Effect of rigid tape on hip joint proprioception in patients with sacroiliac joint dysfunction

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Sacroiliac joint (SIJ) is a critical junction in the lower back that acts as a buffer zone between the ground reaction forces and the force due to body mass. As it plays a major role in humans' locomotion, sacroiliac joint dysfunction (SIJD) may be the cause of pain and reduced functionality. Several interventions have been proposed in order to treat SIJD; however, limited results have been obtained. The purpose of this study was to examine the effect of rigid tape on degree of innominate anterior tilt in the sagittal plane and hip joint proprioception in patients with anterior innominate SIJD. 30 females with anterior innominate SIJD participated in the study. They were randomly assigned in to two groups; experimental (group A) and control (group B). The participants were tested twice; before and after a two-week period, during which group A received repeated application of rigid tape at the involved SIJ. 2x2 Mixed Design MANOVA revealed a significant decrease in the degree of innominate anterior tilt (p<0.05) in the post-test condition compared with the pre-test in group A with no significant difference (p>0.05) in group B. Moreover, there were no significant within or between-group differences in hip joint proprioception (p>0.05). Repeated application of rigid tape successfully reduced excessive innominate anterior tilt in patients with SIJD.

Keywords: Sacroiliac joint, Sacroiliac joint dysfunction, Rigid tape, Proprioception.

INTRODUCTION

Sacroiliac joint dysfunction (SIJD) has been implicated as a contributor to pain in 13% to 30% of patients with low back pain (LBP) (Maigne et al., 1996; Sembrano and Polly, 2009). SIJD is a term used to describe pain in or around the joint formed by the sacrum and innominate bilaterally (Fortin et al., 1994). Pain is presumed to be due to malalignment or abnormal movement of the joints (Dreyfuss et al., 1994). Due to the multi-segmental innervation of the sacroiliac joint (SIJ) (Zelle, 2005), pain arising from the joint may refer to the lower lumbar region, buttock and lower limbs (Maigne et al., 1996; Slipman et al., 2000; Hansen and Helm, 2003).

The most frequently noted SIJ malalignment is described as an anteriorly rotated innominate with reference to the contralateral side (DonTigny, 1990). This malalignment presents as limited innominate posterior rotation (DonTigny, 1990; Cuppett and Paladino, 2001) and musculoskeletal imbalances (DonTigny, 1990; Alderink, 1991). Tightness of muscles such as iliopsoas, rectus femoris, tensor fascia late, obturator internus and piriformis (Prather, 2003) that cross the hip and altered innominate mobility are thought to affect the hip joint. This is supported by studies that have reported asymmetrical range of motion, limited hip mobility (Cibulka and Delitto, 1993; Cibulka et al., 1998; Bussey and Milosavljevic,
Several clinical tests designed to either detect asymmetric SIJ motion or provoke SIJ pain are used to distinguish symptoms related to SIJD (Laslett, 2008). Various combinations of these tests have been suggested for diagnosis of SIJD (Broadhurst and Bond, 1998; Laslett et al., 2005). Due to complex anatomy and biomechanics, the treatment of SIJD remains controversial (Brolinson et al., 2003). Surgical treatment like radiofrequency denervation of the involved SIJ was effective in relieving SIJ pain (Ferrante et al., 2001). However, the invasiveness of this procedure makes other conservative SIJ treatments attractive options for patients suffering SIJD (Zelle, 2005). Joint-specific manipulative techniques in order to restore normal joint dynamics have been studied previously (Cibulka et al., 1988; Bernard and Cassidy 1991; Osterbauer et al., 1993); however, it remains uncertain if pain recurrence can be prevented using this treatment approach (Bernard and Cassidy 1991; Zelle, 2005). Physical therapy strategies conservative treatment includes manual correction of SIJ asymmetry, lumbopelvic stabilization, and correction of muscle imbalance were helpful (Vaughn and Nitsch, 2008). However, outcome data following management of SIJD are limited and, to our knowledge, randomized clinical trials have not been reported.

