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Effect of Taping on Lumbar Kinematics and Muscle Activities During Typing in Individuals With Nonspecific Chronic Low Back Pain

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Abstract

Prolonged sitting can contribute to low back pain. The lumbar taping can be applied to correct the sitting posture. This study aimed to investigate the effect of lumbar taping on lumbar kinematics and the muscle activities of multifidus (MF) and internal oblique in the individuals with nonspecific chronic low back pain (NSCLBP) as they type for 30 minutes. Nineteen subjects with NSCLBP (9 people in non taping group and 10 people in taping group) were recruited. Lumbar taping was applied to the taping group before typing. Both groups started typing in a neutral sitting position with their feet on the floor. The change of posture and S2 posterior tilting (S2P) were measured to investigate kinematic data. Three sensors were attached on T12, L3, and S2 to identify the change of posture. Surface electromyography was used to measure the muscle activities. Palpation meter was used to standardize the angle of pelvic tilt in sagittal plane before typing. All instruments were used to measure each data before and after typing. Independent t-test was used to compare the changing values of lumbar kinematics and muscle activities before and after typing between both groups. The changing values of S2P and change of posture of L3 and S2 were significantly smaller in the taping group compared to the non taping group ($p<.05$). The changing value of muscle activities of MF between before and after typing was significantly smaller in the taping group compared to the non taping group ($p<.05$). In conclusion, the lumbar taping during the 30-minute typing task can be applied to maintain correct sitting posture in the lumbar and pelvis and to maintain activation of MF.

Key Words: Lumbar kinematics; Multifidus; Postural taping; Typing posture.

Introduction

In modern life, many people spend more time sitting with a computer. Epidemiologic studies demonstrate that works that involve prolonged sitting easily lead to lower back pain (LBP) (O'Sullivan et al, 2006). Slump sitting can especially aggravate LBP (Lee and Yoo, 2011b).

Previous studies have demonstrated that prolonged sitting decreases the lumbar lordotic curve and trunk muscle activity (Claus et al, 2008; Makhsous et al, 2009). Furthermore, there are a lot of studies stating that nonspecific chronic lower back pain (NSCLBP) patients with a flexion pattern back pain due to sitting on a chair with almost the end of the available flexion range which may cause tissue damage symptoms of the spine (Burnett et al, 2004; Dankaerts et al, 2006). For people with LBP it is difficult to keep optimal lumbar lordosis and anterior pelvic tilt slightly during prolonged sitting (Dankaerts et al, 2006). It also has been demonstrated that LBP patients often report difficulty in keeping the neutral position of the lumbar spine (Dankaerts et al, 2006).

O'Sullivan et al (2006) mentioned that "lumbo-pel-

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vic sitting" leads to tonic activity in internal oblique (IO), superficial lumbar multifidus (MF) by upright sitting posture upon anterior pelvic tilt, lumbar lordosis, and relaxation of the thorax. It increases the co-activation of the MF and IO (O'Sullivan et al, 2006). When the activation of active structures is reduced, it causes slump sitting position, so that the load moves from active stabilizing structure to passive spinal structures such as ligaments. It might cause LBP (O'Sullivan et al, 2006). According to clinical observations, deficiencies in motor control during sitting may result in changes in posture (O'Sullivan et al, 2003). Clinicians commonly attempt to improve sitting posture by asking patients to sit with anterior pelvic tilt, lumbar lordosis, and relaxation of the thorax to manage NSCLBP (O'Sullivan et al, 2013).

Taping method has been introduced for the limitation of range of motion (ROM) of joints to improve neuromuscular facilitation and proprioceptive function, involving kinesio taping and postural taping. Especially postural taping has been demonstrated a useful intervention to correct joint alignment. Recently, Kang et al (2013) demonstrated that when postural taping was applied to lumbar, it was used to prevent unwanted lumbar posture. It was more effective in decreasing the forward curvature of the spine, reducing pain associated with forward bending spine, and facilitating the activity of the postural muscles in the taping group compare to the non taping group (Greig et al, 2008).

