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Effects of Taping the Lower Back on the Lumbopelvic Region and Hip Joint Kinematics During Sit-to-Stand

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Abstract

Excessive lumbar flexion during sit-to-stand (STS) is a risk factor for lower back pain. Postural taping can prevent unwanted flexion of the lumbar spine. This study aimed to demonstrate the effect of taping the lower back on the lumbopelvic region and hip joint kinematics during STS. Sixteen healthy subjects participated. All subjects performed the STS with and without taping of the lower back. A three-dimensional motion analysis system was used to measure the kinematics of the lumbar spine, pelvis, and hip joint during STS. The angle of the peak lumbar flexion, pelvic anterior tilting, and hip flexion and angular displacement of the lumbar spine between starting position and maximal lumbar flexion were collected. Paired t-tests, or Wilcoxon's rank-sum test for non-parametric distribution, were used to assess differences in the measurements with and without taping. A p-value $<.05$ was taken to indicate a significant difference. Significant differences were observed in the angle of the peak lumbar flexion, pelvic anterior tilting, hip flexion and angular displacement of the lumbar spine ($p<.05$). Taping was associated with a significant decrease in the angle of peak lumbar flexion and angular displacement of the lumbar spine between the starting position and maximal lumbar spine flexion. In addition, the peak angle of pelvic anterior tilting and hip flexion were significantly increased with taping. The findings of this study suggest that taping the lower back can decrease excessive lumbar flexion, and increase the pelvic anterior tilting and hip flexion motion during STS.

Key Words: Hip joint; Kinematics; Lumbopelvic motion; Postural taping; Sit to stand.

Introduction

Sit-to-stand (STS) occurs frequently in daily activity particularly in the working population where individuals perform STS approximately sixty times per day (Dall and Kerr, 2010; Janssen et al, 2002; Parkinson et al, 2013; Shum et al, 2005). The STS movement is necessary for ambulation, and without the ability to perform STS there are many limitations on the ability to perform daily activities (Kuo et al, 2010). The movement patterns of the lumbopelvic region and hip joint during STS in healthy subjects, patients with low back pain, and in elders have been investigated (Dehail et al, 2007; Janssen et al, 2002; Jeng et al, 1990; Kuo et al, 2010).

STS movement occurs with the lumbopelvic region and hip joint in the sagittal plane (Kuo et al, 2010; Nuzik et al, 1986; Tully et al, 2005). In the early stage of the STS movement, the angle of flexion of the lumbar spine and hip joint increases to bring the center of mass forward; the standing position is then achieved while extending the lower extremity (Roebroeck et al, 1994). For this movement, it is important that there is coordination between the lum-

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bopelvic region and the hip joint movement in the sagittal plane (Fotoohabadi et al, 2010; Janssen et al, 2002; Tully et al, 2005). Tully et al (2005) reported that 3° of hip flexion accompany 1° of lumbar flexion during the pre-buttock lift-off phase. During STS, repetitive and excessive lumbar flexion can induce lower back pain, and the altered movement pattern of the lumbopelvic region and hip joint may lead to increased disability (Sahrmann, 2002). Therefore, rehabilitation strategies or education are required to prevent and manage musculoskeletal disorder of the lower back.

According to O'Sullivan (2005), one of the factors associated with onset of lower back pain is persistent low-intensity stress on the lumbar spine during daily activities. Frequent increased motion of the lumbar spine with insufficient hip motion may aggravate lower back pain, and restoring coordination of the lumbar spine and hip joint movement could alleviate lower back pain and prevent recurrent lower back pain (Esola et al, 1996; Kim et al, 2014; McClure et al, 1997; Sahrmann, 2002). Although it is important to prevent excessive and frequent flexion of the lumbar spine during STS, no study of methods of preventing excessive flexion of the lumbar spine during STS have been published.

Clinically, non-elastic taping has been used to restrict joint motion or improve neuromuscular facilitation (Greig et al, 2008; Kang et al, 2013; Karlsson and Andreasson, 1992). Greig et al (2008) reported that after postural taping of the thoracic spine in patients with osteoporosis, there was a decreased angle of thoracic kyphosis. Kang et al (2013) demonstrated that taping the lower back decreased the angle of lumbar spine flexion and increased the angle of pelvic anterior tilting and hip flexion in physical therapists with lower back pain during transfer. Therefore, application of the tape over the skin can provide cutaneous feedback during repetitive movement and prevent unwanted or excessive motion.

Several studies have reported the effects of postural taping in preventing unwanted movement of the spine or extremities (Greig et al, 2008; Kang et al, 2013; Karlsson and Andreasson, 1992); however, none demonstrate the effect of the taping the lower back on lumbopelvic region and hip joint kinematics during STS. Therefore, the purpose of this study was to examine the effect of taping the lower back on lumbopelvic region and hip joint kinematics during STS in healthy subjects. We hypothesized that application to the lower back would decrease the lumbar flexion angle and increase the angle of the pelvic anterior tilting and hip flexion during STS compared to without tape application.