Taping is widely used in the field of rehabilitation as a mean of treatment or prevention of sports-related injuries. The most commonly used tape applications are done with rigid tape to provide protection and support to a joint (Refshauge et al., 2000; Alexander et al., 2003). Rigid tape has been reported to reduce pain and restrict unwanted joint posture (Greig et al., 2008; Vaughn and Nitsch, 2008; Kang et al., 2013) by inducing specific joint movement along the direction of tape attachment (Kang et al., 2013). Since patients with SIJD often exhibit poor posture and SIJ mechanics, rigid tape may provide postural cues and assist with promoting proper SIJ alignment. The optimal posture acquired by rigid tape may effectively improve the proprioceptive feedback and neuromotor control of the patients (Alt et al., 1999; Hinman et al., 2003). Despite its clinical popularity, there is no randomized control studies show the efficacy of rigid tape on innominate anterior tilt in the sagittal plane and hip joint proprioception in this patient population. Therefore, the purpose of this study was to examine the effect of rigid tape on the

**MATERIALS AND METHODS**

**Subjects**

Upon approval of Cairo University's supreme council of postgraduate studies and research, 30 females with SIJD enrolled in the study after giving informed consent. To be included in the study participants were to be diagnosed with SIJD by testing positive in at least three of the four positive clinical tests: standing flexion test, supine to long sitting test, prone knee flexion test and palpation of posterior superior iliac spine heights for asymmetry on sitting (Cibulka et al., 1988). Additionally, participants had to have an anterior innominate tilt greater than 2.5° compared to the other side (Selkow et al. 2009) and unilateral pain over the sacroiliac region for longer than three months (O’Sullivan et al., 2007) that was consistently and predictably aggravated by standing and walking (Hungerford et al., 2003). Participants were excluded if they reported any previous or concurrent orthopedic problems of the spine, signs suggesting nerve root involvement, muscle weakness involving more than one muscle with the same nerve root innervation in the ipsilateral lower extremity, diminished lower extremity reflexes, or any other condition which may affect hip joint ranges of motion (Cibulka et al., 1988). Patients were randomly assigned to two groups; experimental and control. Patients in both groups participated in two testing sessions two weeks apart. Rigid tape, for mechanical correction to the anteriorly tilted innominate, was applied to participants in the experimental group every three days for two weeks between testing sessions. Participants in the control group did not receive any intervention.

**Procedures**

Upon arrival, study procedures were explained and the informed consent, as approved by the Cairo University's supreme council of postgraduate studies and research was obtained. A medical history was taken and clinical measures (described below) were performed. Following testing, rigid tape was applied to the participants in the experimental group and they were scheduled for five follow-up appointments for re-application of tape approximately every three days. Participants in the control group were schedule for a follow up appointment in 2 weeks (Table 1). They were asked to perform their
normal activities and refrain from any formal treatment of their pain. The following measures were collected at testing time points 1 and 2.

**Measurement of degree of innominate tilt in the sagittal plane:**
Scoliometer (Sabia’s Scoliometer, NJ, USA) was used to measure the degree of innominate anterior tilt in the sagittal plane during quiet standing. Both rods were loosened and placed firmly over ipsilateral anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS). The degree of tilt indicated by Lev-O-Gage was measured. Three measures were averaged for analysis.

**Hip joint proprioception:**
Hip joint proprioception was assessed through using an active joint position sense (JPS) test in hip flexion and abduction using the Biodex system III multi-joint testing and rehabilitation system (Biodex medical system, Shirley, NY, USA). During testing JPS of hip flexion, the patients stood with the hip joint axis of rotation aligned with the dynamometer axis of rotation in sagittal plane and with the dynamometer arm aligned parallel to the femur. An attachment arm was positioned at the anterior aspect of the middle third of femur while a resistance pad was placed at the same level but on the posterior aspect. The patients flexed the hip to 45° and held it there for five seconds. They were asked to remember this position and then actively bring their hip back to the neutral position. After a five seconds rest period, patients were asked to actively reproduce the target position as accurately as possible. The absolute error (AE; the difference between the target angle and the reproduced angle) was calculated. Lower values of the AE indicated that JPS was more accurate. All trials were conducted at 30˚/sec. Same testing procedures were performed to assess JPS of hip abduction (15°) except that the patients stood facing the dynamometer with the hip joint axis of rotation aligned with the dynamometer axis of rotation at frontal plane.

