a common problem that often exists in the absence of any identifiable source of nociception (Nachemson, 1992). LBP affects 70–85% of the population at some time in individuals' lives, and estimates of the 1 year incidence of any episode of LBP range between 1.5% and 36% (Hoy et al., 2011). Individuals with LBP demonstrate reduced joint range, spinal mobility, and muscle power at the lumbar spine (Brumagne et al., 2000; Shum et al., 2007; Sung et al., 2010; Wong and Lee, 2004). These impairments may result in dysfunctional spinal coordination as well as increased pain, functional impairments, and disability (Cox et al., 2000; Park et al., 2012).

The impaired trunk movement in subjects with LBP may manifest itself as limited trunk range of motion (ROM) (Hicks et al., 2005). The abnormal movement patterns are mostly in the lumbosacral area where limited motion of the lumbar spine has been reported in subjects with chronic LBP (Shum et al., 2007). Using three-dimensional kinematic studies of the lumbar spine and hips, especially during squatting activities, may lead to a better understanding of these movement limitations.

A squatting posture requires appropriate muscle activation to achieve correct lower limb movement and dynamic balance (Nakagawa et al., 2012). This postural problem is related to the hip joints and can cause musculoskeletal injuries with high postural loads. Therefore, the altered coordination within the lumbosacral complex might be a compensatory response to protect the connective tissues from additional pain or discomfort during movement (Shum et al., 2005, 2007; Sung et al., 2010).

Lumbosacral movement is routinely used to evaluate low back impairments since three-dimensional kinematic assessments of the spine enhance evidence-based practice (Lamoth et al., 2002; Scholtes et al., 2009). The altered mechanics of squatting motions are not well understood since individuals with idiopathic chronic LBP move their spine and pelvis in various patterns. A recent study indicated that a greater maximal lumbosacral rotation angle in the transverse plane was reported in subjects with chronic LBP (Scholtes et al., 2009). However, several contradictory studies indicated that subjects with chronic LBP demonstrated limited spine and hip motion during both sit-to-stand and stand-to-sit transfers (Jo et al., 2011; Shum et al., 2005).

Therefore, the purpose of this study was to investigate three-dimensional angular displacement differences of the hips and

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lumbar spine during squatting activities between subjects with and without idiopathic chronic LBP. It was hypothesized that there would be a significant difference in both lumbar spine and hip joint kinematics in subjects with chronic idiopathic LBP compared to control subjects without LBP during squatting activities. In addition, individual demographic characteristics, such as age, weight, height, and pain/disability level, were considered.

2. Methods

2.1. Target population

Subjects were recruited from the greater city of Seoul, Korea. Subjects who expressed interest in the study became eligible for the study. Those subjects who met the study inclusion criteria received information regarding the study and signed a copy of the Institutional Review Board approved consent form.

In our study, subjects with chronic idiopathic LBP were included since their condition did not originate from a known pathology or trauma. Volunteers in the LBP group were subjects who presented with chronic idiopathic LBP, met study inclusion criteria, and experienced a disturbing impairment or abnormality of the low back for more than a 2-month duration (Klenerman et al., 1995).

Subjects were able to participate if they: (1) were 25 years of age or older, (2) had pain on both sides of the low back for more than 2 months without pain referral into the lower extremities (Hall et al., 2009), (3) reported no increased acute symptoms of back pain during squatting activities, (4) were right leg dominant, and (5) had no structural deficits as confirmed by an orthopedic surgeon. The effect of dominance was also investigated based on the kicking test. The right lower extremity was regarded as the dominant side for all subjects since they preferred to use the right limb to kick a ball (Andersen et al., 2004; Brophy et al., 2010).

Subjects were excluded from participation if they: (1) had a diagnosed psychological illness that might interfere with the study protocol, (2) had overt neurological signs and radiating pain (sensory deficits or motor paralysis), and/or (3) were pregnant. Participants were withdrawn from the study if they requested to withdraw.

A control group, which included volunteers, was used in this study in order to eliminate the risk of confounding effects over the study period as well as to increase internal validity of the data. The control subjects were also age-matched to the LBP subjects in order to obtain comparable results between groups.

