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Deficits in eccentric antagonist/concentric agonist strength ratios: a comparative study of football players with and without osteitis pubis

W.S. MOHAMMAD[1,2], W.M. ELSAIS[3]

[1]Department of Physical Therapy, College of Applied Medical Sciences, Majmaah University, Al-Majmaah, Saudi Arabia
[2]Department of Biomechanics, Faculty of Physical Therapy, Cairo University, Giza, Egypt
[3]Etqan Sports Injuries Clinic, Cairo, Egypt

Abstract. – OBJECTIVE: Dynamic hip stabilizers are essential for optimal performance in football players, particularly during kicking. Although the muscle strength deficits of hip muscles as an etiology of osteitis pubis (OP) in football players have not yet been well investigated, previous assessments give more attention to the concentric mode of strength for both hip flexor and extensor muscles. Functionally, the hip muscles interact in an eccentric/concentric pattern. This study aimed to compare the concentric, eccentric, and eccentric antagonist/concentric agonist ratios for hip flexor and extensor strength between football players with OP and healthy athletes.

PATIENTS AND METHODS: Thirty-four male footballers with OP and eighteen healthy footballers were tested using an isokinetic dynamometer at a speed of 180°/s.

RESULTS: Football players with osteitis pubis demonstrated a significantly lower eccentric extensor/concentric flexor ratio and higher eccentric hip flexor/extensor ratio ($p < 0.05$) when compared with healthy participants.

CONCLUSIONS: The present study demonstrated that football players with OP had a reduced capability to produce eccentric hip extension torque compared to healthy athletes. Consequently, the eccentric rather than the concentric weakness of hip extensors could be suggested as one of the intrinsic contributing factors for OP. Incorporating findings of the current study in clinical practice could afford critical information while evaluating the hip muscles in football players with OP for pre-screening, developing rehabilitation programs, and guiding the decision to return to sports after injury.

Key Words:
Eccentric, Concentric, Ratio, Hip extensors, Football players, Osteitis pubis.

Introduction

In the field of sports medicine, the term "osteitis pubis" (OP) reveals an aching inflammatory syndrome affecting pubic bones, the pubic symphysis, and the neighboring soft tissue[1]. The term "OP" could also interchangeably be used as an expression to define the syndrome of workout-related groin pain or adductor pain[2]. It is a chronic insult affecting football players[3], which can persist for a long period or even terminate the player's career if not properly diagnosed and managed[4,5]. Several factors are known to be involved in the pathogenesis of OP. These include repetitive minor trauma within the pelvis, such as those associated with athletic activity, which predisposes patients to OP. In addition, a number of pathological conditions, such as symphysis osteoarthritis, pelvic trauma, and pelvic surgery could also result in OP[6]. It has also been reported[7,8] that muscle imbalance could be attributed to the development of OP in soccer players. Muscle strength deficits that involve one or more muscle groups surrounding the hip joint could disturb the normal distribution of mechanical forces around the joint. Consequently, this could negatively influence the optimal muscle performance and function of the hip joint[9].

One of the most important fundamental asymmetrical skills required in football is kicking[10], which is highly correlated with the maximum muscle strength of the hip flexors and extensors of the kicking limb[11]. Such activity is achieved not only through concentric muscle action but also through eccentric activation[12]. Electromyographic studies[13] have demonstrated that the agonist mu-

Corresponding Author: Walaa Sayed Mohammad, Ph.D; e-mail: w.mohammad@mu.edu.sa

scles contract in a concentric manner to start and maintain movement, while the antagonist muscles work eccentrically to slow down and stop the agonist movement. For example, the hip flexors contract eccentrically to control the extension of the hip during the backswing phase[14], whereas the hip extensors contract eccentrically to decelerate and medially rotate the hip during the follow-through phase of kicking[15,16], with no significant difference in muscle activity during instep or side-foot kicking[10]. Consequently, evaluating the relative balance of opposing muscle groups (agonist-antagonist muscles) that control joint motion by comparing the strength ratios of both groups is clinically important[17] and can be investigated using various isokinetic ratios. For example, the conventional ratio represents the concentric antagonist/agonist ratio and the functional ratio (eccentric antagonist/concentric agonist) that has been used particularly for the assessment of athletes[18].