The previous study demonstrated that anterior pelvic tilt taping can prevent pelvic posterior deformation in the seated worker in slump sitting (Lee and Yoo, 2011b). The other study found that applied postural taping decreased the electromyography (EMG) activity of the erector spinae in physical therapist during lifting task (Kang et al, 2013). However, no studies have determined the effect of postural taping on specific spine kinematics and how to influence on deep muscle activities which are important in lumbo-pelvic sitting in individuals with LBP. The purpose of this study is to investigate the effects of postural taping on changing the value of posture and muscle activities of IO and MF in people with NSCLBP during 30 minutes of typing. We hypothesize that (1) the changing value of change of posture in the lumbar region would be smaller in the taping group compared to the non taping group and (2) an angle of sacrum 2nd posterior tilting (S2P) and pelvic posterior tilt would be smaller in the taping group than in the non taping group and (3) muscle activities of IO and MF would be significantly decreased in the non taping group.

Methods

Subjects

In total, 29 subjects with LBP were screened and 10 subjects were excluded in this study. Nineteen subjects (10 people in the taping group, 9 people in the non taping group) with NSCLBP were recruited by flyer from students and facility members in Yonsei University Wonju campus. The criteria for study inclusion were the presence of NSCLBP for at least 3 months. They had to report the aggravation of their NSCLBP when movement involves the flexion of the lumbar spine and loss of the segmental lordosis at pain region and their symptoms were absent or decrease while decreasing lumbar flexion (Sahrmann, 2002). Their visual analog scale was more than 3 ㎜ (Leitner et al, 2009; Marshall and Murphy, 2010). The exclusion criteria included (1) surgery in the lower extremities or lower back, (2) lumbar spine fracture, (3) lumbar spine and hip contracture, and neurological diseases, (4) aggravation of symptom with movement with extension of the lower lumbar spine, (5) excess of segmental lordosis at symptomatic level with posture, and (6) pregnancy (Dankaerts et al, 2006). Table 1 shows the information of participants in this study. Before this study, the investigator explained procedures to the participants in detail. All participants signed an informed consent form.

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Table 1. Charicteristics of the subjects (N=19)

Variables	Taping group (n_1=10)	Non taping group (n_2=9)
Age (year)	23.2±2.0[a]	22.0±1.7
Weight (㎏)	70.5±9.7	67.3±7.2
Height (㎝)	175.0±5.9	173.3±5.2
VAS[b] (㎜)	4.6±1.3	4.0±1.2
Duration of LBP[c] (year)	2.7±1.4	3.0±1.9

[a]mean±standard deviation, [b]visual analog scale, [c]low back pain.

Instruments

Polhemus Liberty™

The Polhemus Liberty™ (Polhemus Navigation Science Division, Kaiser Aerospace, Vermont, USA) is an electromagnetic motion analysis device. It was used in the study for measuring lumbar kinematics, involving distance of the change of posture and angle of S2P tilt. The liberty device has electromagnetic fields to make the 3-dimensional position and orientation of its sensors. This system has one transmitter that emits an electromagnetic field and sensors which have embedded orthogonal coils that detect position and orientation. Data were recorded on a personal computer and were processed at a sampling rate of 120 ㎐. The orientation of the source and sensors was defined as a left-hand coordinate system with X-forward, Y-right, and Z-up (Burnett et al, 1998). Its intra-trial reliability is .942 (Mills et al, 2007). The three sensors were attached to the spinous process in T12, L3, and S2 to measure upper lumbar angle, lower lumbar angle and sacral tilt respectively (Dankaerts et al, 2006).

