Isokinetic imbalance of hip muscles in soccer players with osteitis pubis

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Abstract
In this study, we compared the isokinetic torques of hip flexors/extensors and abductors/adductors in soccer players suffering from osteitis pubis (OP), with normal soccer players. Twenty soccer male athletes with OP and 20 normal soccer athletes were included in this study. Peak torque/body weight (PT/BW) was recorded from hip flexor/extensor and abductor/adductor muscles during isokinetic concentric contraction modes at angular velocity of 2.1 rad · s⁻¹, for both groups. The results showed a significant difference between the normal and OP groups for hip flexors (P < 0.05). The normal group had significant, lower PT/BW value than the OP group for their hip flexors (P < 0.05). The hip flexor/extensor PT ratio of OP affected and non-affected limbs was significantly different from that of normal dominant and non-dominant limbs. There were no significant differences between the normal and OP groups for hip extensor, adductor and abductor muscles (P > 0.05). Regarding the hip adductor/abductor PT ratio, there was no significant difference between the normal and OP groups of athletes (P > 0.05). The OP group displayed increase in hip flexor strength that disturbed the hip flexor/extensor torque ratio of OP. Therefore, increasing the hip extensor strength should be part of rehabilitation programmes of patients with OP.

Keywords: Osteitis pubis, isokinetic, hip muscles

Introduction
Osteitis pubis (OP) refers to a painful inflammatory condition involving the pubic bones, pubic symphysis and adjacent structures (Williams, Thomas, & Downes, 2000). It is an injury that is characterised by chronicity (Verrall, Slavotinek, & Fon, 2001), and can run for a prolonged and disabling course, if misdiagnosed or mismanaged (Rodriguez, Miguel, Lima, & Heinrichs, 2001). The use of the term OP, as an umbrella term to describe the syndrome of exercise-related groin pain, has been questioned because of the variability in inflammatory findings of athletes with groin pain (Bradshaw & Holmich, 2007).

In specific sports, such as soccer, the incidence of groin pain has been reported to be as high as 5–13% (Ekstrand & Ringborg, 2001), which leads to time away from training and competition of a professional athlete, and may result in a career-ending injury (McSweeney, Nargahi, Salonen, Theodoropoulos, & White, 2012). Initial presentation of OP often includes insidious onset of adductor pain and abdominal discomfort, along with pain in the pubic symphysis (Holt, Keene, Graf, & Helwig, 1995).

Aggravating athletic activities include sprinting, twisting and cutting (McKim & Taunton, 2001). Common sports that incorporate these activities include soccer, football, ice hockey, running and rugby (Holt et al., 1995; Pham & Scott, 2007). Physical examination findings include tenderness to palpation of the pubic symphysis, and pain with resisted strength testing of the adductor and lower abdominal muscle groups (Rodriguez et al., 2001).

Soccer playing is associated with twisting, turning and cutting. These movements produce forces leading to severe biomechanical strain on the symphysis and its associated support structures (Cunningham et al., 2007; Pham & Scott, 2007). Consequently, a microtare occurs at the pubic attachment of the adductor longus. This is frequently a primary event, followed by the development of osteitis, presumably secondary to the induced muscular instability, laxity and secondary impaction of surfaces at the symphysis. The question is, why a microtare at the adductor attachment occurs so frequently in soccer players is unclear. Although overuse of the adductor longus muscle with associated increased...
contractility and power in the muscle belly cannot be accounted for by the small adductor attachment. It is likely that a microtear might occur as a consequence of tendon stretching and applied traction as a result of twisting and turning or, more likely, secondary to both (Cunningham et al., 2007).