The proper ratio of the eccentric antagonist to the concentric agonist muscles in football players is crucial for optimizing the dynamic stability and function. To date, there are no reports assessing hip flexor and extensor muscles strength in a way that mimics their real performance; however, the abnormal ratio of eccentric/concentric contraction for a certain muscle group may reflect their abnormal performance and their liability to injury[19]. Commonly, therapists and researchers used testing in concentric ratio mode when identifying side-to-side differences or when comparing subjects to each other[7]. However, testing using an isokinetic eccentric mode of contraction can afford more advantages in evaluating many sport-related disorders. Consequently, this study was designed to compare concentric, eccentric, and eccentric antagonist/concentric agonist ratios for hip flexor and extensor muscle strength between healthy football players and those suffering from OP. We hypothesized that football players with OP would be more likely to report lower ratios for hip flexor and extensor muscles strength compared to healthy players.

Patients and Methods

Sample Characteristics

A group of thirty-four male football players diagnosed with OP was assessed in this study. Depending on a prior power analysis (G*power software), the number of participants was carefully set to guarantee that type I error will not exceed 0.05 and type II error will not exceed 0.20. This statistical power analysis specified that a total of 32 subjects would be enough to establish a power of 0.95 with a large effect size of 0.7. This sample size was also confirmed with a similar sample size documented in the previous studies[7,8]. The participants were enrolled in the current study after a referral from an orthopedist or a sports medicine specialist with a diagnosis of the current OP condition. This was followed by a clinical test designed to affirm the participant's diagnosis. The test was considered positive if the participant experiences pain in the pubic bone while performing isometric adduction both in the back lying position and back lying with the hip flexed at an angle of 60° (Squeeze test), and a tender pubic symphysis to palpation. A matched group of eighteen healthy footballers of the same sex, age, height, mass, and body mass index was tested. Healthy subjects were not allowed to participate in the study if they had a past history of the lower extremity, back, or abdominal surgery. Ethical approval was obtained before the beginning of the study, and each of the participants gave their informed consent for participation and publication of results. Ethics approval for this study was attained from Cairo University Institutional Human Research Ethical Committee (Ethics approval no: P.T.REC/012/002933).

Measuring Devices

The hip flexors and extensors' peak torque produced during concentric and eccentric muscle contraction modes were quantified using the Biodex System 3 isokinetic dynamometer (Biodex Medical Systems, Shirley, NY, USA). The dynamometer quantifies the internal torque generated by a set of muscles while keeping the tested segment at a constant angular velocity (180°/s) and a predetermined movement range. Biodex dynamometer calibration was carried out before each measurement session.

Procedures

After giving their informed consent, each participant was instructed to change into their comfortable sportswear. This was followed by a clear simple illustration of the testing procedures using a recorded video. The participants were allowed to perform a 10-min warm-up stretching session before testing. The tests for the hip flexor and extensor muscle groups were performed in a random arrangement to avoid the dependent ordering effect. A five-minute recess was allowed be-

Table I. Demographic data for the healthy and osteitis pubis groups (Mean ± SD).

Groups	Healthy athlete group	Osteitis Pubis group	*p*-value
Age (years)	21.40 ± 3.71	20.84 ± 3.49	0.66
Weight (kg)	71.83 ± 8.33	72.43 ± 6.01	0.06
Height (m)	1.77 ± 0.050	1.77 ± 0.054	0.82
Body mass index (kg/m2)	23.61 ± 1.99	23.10± 1.64	0.28

tween each group of muscle tests to avoid muscle fatigue. The isokinetic concentric and eccentric modes for hip flexion/extension were performed at a speed of 180°/sec, which has high reproducibility. When testing hip flexor and extensor muscles[20], it was also adopted for football players in previous studies[21,22] and was supported by isokinetic manual guidelines. The testing process consists of two sets of activities, with each one containing five repetitions[23], with a one-minute recess between sets. In each hip muscle group testing, the effect of gravity was compensated by gravity automatic correction.