2.2. Outcome measures

Pain and disability were inferred from self-reported scores on the Oswestry Disability Index (ODI). The ODI is one of the most frequently used tools for measuring chronic disability (Ciccone et al., 1996) and scores were recorded at the time of data collection. A sum is calculated and presented as a percentage, where 0% represents no disability and 100% the worst possible disability (Fairbank et al., 1980).

The squatting activity was conducted at the Motion Analysis Laboratory. The participants were given disposable hospital slipper socks with nonskid bottoms to wear during the test and had the Helen Hayes full body (with head) reflective marker set attached to specific sites on their bodies with adhesive tape rings (Sung et al., 2010). As shown in Fig. 1, the reflective markers were placed on landmarks of the foot, shank, thigh, pelvis, and lumbar spine to capture both limb and lumbosacral motions. The hip flexion angle was measured relative to the pelvic axis and was approximately 90° at the time of squatting position. The lumbar spine was considered as a rigid body segment, and the planes of motion included the frontal, sagittal, and transverse planes, which were calculated relative to the core spine axis during the squatting activity.

The core spine axis is the direct upward perpendicular axis from the pelvic plane of the second sacrum level. The pelvic plane was comprised of both sides of the anterior superior iliac spines (ASISs) and the second sacrum level. This pelvic plane model was utilized in several of our previous studies (Sung and Kim, 2011; Sung et al.,

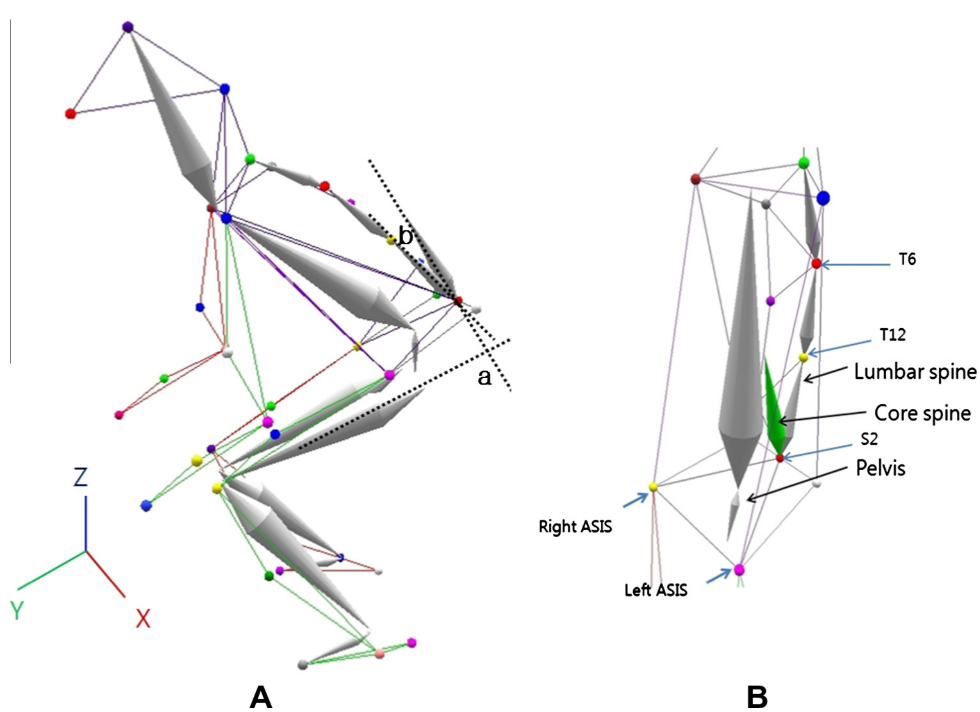

Fig. 1. A squatting task in standing position. (A) Subjects were instructed to squat while holding the basket at arm length. (B) The core spine was calculated based on the perpendicular coordinate on the second sacrum level on the pelvic plane. (a: hip angle, b: lumbar angle, ASIS: anterior superior iliac spine, T6: sixth thoracic spine level, T12: 12th thoracic spine level, S2: second sacrum level).