The most likely mechanism of OP is repetitive stress from increased shearing forces on the pubic symphysis or from increased stress placed on the joint from the traction of the pelvic musculature, especially in the presence of muscle imbalance (Fricker, 1997). The pathogenesis of OP remains obscure. Evaluation of muscle strength in OP cases was restricted to subjective manual muscle testing which revealed hip flexor, extensor, adductor muscle weakness (Fricker, Taunton, & Ammann, 1991). There is a lack in the literature that has evaluated objectively the isokinetic strength of the major hip muscle groups in OP athletes. So, the purpose of this study was to compare the isokinetic torques of hip flexors/extensors and adductors/abductors in soccer players suffering from OP with normal soccer players. In the present study, we attempted to test the hypothesis that flexors/extensors and adductor/adductor torque ratios of the hip joint might be altered in soccer players suffering from OP.

Methods

Participants

A sample of 20 soccer male athletes suffering of OP was randomly selected from 30 cases referred from an orthopaedic clinic. Clinical examination was conducted by a sports medicine specialist and an orthopaedic surgeon team who referred the OP cases to our isokinetic lab. The OP group demonstrated severe pubic pain (Visual Analog Scale score of was 7.4 cm) and weakness with isometric adduction, (Squeeze test both in supine and supine with 60° hip flexion using a sphygmomanometer) as the soccer players with OP produced significantly less force on the squeeze test when compared with normal, healthy athletes. Pubic symphysis palpation also produced pain. The diagnosis is confirmed by magnetic resonance imaging (MRI); the differential diagnosis for OP is extensive and includes many other syndromes resulting in groin pain. Imaging, particularly in the form of MRI, is helpful in making the diagnosis (Hiti, Stevens, Jamati, Garza, & Matheson, 2011; Khan, Zoga, & Meyers, 2013).

Another group of 20 normal soccer athletes were matched with the patient group regarding age, sex, BW and body height. They had no history of lower extremity surgery or trauma or back or hip injury. About 90.0% of normal athletes were right leg-dominant, while 95.0% of OP soccer athletes were right leg-dominant. Table I presents the demographic data of the participants of both groups. The exclusion criteria were previous history of surgery or trauma in the back or lower extremity. Prior to actual measurements, participants received an explanation of the study procedures and they provided informed consent. The research was approved by the ethics committee of the Faculty of Physical Therapy, Cairo University.

Table I. Demographic data for healthy and osteitis pubis groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control group (n = 20)</th>
<th>Osteitis pubis group (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>20.78 ± 3.35</td>
<td>19.94 ± 3.51</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.00 ± 4.15</td>
<td>176.16 ± 4.93</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.33 ± 7.35</td>
<td>70.91 ± 7.26</td>
</tr>
<tr>
<td>Body mass index</td>
<td>22.92 ± 1.33</td>
<td>22.78 ± 1.07</td>
</tr>
</tbody>
</table>

Instrumentation

Biodex 3 Multi-joint Testing and Rehabilitation System (Biodex Medical System, Shirley, NY, USA) was used to record muscle torque in each participant. Torque values were automatically adjusted for gravity by Biodex Advantage Software v.3.33. Measures of torque and angular velocity, using a variety of isokinetic dynamometers, have been found to be both mechanically reliable and valid (Drouin, Valovich, Shultz, Gansneder, & Perrin, 2004; Pincivero, Lephart, & Karunakara, 1997).

Procedures

Participants executed a 10 min warm-up bout prior to entering the laboratory and collecting hip strength measures. The warm-up procedure consisted of stretching exercises for the hip flexor and extensor, hip abductor and adductor muscles. Stretching exercise was done for 10 min (10 s hold stretch/10 s relax). Throughout all testing with the isokinetic dynamometer, participants were verbally encouraged to perform maximal contractions through the following ranges of motion (ROM): the range of movement for hip flexion/extension was 110° (recorded from 20° hyperextension to 90° of flexion); range of movement for hip abduction/adduction was 65° (recorded from 20° adduction to 45° abduction). Participants were instructed to stop the test if they felt any unusual pain (intolerable pain for the OP group) or discomfort (for the normal group) during the procedure, using comfort stop buttons.