The typical hip range for flexion/extension was 110° (20° extension to 90° flexion). Maximum concentric voluntary efforts were measured when participants were required to perform two sets of activities, each one being made of five repetitions of hip flexion-extension at an angular velocity of 180°/sec in the concentric contraction mode[23]. Similarly, maximum eccentric voluntary efforts will be measured from hip muscles at the same angular velocity. The highest hip flexors and extensors concentric and eccentric peak torque (PT) values across all repetitions were considered for further analyses. All participants were motivated to utilize their highest effort through all tests.

The conventional concentric hip flexors/extensors (ConcFlex/ConcExt) ratio was computed by dividing hip flexors concentric PT values by hip extensors concentric PT values, whereas the eccentric flexors/eccentric extensors ratio (EccFlex/EccExt) ratio was computed by dividing hip flexors eccentric PT values by hip extensors eccentric PT values. Functional ratios were represented by eccentric antagonist/concentric agonist ratios. The eccentric extensors/concentric flexors (EccExt/ConcFlex) ratio was computed by dividing extensors eccentric PT values by flexors concentric PT values, and the eccentric flexors/concentric extensors (EccFlex/ConExt) ratio was computed by dividing flexors eccentric PT values by extensors concentric PT values.

Statistical Analysis

Firstly, the assumptions of parametric statistical tests were checked through the estimation of Q-Q plots, and the Shapiro-Wilk test to test all variables for normality of data distribution. All continuous data were found to be normally distributed. Then, the one-way analysis of variance was performed to compare the anthropometric data (age, weight, height, and body mass index) of the healthy and OP-affected athletes. The one-way multivariate analysis of variance (one-way MANOVA) was performed for the tested parameters with a significance threshold of $p < 0.05$ for all statistical tests. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (version 26.0 for Windows; SPSS Inc, Chicago, IL, USA).

Results

The demographic data of the participants of healthy and OP-affected football players are shown in Table I. The concentric and eccentric

Table II. Hip flexor and extensor muscle ratios of healthy and osteitis pubis-affected athletes (Mean ± SD).

Test statistics	Healthy athlete group	Osteitis Pubis group	*p*-value
ConcFlex/ConcExt	0.83 ± 0.21	0.88 ± 0.16	0.353
EccFlex/EccExt	0.87 ± 0.18	1.03 ± 0.23	0.013*
EccExt/ConcFlex	1.17 ± 0.28	0.90 ± 0.25	0.000*
EccFlex/ConcExt	0.81 ± 0.24	0.78 ± 0.15	0.617

*Significant < 0.05

functional ratios for the hip flexor and extensor muscles of both groups are shown in Table II. For the ConcFlex/ConcExt and EccFlex/ConExt ratios, there were no significant differences between the healthy and OP groups ($p > 0.05$). However, there was a significant decrease in the EccExt/ConcFlex and a significant increase in the EccFlex/EccExt ratios in the OP group ($p < 0.05$), as shown in Table II.

Discussion

Commonly, clinicians and researchers bilaterally compare strength values of similar muscle groups using the concentric mode to assess the muscle activation differences between healthy athletes and OP-affected ones[7]. However, an isokinetic assessment affords technological advances to enhance the assessment of many sport-related disorders using the eccentric mode of contraction, considering that several muscles work in concentric and eccentric patterns during the various phases of kicking. Consequently, any deviations in eccentric/concentric ratios may result in a better understanding of the underlying mechanism and the potential risk of injury[19]. There are currently no comprehensive datasets that have compared the functional ratios, eccentric antagonist/concentric agonist, of hip flexors and extensors between healthy and OP-affected football players. Therefore, this is the first study to carry out such a comparison. Few studies have endeavored to explain the role of muscle strength and muscle balance in injury prevention and injury etiology in OP-affected athletes[7,12]; however, an isometric strength or ratio for concentric agonist/concentric antagonist has been reported. In spite of the importance of this ratio in delivering standard guides for evaluating OP athletes, they may not account for the exact muscle function during task performance; therefore, they may overlook important muscle imbalances.