Electromyography

Surface EMG was used for measuring the activity of IO and MF muscle during typing for 30 minutes. Four channels of EMG data were collected using commercially available EMG collection hardware (Noraxon TeleMyo 2400T, Noraxon, Scottsdale, AZ, USA) and analyzed using software (MyoResearch XP Master Edition 1.06, Noraxon, Scottsdale, AZ, USA). Electromyographic data were sampled at 1000 ㎐, and the band pass set from 20 ㎐ to 250 ㎐. Surface EMG bipolar Ag/AgCl disposable electrode pairs were placed over both sides of MF and IO. Before the application of an electrode, the skin was shaved and cleaned with alcohol to reduce surface impedance (Ahn et al, 2014). The electrode was applied to MF (2 ㎝ lateral to the spinous process of L4) (Claus et al, 2009) (Figure 1) and IO (medial to anterior superior iliac spine aligned inferomedially toward the pubis) (Ng et al, 1998). To make sure correct the electrode placement was correct, we palpated each of the muscles being tested, observing the EMG signal on the computer.

Palpation meter (PALM)

In this study, the palpation meter (PALM) was used to measure inclination angles between the ipsilateral the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) on the body. The PALM (Performance Attainment Associates, St Paul, MN, USA), has an inclinometer and two caliper

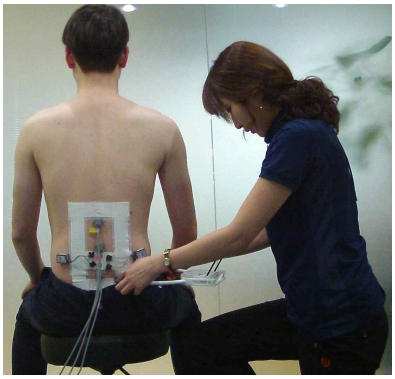

Figure 1. Measurement of lumbar kinematics and muscle activity.

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arms (Lee and Yoo, 2011a). The inclinometer involves a semicircular arc that is able to move within the range of 0~30° in either direction from the midline at 1° intervals. The PALM is a reliable, valid, and cost-effective clinical tool (Petrone et al, 2003). The intra-test reliability of the PALM was .90 and inter-test reliability was .85 (Figure 2).

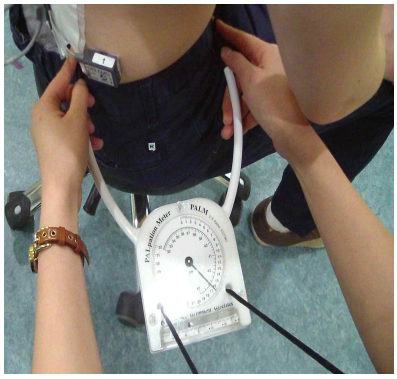

Figure 2. Measurement of pelvic kinematics with palpation meter.

Taping

Postural taping was applied to the lower back. Postural taping was modified to allow space for measuring both sides of MF activity and attaching sensors of liberty (Kang et al, 2013). Non-elastic tape (Battlewin Tape, Nichiban Co. Ltd., Tokyo, Japan) was applied for postural taping to restrict lumbar flexion (Greig et al, 2008). Hypoallergenic tape (3M™ Soft Cloth Tape with Liner, Demieng Industrial Co. Ltd., Seoul, Korea) was used under the non-elastic tape for minimization of skin irritation. To make pelvic anterior tilt, non-elastic tape was attached in neutral sitting position (0° between ASIS and PSIS in sagittal plane by PALM) with relaxed their thorax (O'Sullivan et al, 2006).

Tapes were attached transversely to the back across the 11th thoracic spine and just under the bilateral PSIS. Afterwards, two longitudinal pieces were connected from the end of the 11th thoracic spine tape to the end of PSIS tape with 4 ㎝ interval from spine to maintain neutral position (Figure 3).

Figure 3. Application of postural taping.

Procedure

A desk and chair were adjustable. The desk was elevated until it allowed a 90° elbow angle in line with the trunk. Both hip and knee angles were measured by goniometer. The chair was adjusted to make 90° of the hips and knees with the fixed feet on the floor (O'Sullivan et al, 2012) for the starting position. A laptop has a 10 ㎝ distance from the edge of the desk. To be close to lumbopelvic sitting, participants started a 0° pelvic tilt between ipsilateral ASIS and PSIS in sagittal plane. The experimental group were applied postural taping before the typing task. Both groups were only asked to concentrate on typing a literature comfortably with their feet on the floor. Participants typed a typing practice program, involving some literature for 30 minutes. EMG data and 3 dimensional-measurement (Polhemus Liberty™) data were recorded twice (before the typing task and after 30 minutes after typing task). After 30-minute typing, the inclination between ipsilateral ASIS and PSIS was measured by PALM.