The non-involved side of OP group was tested first, followed by the involved one; whereas in the normal group, the dominant limb was tested first. The testing limb order, in the study and normal groups, was done according to recommendations.
from the isokinetic manual (Biodex Medical System, Shirley, NY, USA). Leg dominance was demonstrated by the preferred kicking leg. Muscle group testing was conducted in a randomised order to prevent learning effects. A 5 min rest period was given between muscle group tests.

Testing was performed with the participants in the standing position, as it was the most functional position, although associated with less stabilisation. In order to allow performing hip movement tests from the standing position, the hip attachment was inserted into the knee adaptor and secured to the dynamometer. Participants performed isokinetic concentric hip flexion/extension and abduction/adduction at angular velocity of 2.1 rad · s⁻¹, as previously recommended in the literature (Masuda, Kikuhara, Demura, Katsuta, & Yamanaka, 2005; Masuda, Kikuhara, Takahashi, & Yamanaka, 2003), and as supported by recommendations from the isokinetic manual.

According to Brown and Whitehurst (2000), for hip flexion/extension and abduction/adduction, the test contained two sets, each one consisting of five repetitions, with a rest period of 60 s between each set. During hip flexion and extension, the player was positioned in the standing position lateral to the dynamometer system, the limb in neutral position, with the axis of the dynamometer aligned superior and anterior to the greater trochanter (Figure 1). During hip abduction and adduction, the player was positioned in the standing position facing away from the dynamometer with the axis of the dynamometer aligned with the anterior superior iliac spine (Figure 2). The parameter evaluated was the PT (expressed in Nm), normalised to the participants’ BW (expressed in Nm/kg).

Statistical analysis

Data were analysed using a Statistical Package for Social Sciences (SPSS) version 15.0. Analysis of variance (ANOVA) was used to compare muscle strength of hip flexors, extensors, abductors and adductors in normal versus OP participants. Level of significance for all tests was set at 0.05 for all statistical tests, with the least significant difference used to locate the source of differences.

Results

The PT values for the hip flexor/extensor and abductor/adductor muscles at 2.1 rad · s⁻¹ angular velocity are shown in Table II. There was no relationship between leg dominance and injury status. Among the OP group, the Chi-Square (χ²) analysis of dominance versus affected limb was not significant (χ² = 0.5; P = 0.48). Sixty per cent of the injury occurred to the dominant leg of the OP athletes, while 40% occurred to the non-dominant leg.

Analysis of variance revealed that there were no significant differences in the normal group (between the dominant and non-dominant limbs) for any of the hip muscles (P = 0.624), as the PT/BW value of hip muscles of normal group was grossly similar for dominant and non-dominant limbs. In addition, there were no significant differences (P = 0.230) in
Table II. The mean values of peak torque (± s) for the hip muscles during concentric modes of contraction at angular velocity of 120°/s.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Osteitis pubis group</th>
<th>Control group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Affected side</td>
<td>Non-affected side</td>
<td>Dominant side</td>
</tr>
<tr>
<td>Hip flexors</td>
<td>156.45 ± 25.49</td>
<td>137.32 ± 18.76</td>
<td>113.12 ± 23.76</td>
</tr>
<tr>
<td>Hip extensors</td>
<td>174.75 ± 24.85</td>
<td>180.15 ± 18.97</td>
<td>170.33 ± 12.47</td>
</tr>
<tr>
<td>Hip abductors</td>
<td>171.79 ± 24.77</td>
<td>127.99 ± 39.73</td>
<td>127.74 ± 35.13</td>
</tr>
</tbody>
</table>

Table III. The hip flexor/extensor and adductor/abductor ratio at angular velocity of 120°/s.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Osteitis pubis group</th>
<th>Control group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Affected side</td>
<td>Non-affected side</td>
<td>Dominant side</td>
</tr>
<tr>
<td>Hip flexors/extensors</td>
<td>0.90 ± 1.02</td>
<td>0.76 ± 0.99</td>
<td>0.66 ± 1.91</td>
</tr>
<tr>
<td>Hip adductors/abductors</td>
<td>1.45 ± 0.93</td>
<td>1.35 ± 0.34</td>
<td>1.40 ± 0.53</td>
</tr>
</tbody>
</table>

PT/BW value of hip muscles in OP group between the affected and non-affected limbs.

