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A kinematic analysis for shoulder and pelvis coordination during axial trunk rotation in subjects with and without recurrent low back pain

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ABSTRACT

The purpose of this study was to compare the kinematics of the shoulder and pelvis based on range of motion (ROM), angular velocity, and relative phase (RP) values during trunk axial rotation. Nineteen subjects with recurrent low back pain (LBP) and 19 age-matched control subjects who are all right limb dominant participated in this study. All participants were asked to perform axial trunk rotation activities at a self-selected speed to the end of maximum range in a standing position. The outcome measures included ROM, angular velocity, and RP on the shoulder and pelvis in the transverse plane and were analyzed based on the demographic characteristics between groups. The LBP group demonstrated decreased ROM ($p = 0.02$) and angular velocity ($p = 0.02$) for the pelvis; however, there was no group difference for the shoulder girdle. The ROM difference between the shoulder and pelvic transverse planes had a significant interaction with age ($F = 14.75$, $p = 0.001$). The LBP group demonstrated a higher negative correlation between the shoulder ($r = -0.74$, $p = 0.001$) and pelvis ($r = -0.72$, $p = 0.001$) as age increased while no significant correlations were found in the control group. The results of this study indicated that there was a difference in pelvic rotation in the transverse plane between groups during axial trunk rotation. It would be important to coordinate postural stability between the shoulder and pelvic girdles during ambulation; however, the pattern of trunk movement decreased with age due to possible pelvic stiffness in subjects with recurrent LBP. Therefore, improved pelvic flexibility for coordinated trunk movement patterns would help subjects with recurrent LBP.

1. Introduction

Low back pain (LBP) is among the most common conditions for which patients seek medical care, and the estimated lifetime prevalence of pain could be up to 80% [1]. It has been documented that subjects with LBP demonstrate aberrant motion during dynamic movements, such as gait [2,3], forward bending, and reach [4,5]. Prior studies have shown that LBP subjects move differently than subjects without LBP [6,7]; however, the impact of kinematic differences is unclear. In general, it is unlikely that clinicians would be able to ascertain the relatively small range of motion (ROM) differences for specific intervention.

The pattern of spinal kinematic characteristics has been extensively studied; however, there is a lack of investigation regarding trunk coordination during axial rotation in subjects with and without recurrent LBP. A recent report indicated that the three-dimensional magnitude of spinal movements was significantly reduced in subjects with LBP [8]. Other compensational adaptations of trunk-pelvis coordination studies also indicated different asymmetrical patterns in subjects with LBP [2,3]. For example, there was a significant decrease in lumbar flexion and an increase in thoracic flexion compared with healthy controls during forward bending or forward reaching tasks [4,5].

It has been reported that postural instability might be due to reduced sensitivity of lumbo-pelvic and sacral proprioception [9] as well as an imbalance of the trunk muscles between weak abdominal muscles and tight lumbar extensors in subjects with recurrent LBP [10] as well as the sequential kinematic relationship on the shoulder, spine, and pelvis [11]. Subjects with LBP demonstrated higher activity for the external oblique muscle and lower activity for the multifidus during axial rotation to the left, while lesser activity of the rectus abdominis was exhibited during axial rotation to the right [12]. They also demonstrated asymmetrical patterns of muscle activity and torque output during spinal movements [12–14] and a higher flexion coupling torque during axial rotation asymmetrically due to muscle imbalance [12,15].

The dynamic interaction between the shoulder and pelvic girdles during trunk rotation is important during different movement patterns, which occur in most activities of daily living.

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Table 1
Summary of subject demographics and bivariate relationship with selected demographics.

Variable	LBP group	Control group	Statistic	p
Number of subjects	19	19		
Age (years)				
Range	58–79	56–78	$t = 0.11$	$p > 0.05$
Mean ± SD	68.8 ± 5.4	69.0 ± 5.7		
Gender				
Female	15	11	$\chi^2 = 1.94$	$p > 0.05$
Male	4	8		
Height (cm)				
Range	155–187	159–184	$t = 0.70$	$p > 0.05$
Mean ± SD	157.1 ± 9.4	159.2 ± 9.2		
Body weight (kg)				
Range	52–82	50–79	$t = 0.31$	$p > 0.05$
Mean ± SD	63.2 ± 10.5	59.9 ± 9.0		

SD: standard deviation, t: t-test, χ^2: Chi-square, p: Probability.

For example, poor mobility of the axial structures and altered postural alignment result in decreased whole spinal ROM [16,17]. In order to evaluate the integrated functional performance during trunk rotation, the relative phase (RP) based on angular displacement and angular velocity was utilized in our study.