Data collection

To measure the changing values of the change of posture, S2P, and muscle activities of MF and IO pre-test value was subtracted from the post-test value.

Change of posture, sacral posterior tilt

The change of posture was decided to know the

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vector which the participants moved from the starting position such as lumbopelvic sitting. Data were recorded over a one-minute period, with the sampling frequency at 120 Hz by liberty device and averaged over the middle of the 30-second period. All participants positioned in lumbopelvic sitting for the starting position of the test (Burnett et al, 1998). The starting position was defined as a 0° pelvic inclination between ASIS and PSIS of the sagittal plane by PALM. Three variables could change their being: one rotation (flexion-extension angle) and three translations (X, Y and Z coordinate values) according to the therapist-assisted criterion.

Sacral posterior tilt was measured by observation of variable for one rotation (flexion-extension angle). This inclination of the sensor is a value at S2 relative to the vertical (Dolan et al, 2000). A positive angle indicates a posterior sacral tilt.

The change of posture had been decided to be combined variables of two translations to determine the immensity of the vector. The two translation variables were the X (anteroposterior), Y (mediolateral), and Z (superoinferior) directions. The sensors were calculated respectively to the source and the magnitude vector was calculated with the following formula:

$$\sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2 + (Z_a - Z_b)^2}$$

- the X_a coordinate after 30-minute task
- the X_b coordinate before 30-minute task
- the Y_a coordinate after 30-minute task
- the Y_b coordinate before 30-minute task
- the Z_a coordinate after 30-minute task
- the Z_b coordinate before 30-minute task

Where the change of posture is the immensity of the X, Y, and Z translation vector, each data was averaged to calculate it.

Pelvic angle

The inclination of pelvic tilt was measured by the PALM. The pelvic inclination was measured after the 30-minute typing task in sitting position. The examiner palpated the ipsilateral ASIS and the PSIS protrusion with the index fingers. Both index fingers were inserted in the hole of the PALM. It was done to measure the inclination of pelvic tilting in the sagittal plane. Anterior pelvic tilt presents plus (+) value and posterior pelvic tilt presents minus (-) value (Hwang et al, 2014).

Muscle activity

EMG data was collected for 5 seconds with the middle 3 seconds used for the starting position after 30 minutes task. According to a previous study, maximal voluntary isometric contraction (MVIC) was not proper to people with pain, so that the sub maximal voluntary contractions was meant to normalize data to allow for a comparison between subjects with LBP (Dankaerts et al, 2004). To measure the sub-MVIC of IO muscle, the subjects were in crook lying, with hips flexed to 45° and the knees flexed to 90°. The subject lifted both legs 1 ㎝ off the surface and asked to hold each for 5 seconds. It was measured for 5 seconds 3 times and given 5 seconds each trial to rest. To measure the sub-MVIC of the MF muscle, “double leg raise” was used for MF. The subjects were in a prone lying position, with their knees bent to 90° and both knees lifted 5 ㎝ off the ground for 3 seconds. All data were also measured 3 times and given 5 seconds each trial to rest. 3 trials used the middle 3 seconds within 5 seconds and were averaged (Dankaerts et al, 2004).

Statistical analysis

For statistical analysis SPSS ver. 21.0 (SPSS Inc., Chicago, IL, USA) was used. An independent t-test was used to compare the changing values of lumbar kinematics such as the change of posture, S2P, and pelvic tilt and applied for the changing value of muscle activities of MF and IO between the taping group and non taping group. The level of statistical significance was set at $p<.05$.