For the hip flexors, there was a significant difference between the normal and OP groups (P < 0.05), the normal group had significant, lower PT/BW value than the OP group for their hip flexors (P = 0.028). The hip flexor PT/BW value of affected limb of the OP group was significantly different from that of the dominant limb of the normal group (P = 0.039). Moreover, there was a significant difference (P = 0.037) between the non-dominant limb of the normal group and the affected limb of the OP group. Considering the hip flexor/extensor PT ratio, the normal group had significantly lower ratio than the OP group (P = 0.002), as shown in Table III.

However, none of the other muscle groups (hip extensors, adductors and abductors muscles) demonstrated significant differences between the normal and OP groups (P = 0.381, 0.891, 0.887, respectively). Regarding the hip adductor/abductor PT ratio, there was no significant difference (P > 0.05) between the normal and OP groups of athletes, as shown in Table III.

Discussion

This study was conducted to compare the isokinetic torques of hip flexors/extensors and abductors/adductors in soccer players suffering from OP with normal soccer players. Angular velocity of 2.1 rad · s⁻¹ was chosen to be the testing speed in a trial to emulate the muscular performance during high-speed sport-specific activities such as sprinting, kicking and cutting, which were reported to be pain provocative (Kachingwe & Grech, 2008).

The results demonstrated the absence of any significant effect of leg dominance on the injury status. It is concluded that the site of affection in the OP group (left or right) was not influenced by leg dominance. This may be due to the symmetry in training programme for both lower limbs. This result is similar to that of O’Connor’s (2004), who found that the site of the adductor strain (left, right or bilateral) was not influenced by leg dominance among groups with and without a groin injury of professional rugby league players. However, Sudarshan (2012) reported that OP boy suffers from accompanied left sacroiliac joint dysfunction, reduced left internal rotation of the hip, tightness of bilateral hip flexors and poor motor control of the lumbo-pelvic muscles. Physical therapy, along with exercises improving the lumbo-pelvic stability, increases the hip range of motion and muscle length. The patient had complete resolution of pain by the ninth week and returned to fast bowling without any discomfort.

The PT/BW values of hip muscles for OP soccer players are unique to this study. No other study was found to measure PT values for hip flexion, extension, adduction and abduction. However, several studies reported PT of hip muscles in normal athletes (Masuda et al., 2005; Rahnama, Lees, & Bambaecichi, 2005) or the effect of specific training programme on the symptoms of OP (Cunningham et al., 2007; Hölmich et al., 1999; Lynch & Renström, 1999; Read, 2008; Rodriguez et al., 2001).

The PT/BW values of the dominant and non-dominant limbs in the normal group were similar. This suggests that although all players favoured one foot in kicking and receiving the ball, this had no effect on the strength of the limb. A possible explanation is that isokinetic movements can not replicate the way muscles and joints work during actual soccer kick conditions, another explanation is the symmetry in training intensity, duration and frequency of both lower extremities. These results are supported by some studies. For example, Masuda et al. (2003) found that there was no difference in musculature
in terms of muscle cross-sectional area and strength between the dominant and non-dominant legs among well-trained soccer players. Biomechanical analyses of instep soccer kick have failed to demonstrate any significant difference in isokinetic strength between dominant and non-dominant legs of soccer players (Kellis & Katis, 2007). On the contrary, Wyatt and Edwards (1981) demonstrated significant asymmetry between dominant and non-dominant limbs in male participants. The sample selection and the variation among the isokinetic testing devices may be the cause of the difference. Similarly, in this study, the mean PT/BW values of the affected and non-affected limbs of the OP group were similar. Possible explanations include bilateral affection of hip muscles or symmetry in strength training programmes.