According to the results of this study, the hip ConcFlex/ConcExt ratio is higher in the OP group, which is consistent with previously reported findings[7]. This may be due to higher activity or tightness in the hip flexors, which in turn caused exaggerated anterior pelvic tilting with excessive arching of the lumbar spine. Due to the agonist-antagonist relation, the hip extensors, primarily the gluteus maximus, become overstretched and weak compared to the hip flexors, which causes inadequate hip extension while kicking, resulting in OP[24]. Nevertheless, a general strength evaluation is clinically essential, a functional ratio between antagonists and agonists is the principal prerequisite to achieving an appropriate performance of the hip muscles. In a bid to mimic the functional demands on the hip flexors and extensors muscles in football players, this study presented a new perspective in evaluating an eccentric mode of strength.

According to our results, there was no significant difference in the ConcFlex/ConcExt and EccFlex/ConcExt ratios; however, the EccExt/ConcFlex ratio is significantly lower in OP-affected athletes. This indicates that the eccentric antagonists are significantly stronger than the concentric agonists, with ratios of 1.17 and 0.90 for healthy and OP-affected athletes, respectively. This would suggest that for healthy athletes, the deceleration force of hip extensors should be ~20% more than the concentric force of hip flexors to maintain hip stability and initiate the follow-through phase of the kicking movement. This hypothesis is confirmed by the significantly higher EccFlex/EccExt ratio in OP, which indicates the inability of the hip extensors to contract eccentrically in OP-affected athletes. Again, this may be due to the excessive activity of hip flexors that caused exaggerated anterior pelvic tilting and inhibition for the hip extensors.

Despite the paucity of studies available for comparison with the current results, the study by Conneely et al[25] had results similar to those of the current study, as they found that the patients with OP tend to extremely extend their lumbar region and anteriorly tilt their pelvis while extending their hip due to their incapability to voluntarily separate these movements. Additionally, a better understanding of the normal actions of the muscles around the hip joint may shed light on the pathogenesis of OP. The hip flexion position, which is adopted during the kicking task, naturally enhances the muscle torque of the eccentric hip extensor. Therefore, with the hip noticeably flexed, the adductor muscles generate an extension torque that supports the main hip extensors. Consequently, in the case of hip extensor weakness, there will be limited capacity to produce force in functional activities and would be expected to result in synergistic dominance (the adductor muscles)[26], which in turn puts a strain/passive tension on their attachments, causing OP in the process. This justification is consistent with the findings reported by Mohammad and Elsais[8] and Thorborg et al[12], who observed higher adductor muscle strength in

footballers with groin pain compared to those in the control group. The explanation of our results is supported by the consensus in the previous investigations that OP in footballers is linked to the repeated minor loads on the hip adductor muscles during kicking[27], and this also explains why adductor and pubic symphysis pain are frequently reported in patients with OP[28]. Accordingly, an eccentric rather than a concentric weakness of hip extensors could be suggested as one of the intrinsic contributing factors for OP, since eccentric contractions guard the player from insult by dispelling the kinetic and elastic forces generated by the kicking limb[29].

Conclusions

This is the first investigation to present the concept of hip eccentric antagonist/concentric agonist ratio in football players with OP. Previous reports of hip muscle imbalance ratios were based on concentric strength values only. Football players with OP showed a reduced EccExt/ConcFlex ratio and an increased EccFlex/EccExt ratio when compared to healthy players. The reduced capability to create an eccentric hip extension torque may lead to a limited ability to prevent excessive hip flexion, which would stimulate adductor muscle activity, causing excessive stress on the symphysis pubis, which may, in turn, lead to the development of OP. These outcomes attract attention to the dominant role of eccentric hip extensors in controlling the lower body mechanics during kicking. Thus, therapists should evaluate the strength of hip muscles (preferably in an eccentric mode) and incorporate strengthening exercises for hip extensors in an eccentric mode when applying management protocols for OP-affected football players.

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Conflict of Interest

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article

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ORCID ID

Walaa Mohammad ORCID ID: 0000-0003-0110-797X
Walaa Elsais ORCID ID: 0000-0003-2941-3004

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