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Results

Lumbar and pelvic kinematics

The results showed that the difference of the changing values of lumbar kinematics before and after typing between the taping group and non taping group (Figure 4). The change of posture values of L3 (3.10±2.60 ㎝ vs. 6.99±3.30 ㎝) and S2 (2.30±1.87 ㎝ vs. 6.85±3.00 ㎝) were significantly smaller in the taping group compared to non taping group (p=.011, p=.001). There was no significant difference in the change of posture value of T12 (4.80±4.42 ㎝ vs. 6.72±3.24 ㎝) between the taping group and non taping group (p=.30).

The changing value of S2 posterior tilting was significantly greater in the non taping than in taping group (p=.011). There was a significant difference between the taping group and non taping group in the PALM value significantly (p<.05). It displayed a difference in the changing value of the pelvic posterior tilt angle between two groups in the sagittal planes (Table 2).

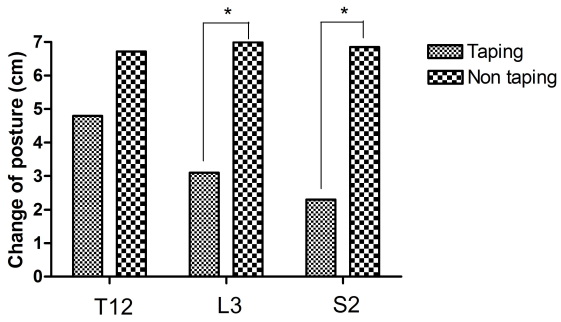

Figure 4. Comparison of the change of posture between subjects with and without taping (*p<.05).

Muscle activities of multifidus and internal oblique

The results indicated for a changing value of muscle activities before and after typing. The change in both sides of the MF activities before and after typing was significantly smaller in the taping group compared to the non taping group (p<.05). But there was no significant difference in the change in both sides of the IO activities before and after typing between groups (p>.05) (Table 3).

Discussion

We investigated the effect of lumbar taping on lumbar kinematics and muscle activity during typing task in individuals with LBP. This study demonstrated that applied lumbar taping decreased the lumbar flexion and pelvic posterior tilt and main-

Table 2. Comparison of sacrum 2nd posterior tilting and pelvic tilt between the taping group and non taping group

	Taping group	Non taping group	t	p
S2P[a] (°)	9.77±14.60[b]	33.88±21.84	2.86	.011*
Pelvic tilt (°)	5.83±3.76	17.20±4.80	5.78	<.001*

[a]sacrum 2nd posterior tilting, [b]mean±standard deviation, *statistically significant at the level of p<.05.

Table 3. Comparison of the changing value of multifidus and internal oblique muscle activity (% sub-MVIC) between the taping group and the non taping group

	Taping group	Non taping group	t	p
Right MF[a]	1.53±6.68[b]	-7.26±6.71	-2.86	.011*
Left MF	4.23±6.71	-3.29±6.14	-2.54	.021*
Right IO[c]	-10.20±10.41	-24.40±27.18	-1.54	.143
Left IO	-15.40±19.19	-15.20±14.62	.03	.980

[a]multifidus, [b]mean±standard deviation, [c]internal oblique, *statistically significant at the level of p<.05.

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tained the MF activities during 30-minute typing. However there was no significant difference in the change of posture of T12 and IO activities between the non taping group and taping group.

In spine kinematics, the changing values of the change of posture of L3 and S2 were significantly smaller in the taping group compared to the non taping group. Previous study indicated that the participants with LBP have reduced ability to reposition their lumbar spine exactly in a neutral spinal posture because of a deficiency of proprioceptive awareness in the lumbar region when they sat (O'Sullivan et al, 2003). Applied taping might help having proprioceptive awareness in participants with LBP (Lee and Yoo, 2011b). Other studies demonstrated that provided spinal stiffness by posture taping may help in decreasing the thoracic kyphosis posture (Greig et al, 2008). Thus, mechanical support by lumbar taping might help in maintaining the neutral sitting posture in people with LBP. Applied lumbar taping might prevent lumbar flexion posture. However, the change of posture values of T12 were smaller in the taping group compared to the non taping group but there was no significant difference. O'Sullivan et al (2006) reported that there was a greater significant difference in the thorax, lumbar and pelvis between upright sitting posture and slump sitting. However there are two possibilities which the change of posture of T12 was not significant. First, the participants in this study were measured in habitual sitting posture. We did not ask them to position completely upright and slump sitting posture like the previous study. Second, The length of taping from T11 to S3 might be related to these results. It is not long enough to control thorax region. Therefore, the thorax might be less influenced by taping than the lumbar and pelvis.