One of the most interesting findings of this study is that only the PT/BW value of hip flexor muscles was significantly higher in the OP group (both in affected and non-affected limbs). The posterior muscle group of the thigh is at maximum strain during kicking activity (extreme hip joint flexion at a simultaneous finite extension of the knee joint). When the hip flexors are excessively active or tight; they cause exaggerated pelvic anterior tilt, and the lumbar spine becomes excessively arched. Tight hip flexors cause the primary hip extensors (the gluteal group) to become lengthened and weak because of their agonist–antagonist action. When the primary hip extensors become relatively weak compared to the hip flexors, insufficient hip extension occurs during kicking, consequently leading to OP (Arnason et al., 2004).

This hypothesis is supported by the observation that strength asymmetry of lower extremities may overload the pubic area (Delahaye et al., 2003). So, weakness of hip extensors is associated with hyperactivity of hip flexors; the resulting imbalance leads to anterior pelvic tilt, which in turn increases the stresses on the symphysis pubis and the sacroiliac joint. These stresses lead to the development of OP. Our results are also supported by a significant relationship measured in female athletes correlating hip extensor weakness to sustaining an injury (Nadler, Malanga, DePrince, Stitik, & Feinberg, 2000). In an attempt to find a possible cause for that imbalance between hip flexors and extensors, Fricker et al. (1991) hypothesised that the nerve supply to the muscles and associated pelvic structures might be involved in OP cases. Pelvic pain, induced either by pelvic vascular impairment or inflammation, may cause reflex muscle spasm of hip rotators, flexors and adductors in particular.

The muscle balance in any joint is determined by the ratio of torques between agonist and antagonist muscle groups. The coordination of movements depends on the coordinated actions of muscles on the opposite sides of a joint. This prevents injuries of muscles, tendons and joint elements during fast movements. The deficiency of strength in one muscle or muscle group can lead to imbalance in the joint actions, which in turn can cause traumas of muscles and joints due to the anomalous distribution of mechanical stresses and strains (Pontaga, 2003). The current study revealed a significant increase in the hip flexor/extensor ratio of the OP group which was due to the hyperactivity of hip flexor muscles in this group. This result is similar to the data obtained by Poulmedis (1985) among Greek soccer players at angular velocity of 3.1 rad · s⁻¹, whereas the results of Calmels, Nellen, van der Borne, Jouardin, and Minaire (1997) showed slight differences which could be explained by the difference in the sporting level of the populations, level of competition and different angular velocities selected for testing.

The insignificant difference in hip adductor or abductor PT/BW values between the normal and OP groups of athletes can be referred to the similarity in training mode, loads, body physique or the same strengthening of muscle groups; the participants playing the same game and most of them in youth teams. Regarding the hip adductor/abductor PT ratio, the non-significant difference between the control and OP groups of athlete may be due to the absence of significant difference existing in the PT/BW of hip adductors and abductors between both groups. The result of the present study was consistent with the data obtained by Masuda et al. (2005) and Poulmedis (1985) among soccer players at an angular velocity of 3.1 rad · s⁻¹. The obtained values by O’Connor (2004) in healthy athletes were similar to those obtained from OP group in the current study. Moreover, the hip adductor/abductor ratio of the OP group was not different from that published in previous studies (Hölhmich et al., 1999; Masuda et al., 2005), hence this agonist/antagonist ratio only has no effect in OP problem.

Conclusion

Based on the findings of this investigation, assessing hip flexor, extensor, adductor, and abductor muscle strength is a crucial step in the evaluation of patients with OP. The hip flexor torque of the OP group was higher than hip flexor torque of the normal group. However, no difference between the two groups for torques of other muscles was found. Therefore, including exercise that increases the strength of hip extensors should be a part of rehabilitation programmes developed for patients with OP. Finally, the absence of difference in PT/BW values between the affected and non-affected limbs in the OP group may indicate that OP patients are prone to bilateral
affection and underlines the need for devising a bilateral rehabilitation programme.

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