Although the concept of RP during the cycle of axial trunk rotation was reported, the integrated movement pattern on the trunk in subjects with recurrent LBP was not reported [18]. The coordinated functional trunk motion might be incorporated with shoulder and pelvic ROM for flexibility of the thorax [19]. However, there is still a lack of investigation regarding coordination between shoulder and pelvic motion between subjects with and without LBP.

A trunk rotational activity requires integrated spinal motion due to various internal and external forces [20,21]. Since the spine is a complex structure exhibiting multi-axial motion, kinematic studies of spinal motion should be investigated with three-dimensional neuromuscular mechanisms [22]. In addition, the ageing process of spinal kinematic integration for the musculoskeletal symptoms could be related to ROM [23]. However, the specific kinematic coordination between the shoulder and pelvic girdles during axial trunk rotation has not been investigated.

Therefore, the purpose of this study was to compare shoulder-pelvic coordination during trunk axial rotation between subjects with and without recurrent LBP. It was hypothesized that the measurement outcomes (ROM, absolute angular velocities, and RP) would decrease based on demographic characteristics, such as age, in subjects with recurrent LBP.

2. Methods

2.1. Participants

Participants who met the study inclusion criteria received information regarding the study and signed a copy of the Institutional Review Board approved consent form. Those participants attended data collection sessions at the motion analysis laboratory in a university setting.

Those subjects in the LBP group who met the following inclusion criteria received at least one current work-related spinal diagnosis and reported at least one work-related injury [24]. Those subjects in the LBP group: (1) were 50 years of age or older, (2) had LBP for more than two months without pain referral into the lower extremities, (3) reported no increased acute symptoms of LBP during trunk rotational activities, (4) were right leg dominant, (5) had no structural deficits, such as scoliosis, kyphosis, or spondylitis, as reported by their primary care physician, and (6) had repeated pain episodes of the back for more than a two-month duration. The age-matched control group included volunteers without recurrent LBP in order to eliminate the risk of confounding effects over the study period as well as to increase internal validity of the data. Participants were withdrawn from the study if they requested to withdraw.

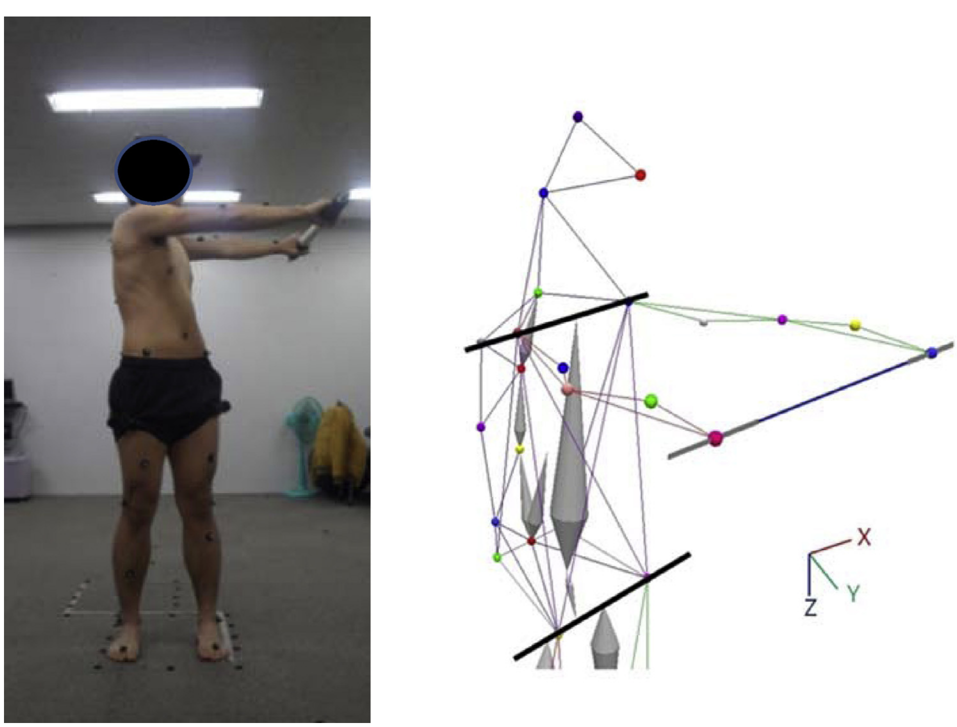

Fig. 1. An illustration of shoulder rotation position in the transverse plane and the position of the markers. The thick lines represent the shoulder and pelvis axes.