**Rigid tape description and application:**
Patients in the experimental group received rigid taping at the involved SIJ. Two types of tapes were used in this study; zinc oxide tape (Leukotape classic 5cm×10m; BSN medical S.A.S, made in France) and hypo-allergic tape (Fixomull®stretch 10cm×10m; BSN medical GmbH, D-22771 Hamburg, Germany). Two strips of rigid tape were applied following the attachment of hypo-allergic tape to correct excessive ilium anterior tilt. The first piece of rigid tape was applied to restrain anterior ilial translation and was firmly pulled from the ASIS to PSIS in a straight anterior to posterior direction. While, the second piece was applied to restrain anterior ilial tilt and was firmly pulled from the ASIS in an arching manner to the PSIS. During application of these strips, subjects were positioned in side lying on the non-involved side while the hip joint of the involved side flexed to 45° degrees and the femur supported in neutral rotation (Vaughn and Nitch 2008).

**Data analysis**
Independent sample t-tests were used to determine if differences existed between groups in age, body mass and height. Differences between groups and across time were assessed for the primary outcomes variables: degree of innominate anterior tilt and AE of hip flexion and abduction. Initially, data were screened for normality assumption through using the Kolmogorov-Smirnov and Shapiro-Wilk’s normality tests and testing for the presence of extreme scores and significant skewness and kurtosis. Once data were found not to violate the normality assumption, parametric analysis was conducted. 2x2 Mixed Design MANOVA was conducted to compare the degree of innominate anterior tilt and AE of hip flexion and abduction between group A and B in each of the pre-test and post-test conditions and to compare between the pre-test and post-test conditions for the tested variables in each of the tested groups. All statistical measures were performed using the Statistical Package for Social Sciences (SPSS) v17. The level of significance was set at $p < 0.05$ for all tests.

**RESULTS**
Age, body mass, and height did not differ between groups (Table 2). No significant differences were observed between groups in the pre-test for the degree of innominate anterior tilt and AE of hip flexion and abduction ($p > 0.05$; Table 3). When compared to the pre-test the degree of innominate anterior tilt decreased in the post-test in the experimental group ($p < 0.05$) but not in the control group ($p > 0.05$; Table 3). No differences were observed across time for AE of hip flexion and abduction in either group ($p > 0.05$; Table 3).
Table 1. Study schedule for clinical testing and application of rigid tape.

<table>
<thead>
<tr>
<th>Visit (days)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Control</td>
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</tr>
</tbody>
</table>

Shaded boxes = Clinical testing.
X = Application of rigid tape.

Table 2. Mean (SD) and independent t-tests for the participants’ demographic data.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Experimental (n=15)</th>
<th>Control (n=15)</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean ± SD</td>
<td>37.33 ± 4.53</td>
<td>36.26 ± 3.08</td>
<td>0.754</td>
<td>0.458</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>73.68 ± 4.94</td>
<td>76.13 ± 5.16</td>
<td>1.228</td>
<td>0.230</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.8 ± 3.87</td>
<td>170.6 ± 4.18</td>
<td>1.222</td>
<td>0.232</td>
</tr>
</tbody>
</table>

Table 3. Mean (SD) of groups, mean (SD) within groups, between groups and within groups p values for the degree of innominate anterior tilt and AE of hip flexion and abduction in the experimental and control groups in the pre and post-tests.

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Experimental (n=15)</th>
<th>Control (n=15)</th>
<th>Between group p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innominate anterior tilt</td>
<td>pre-test</td>
<td>6.8 ± 1.2</td>
<td>6.2 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>post-test</td>
<td>3.6 ± 1</td>
<td>5.9 ± 1.4</td>
</tr>
<tr>
<td>Within group p value</td>
<td>0.000*</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>AE of hip flexion</td>
<td>pre-test</td>
<td>4.7 ± 1.2</td>
<td>4.6 ± 1.8</td>
</tr>
<tr>
<td></td>
<td>post-test</td>
<td>4.5 ± 1.08</td>
<td>4.58 ± 1.5</td>
</tr>
<tr>
<td>Within group p value</td>
<td>0.290</td>
<td>0.750</td>
<td></td>
</tr>
<tr>
<td>AE of hip abduction</td>
<td>pre-test</td>
<td>4.9 ± 1.6</td>
<td>4.28 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>post-test</td>
<td>4.6 ± 1.6</td>
<td>4.08 ± 1.8</td>
</tr>
<tr>
<td>Within group p value</td>
<td>0.140</td>
<td>0.350</td>
<td></td>
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</table>

*Significant at alpha level < 0.05.