Methods

Subjects

Sixteen healthy subjects participated in this study (Table 1). Inclusion criteria were those with 1) no experience of low back pain in the previous 6 months, and 2) no limited movement of the lower leg and lower back because of recent injury within the last 6 months. All subjects were provided with an explanation of the purpose and procedure of this study and provided informed consent.

Instrumentation

A three-dimensional motion analysis system with six cameras (Vicon MX system, Oxford Metrics Ltd., Oxford, UK) was used to collect kinematics of the lumbar spine, pelvis, and hip joint during STS. The sampling rate was 100 ㎐. Sixteen reflective markers were attached bilaterally on the posterior superior iliac spine, anterior superior iliac spine, lateral thigh,

Table 1. General characteristics of subjects (N=16)

Characteristics	Mean±SD[a]
Age (year)	21.8±1.7
Height (㎝)	174.3±4.6
Weight (㎏)	63.9±8.2
BMI[b] (㎏/㎡)	21.0±2.2

[a]mean±standard deviation, [b]body mass index.

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knee joint, tibia, lateral malleolus, second metatasal head, and calcaneous (Kim et al, 2014). Four reflective markers were attached on the spinous process of the twelfth thorax, first lumbar spine, and 3 ㎝ to the left and right sides of the spinous process of the first lumbar spine (Kim et al, 2014). One marker was attached on the spinous process of the first thoracic spine (T1). Pelvic kinematics were measured relative to the coordinate system in the experimental room, and kinematics of the lumbar spine and hip joint were measured relative to the pelvic segment.

Taping application on the lower back

Postural taping following the method suggested by Kang et al (2013) was applied to the lower back to prevent excessive lumbar flexion. To minimize skin irritation, hypoallergenic tape (Endura Fix Tape, Endura-Tape Pty. Ltd., Clareville, Australia) was applied underneath the non-elastic taping (Battlewin Tape, Nichiban Co. Ltd., Tokyo, Japan). The two tapes were attached transversely at the twelfth thorax and posterior superior iliac spine level. Three tapes were vertically attached to connect two transverse tapes: over the spinous process, and bilaterally spinous process (Figure 1).

Procedures

All subjects performed STS: 1) without taping the lower back, and 2) with taping the lower back.

Figure 1. Taping applied lower back.

Subjects performed the STS without taping of the lower back, prior to STS with taping of the lower back to prevent bias in the data due to any sustained effect of taping. STS was performed from a stool that had no back or armrests. The starting position was sitting on the stool with both arms crossed on the chest and hip and knee flexed at 90° with the lower leg vertical to the floor. The height of the stool was adjusted for each subject to the length of the subject's leg from the floor to the mid-knee-joint line. All subjects underwent a familiarization session with the experimental conditions with and without taping; after subjects completed this session, data collection commenced. All subjects performed STS three times in each condition with a 1-min rest between trials and with 10-min rest between tasks.

Data analysis

All kinematic data collected underwent Woltring filter using the Nexus software ver. 1.4 (Nexus, Vicon Motion Systems Ltd., Oxford, UK). Raw data were exported to Microsoft Excel ver. 2010 (Excel, Microsoft Corporation, Washington, US) for analysis. The angle of the peak lumbar flexion, peak pelvic anterior tilting, and peak hip flexion and angular displacement of the lumbar spine in sagittal plane between the starting position and maximal lumbar flexion during STS were used in the statistical analysis. Starting position was determined by horizontal displacement of the T1 marker (Tully et al, 2005). Measures for each of the movements were averaged across the three repetitions of the test.

Statistical analysis

Statistical analysis was conducted using SPSS ver. 21.0 (SPSS Inc., Chicago, IL, USA). Means and standard deviations were calculated for lumbopelvic region and hip motion kinematics during STS with and without taping. To assess the normality of the distribution of the collected data, a Kolmogorov-Smirnov Z test was used. Paired t-tests for parametric varia-

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bles and Wilcoxon rank-sum tests for non-parametric variables were used to identify significant differences for each variable between with and without taping. Significance was set at $p<.05$.

Results

Means and standard deviations of the kinematics in lumbar spine, pelvis, and hip joint are presented in Table 2. Significant differences in the angle of the peak lumbar flexion, pelvic anterior tilting and hip flexion, and angular displacement of the lumbar spine between the starting position and maximal lumbar flexion were demonstrated ($p<.05$). Angle of the peak lumbar flexion and angular displacement of the lumbar spine between the starting position and maximal lumbar flexion were significantly decreased during STS with taping than without taping. Peak angle of the pelvic anterior tilting and hip flexion were significantly increased during STS with taping than without taping.

Discussion

The importance of the coordination between the lumbopelvic region and hip joint has been reported in STS (Jeng et al, 1990; Kerr et al, 1997; Kuo et al, 2010; Tully et al, 2005). Excessive lumbar flexion could be a risk factor for lower back pain (Kang et al, 2013; Kim et al, 2014; Sahrmann 2002). This study therefore aimed to assess the effect of taping the lower back on the kinematics of the lumbopelvic region and hip joint during STS. The results showed a decrease in the lumbar flexion angle and angular displacement of the lumbar spine between the starting position and maximal lumbar flexion, and an increase in the angle of the pelvic anterior tilting and hip flexion, after tape application.