In pelvic kinematics, S2P and PALM value in sagittal plane were significantly smaller in the taping group compared to the non taping group. This result showed that lumbar taping helped in maintaining the neutral sitting posture in participants with LBP. Sitting posture is associated with pelvic posture and the inclination of sacrum and pelvic were related to lumbar lordosis (Vaz et al, 2002). As the subjects with LBP may have loss in proprioception and change in their body schema, it could be more difficult to maintain lumbar lordosis and pelvic anterior tilt (O'Sullivan et al, 2012). Taping may be used as stimulation of cutaneous mechanoreceptors in the taping group (Murray and Husk, 2001). This stimulation might prevent pelvic posterior tilt while seated.

The changing value of MF activities between before and after typing was significantly smaller in the taping group compared to the non taping group. The people with LBP tend to be slump sitting during prolonged sitting. Slump sitting decreases MF and IO activities (O'Sullivan et al, 2003). In this study, MF activities were increased after typing in the taping group compared to the non taping group. Postural taping prevented their slump sitting posture by proprioceptive awareness in lumbar region (Kang et al, 2013; O'Sullivan et al, 2003). It led lumbar extension, so that MF activated as a lumbar extensor muscle. It helped maintaining upright sitting posture like as the starting position. Therefore, this result showed that taping might help to activate MF. MF is an important muscle for the upright sitting posture and local lumbar lordoser (O'Sullivan et al, 2003). It might have benefits to translate mechanical stress to the spine without heavy compressive loading (O'Sullivan et al, 2013). MF activation might be a good intervention for the LBP patients. A previous study reported that postural biofeedback can facilitate a more neutral sitting posture with less unstable posture change (O'Sullivan et al, 2013). In this study, the taping effect could be interpreted as a sensory feedback to help maintain neutral sitting so that it helped activating MF.

However, there was no significant difference in both sides of IO activities. A previous study demonstrated that MF and IO muscle activity significantly increased in upright sitting compared to slump sit-

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ting (O'Sullivan et al, 2006). However, typing for 30 minutes was static task in this study. Starting position was not completely upright sitting, and end position was not completely slump sitting on purpose unlike in previous study. It might not have a significant difference in internal oblique activity between both groups. Sahrmann (2002) reported the main action of IO flexes in the vertebral column and rotates the trunk or pelvis. In this study, typing posture was only related to lumbar flexion and extension, not rotation so that IO might not be strongly activated.

Previous study demonstrated the effect of anterior pelvic taping on pelvic posterior deformity in slump sitting for 30 minutes by normally seated workers (without taping: from 8.30±1.80° to 6.26±2.44°, with taping: from 9.50±1.92° to 10.61±3.17°) (Lee and Yoo, 2011b) but it did not investigate trunk posture and muscle activity in people with LBP. This study investigated the effect of lumbar taping on the thoracic, lumbar, pelvic posture, and muscle activities during 30 minutes of typing in people with LBP. Application of lumbar taping can help to maintain and educate the correct sitting posture for LBP.

The limitation of our investigation should be noted. First, taping was not applied in long terms so it was difficult to compare pain level between groups. Second, we used surface EMG for measuring MF and IO activities but some of the studies suggested using invasive technique to measure the deeper muscles because of difficulty in measuring local muscles (Drysdale et al, 2004). Third, the taping effect on sensory feedback has not been studied enough. Further study is required for an investigation of pain in long term effects and an influence of sensory feedback.

Conclusion

This study investigated the effect of lumbar taping on muscle activity and lumbar kinematics during 30-minute typing. Our results demonstrate that the neutral sitting posture and MF activity were maintained in the taping group. In clinical application, this result would be a good intervention for LBP patients to maintain correct posture and to activate MF.

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