DISCUSSION

Results from the current study found a decreased in the degree of innominate anterior tilt in the post-test condition compared with the pre-test one in the experimental group, but not in the control group. At the initial testing session both groups reported similar degree of innominate anterior tilt (6.8 and 6.2). After 15 days, degree of innominate anterior tilt decreased 3 points in the experimental group but did not change in the control group. The mechanism underlying improvements following treatment with rigid tape is not clear. Rigid tape as a treatment for SIJD is thought to restrict unwanted joint posture, induce specific joint movement along the direction of tape attachment (Greig et al., 2008) and increased afference of skin sensors due to tape skin contact (Barbanera et al., 2014).

While the improved innominate anterior tilt resulted from the rigid tape intervention in the current study, it is not known if the tape itself provided a mechanical correction or if these improvements were the result of cues provided by the tape. Our findings are supported by those reported by Lee and Yoo (2012). They found that kinesiotape applied for two weeks significantly reduced anterior pelvic tilt angle and improved SIJ mobility and function in a female patient with anterior innominate SIJD. However, as a mechanical correction of innominate anterior tilt may not be expected with the more flexible kinesiotape the improvements in symptoms could be attributed to cue provided by the tape skin contact (Barbanera et al., 2014). Also, the above findings are in agreement with those reported by Vaughn and Nitsch (2008). They described a treatment program that aimed to diagnose and treat a female collegiate tennis player with a right ilial anterior rotation hypermobility. They declared that the performed treatment program besides pelvic taping had the ability to adequately reduce the intensity of pain and improve SIJ symmetry.

Being interested in measuring the effects of rigid tape on hip JPS, the findings revealed non-significant differences in them between both conditions in either group. Although numerous studies found that Kinesiotape or rigid tape can stimulate cutaneous mechanoreceptors and
improve proprioception (Aytar et al., 2011; Campolo et al., 2013) other studies suggest they do not (Callaghan et al., 2008; Keenan et al., 2016). Our findings are supported by that reported by Callaghan et al., (2008). They found that rigid taping of the patella did not enhance the JPS of their patients compared with the controls. Controversially, our finding of insignificant difference in the hip JPS was opposed by the significance reported by Heit et al., (1996). They examined the effects of ankle bracing and taping on ankle JPS in 26 subjects. The result of this study revealed that ankle bracing improves JPS in the motion of planter flexion, while ankle taping improves JPS in the motions of planter flexion and inversion. Also, the findings of the current study do not concur with those reported by Spanos et al., (2008). They conducted a study to determine the effect of rigid tape on JPS of the ankle amongst athletes with ankle inversion sprains. JPS was measured in a non-weight bearing position. The results of this study yielded a somewhat improved proprioceptive capability of the ankle with the application of the rigid tape.

Muscle and joint mechanoreceptors have been reported to have the important role in the elaboration of JPS (Barrack et al., 1984; Hiemstra et al., 2001; Riemann and Lephart, 2002) and cutaneous sense plays only a minimal role especially when using JPS as an outcome measure (Collins et al., 2005). Based on this, it seems that exercises that aimed to adjust the positional sensitivity of the muscular receptors may have more beneficial effect on JPS more than using rigid tape alone. The effects of rigid tape alone were investigated in this study without any other intervention; therefore, it is not known if rigid taping provides additional benefits when combined with other conservative modalities including joint manipulation and stretching. Future studies should investigate the long-term effect of rigid tape on anterior innominate SIJD and the effectiveness of rigid tape in addition to therapeutic exercise for improving of hip joint proprioception.

The findings of this study are limited by the inability to infer the findings to male population with the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female participants. Female patients were tested due to the study being conducted on female patients. They conducted a study to determine the effect of rigid tape on JPS of the ankle amongst athletes with ankle inversion sprains. JPS was measured in a non-weight bearing position. The results of this study yielded a somewhat improved proprioceptive capability of the ankle with the application of the rigid tape.

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The findings of this study are limited by the inability to infer the findings to male population with the study being conducted on female participants. Female patients were tested due to the higher incidence of SIJD in females (Vaughn and Nitsch, 2008). It is not known if similar results would apply in male participants or those who present with different types SIJD.

CONCLUSION
Rigid taping is capable of reducing the degree of innominate anterior tilt to some extent in patients with anterior innominate SIJD.

CONFLICT OF INTEREST
The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT
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AUTHOR CONTRIBUTIONS
NHN designed and performed the experiments and also wrote the manuscript. GAM, SME, and IME performed continuous guidance and suggestions during the performance of experiments, data analysis and reviewed the manuscript.

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