We standardized the starting position to arms crossed on the chest and the hip and knee flexed 90°. During STS, arm usage could influence on trunk kinematics (Tully et al, 2005). In addition, Fleckenstein et al (1988) reported that the more knee joint was extended, the more the hip joint angular displacement was increased during STS. Thus, to avoid the effect of the arm, hip, and knee joint position in starting position on angular displacement of the lumbopelvic region and hip joint during STS, we controlled starting position.

Feedback is considered to have an important effect on motor leaning (Kisner and Colby, 2012; Winstein, 1991). To achieve effective performance and motor skill, cutaneous sensory input using a bar, manual facilitation, or taping has been used in rehabilitation programs (Choung et al, 2011; Hsu et al, 2009; Kang et al, 2013). Choung et al (2011) demonstrated that the lumbar flexion angle significantly decreased, and bilateral hip flexion significantly increased, during forward bending using manual facilitation or a stick compared to when forward bending was performed without an aid. Additionally, Kang et al (2013) reported that unwanted and excessive lumbar flexion during transfer in physical therapists with lower back pain decreased with postural taping of the low-

Table 2. Kinematics of the lumbar spine, pelvis, and hip joint during STS with and without taping

Variables	With taping	Without taping	Mean difference (95% CI[a])	p
Peak lumbar flexion	24.43±12.00[b]	14.39±7.67	−10.49 (−17.08 to −3.02)	.008*
Peak pelvic anterior tilting	21.13±7.98	23.16±6.30	2.03 (.39 to 3.66)	.018*
Peak hip flexion	82.19±18.07	84.82±19.43	2.63 (.29 to 4.97)	.030*
Displacement of the lumbar spine	10.65±8.44	4.98±3.58	−5.67 (−11.29 to .05)	.017*

[a]confidence interval, [b]mean±standard deviation, *$p<.05$.

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er back. The non-elastic tape used in this study is an easy to apply and inexpensive method of preventing excessive unwanted lumbar flexion.

Our study showed that the angle of peak lumbar flexion and angular displacement of the lumbar spine in the sagittal plane between the starting position and the maximal lumbar motion significantly decreased after application of tape to the lower back, with average differences of 10.49° and 5.67°, respectively. The angle of the peak pelvic anterior tilting and hip flexion significantly increased to 2.03° and 2.63°, respectively ($p<.05$). When participants performed the STS with tape on their lower back, if the lumbar flexion movement increased, the tape would provide cutaneous input to prevent excessive forward flexion by pulling on the skin. Limiting this movement would increase the activation of the erector spine muscle, which supports the lumbar spine when extended (van Dieën et al, 2003). Additionally, changes in the angle in the lumbopelvic region and hip joint can be explained by the change movement strategy to perform the STS after taping. Participants may use a movement to rise up from the stool avoiding tension from the tape that would result in increased peak pelvic anterior tilting and hip flexion. This method of STS can be used by individuals with greater stiffness of the hip joint and recommended to patients accompanying excessive lumbar flexion during STS.

In our study, peak values of the pelvic anterior tilting and hip flexion were used, and these values were significantly increased during STS with taping. Hip flexion angle was defined by relative femur bone angle of the pelvic segment. Thus, peak angle of the hip flexion may increase in according with increasing pelvic anterior tilting after tape application.

Thus study had several limitations. First, all participants were male and in their early twenties. This makes it difficult to generalize findings to females or those of other age groups. Further studies with a wider sample population are required. Second, this study was performed in healthy subjects; therefore, the effect of taping the lower back on the movement patterns of the lumbopelvic region and hip joint in people with lower back pain is unknown. Third, we investigated the immediate effect of taping the lower back on the kinematics of the lumbopelvic region and hip joint during STS. We do not know whether the change in the movement pattern of the lumbopelvic region and hip joint would become evident after tape removal or persist after long-term tape application.

This study demonstrates the immediate effect of taping the lower back on lumbopelvic region and hip joint kinematics in healthy subjects during STS. These findings may be useful in preventing excessive lumbar flexion in individuals who perform STS repetitively, or patients who experience lower back pain during STS. Tape application could also be useful for educating patients in the movement patterns of the lumbopelvic region and hip joint during STS.

Conclusion

This study demonstrated the effects of taping the lower back on lumbopelvic region and hip joint kinematics during STS. The results showed that taping resulted in a decreased angle of the lumbar flexion and angular displacement of the lumbar spine between the starting position and maximal lumbar flexion, and an increased angle of the pelvic anterior tilting and hip flexion. These results suggest that taping can prevent excessive lumbar flexion motion and facilitate hip joint movement during STS. Therefore, taping of the lower back is recommended for education and management of individuals with excessive lumbar flexion during STS.

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