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Iliopsoas Flexibility in Subjects with Bilateral Flexible Flatfoot

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Abstract : Purpose: to investigate iliopsoas flexibility in subjects with bilateral flexible flatfoot. Methods: comparison was held between a flexible flatfoot group (15 subjects) and normal foot alignment group (15 subjects). Navicular drop test was used to evaluate the medial longitudinal arch of both groups. The modified Thomas test was used to assess iliopsoas flexibility for both groups. The differences between both groups were assessed by using an unpaired t test.
Results: there was a significant decrease in iliopsoas flexibility on both sides in the bilateral FFF group compared to the normal group.
Conclusion: Reduction in iliopsoas flexibility was observed in subjects with bilateral flexible flatfoot when compared to normal controls. Considering that iliopsoas has a direct attachment to the spine, the pelvis and the femur, our results may support that foot misalignment can be a contributing factor to the dysfunction of the lumbopelvic-hip complex.
Keywords: flatfoot, iliopsoas, hip, low back pain, flexibility.

Introduction

The foot is the point of contact between the ground and the rest of the body during weight bearing activities so that, normal foot alignment is essential for normal mechanics and sensorimotor function of the body[1]. Flat foot deformity is a very common deformity among the musculoskeletal deformities[2]. The most common form of flat foot is termed a flexible flatfoot (FFF)[3] which is a clinical problem that represents the collapse of the medial longitudinal arch, hindfoot valgus, and forefoot abduction when the foot is loaded[4].

On weight bearing activities, subtalar joint hyperpronation, that associate FFF, leads to internal rotation of both the tibia and femur with more pelvic anteversion and lumbar lordosis[2,5,6]. The pelvis position can influence the length-tension relationship of muscles originating from it, that anterior positioning of the pelvis is associated with tightness of the hip flexors[7]. Kendall[8]observed muscle length-associated changes in subjects who had musculoskeletal misalignments. Repeated abnormal movements or abnormal sustained postures can cause adaptations in muscle length, strength, and stiffness; consecutively, these adaptations may lead to movement impairments[9,10]. Also excessive pronation, during walking, leads to a timing disruption of the lower limb joints that necessitates compensatory motions of the knee, hip, pelvis, or spine. These compensatory motions create an increased flow of energy through the kinetic chain that will have to be dissipated by muscle action or by the inert tissues around joints. The repetitive actions over these structures may lead to the formation of pathological conditions of the kinetic chain[11].

The iliopsoas is a long muscle, exerting a potent kinetic influence across the trunk, lumbar spine, lumbosacral junction, and hip joint. Crossing anterior to the hip, it is a dominant flexor, drawing the femur to the pelvis or the pelvis toward the femur. In the latter movement, the iliopsoas can anteriorly tilt the pelvis, a motion that increases the lordosis of the lumbar region[12]. It is the only muscle group in the body with direct attachment to the spine, the pelvis and the femur, therefore, it has the potential to influence and be influenced by movements at both the spine and the hip joints[13]. In addition, it has the anatomical prerequisites to simultaneously and directly contribute to the stability of the trunk, pelvis and leg[14].Iliopsoas tightness has been reported as a cause of low back pain (LBP)[15,16] and as a risk factor for some of the lower limb injuries[17,18,19].

Foot hyperpronation is associated with mechanical low back pain (LBP)[20]. It was hypothesized that the altered pelvis position that is present in FFF may result in iliopsoas dysfunction, which may be a cause of LBP[21].There is no study in the literature tested this hypothesis, so the purpose of this study was to determine the influence of bilateral FFF on the flexibility of the iliopsoas muscle.

Experimental

Subjects

Thirty subjects (20-24 years of age) participated in this study and were enrolled in two groups: a group of subjects having bilateral FFF (n=15: 2 males and 13 females) and a group of subjects having normal foot alignment (n=15: 4 males and 11 females). Subjects were enrolled to the FFF group if they had more than 10mm difference in navicular drop test (ND), while they were included in the control group if they had less than 10mm difference in ND[22,23]. Subjects were excluded if they had a history of congenital deformity or surgery in either lower limb or the trunk, or they had an injury to either lower limb or trunk in the previous year.

All participants read and signed a consent form prior to the beginning of testing. This study was approved by the Institutional Ethics Committee of the Faculty of Physical Therapy, Cairo University, Egypt.

Procedures

Assessment of foot by using Navicular Drop test

ND was used to evaluate the medial longitudinal arch and excessive pronation[24]. Barefoot subject was asked to sit with his/her feet flat on a firm surface, with the knee flexed to 90° and ankle joints in neutral position. The most prominent point of the navicular tubercle was palpated and marked with a marker pen. Index card was placed on the inner aspect of the hindfoot, with the card placed on the floor in a vertical position passing the navicular bone. The level of the navicular tubercle was marked on the card. The subject was then asked to assume a normal, bilateral, weight bearing stance; the navicular tubercle was again palpated and its new position was marked on the card. The difference between the two points on the card was measured with a ruler displaying the ND amount in millimeters. One experienced examiner performed all assessments and the measurements were taken 3 times and an average was calculated[22,24].

Measuring the flexibility of iliopsoas

The modified Thomas test was used to assess tightness of the iliopsoas muscle[25]. The participant lies supine with the hip joint positioned over the edge of the examination table and flexes the hip, bringing the knee to the chest and holding it while the low back, sacrum, and pelvis remain horizontal and are stabilized by the examiner. Next, a digital inclinometer (Pro 360 digital protractor; Smart Tool Technology, Inc, Oklahoma City, OK; accuracy = ±0.1°, maximum resolution = 0.1°) was placed at the midpoint between the anteriorsuperior iliac spine and the patella, along the longitudinal axis of the anterior aspect of the thigh, to objectively measure iliopsoas muscle flexibility. Measurements from the inclinometer were recorded to the nearest 0.1°. The order of testing and limb tested were randomized, and the procedure was repeated for the opposite limb[25]. Normal iliopsoas flexibility, as reported by Harvey[26], equals−11.9°, which means that the tested thigh will hang below the horizontal. Ferber[25] found that normal iliopsoas flexibility range between−9.6° to−21.3°.

Results

Physical characteristics of subjects, ND and Thomas test were compared between both groups using unpaired t test. For all statistical tests, the level of significance was set at $\alpha = 0.05$. SPSS statistical package for social sciences (version 19; IBM SPSS, Chicago, IL, USA) was used to accomplish all statistical analysis.

Descriptive statistics for Physical characteristics of subjects:

For FFF group, the mean age, weight and height were (21.13± 0.64, 64.25± 15.16 and 160.00± 6.52) respectively. For normal group, the mean age, weight and height were (21.75± 1.16, 60.00± 10.80 and 163.38± 11.64) respectively. There was no significant difference between both groups regarding the mean age, weight and height ($p > 0.05$).

Comparison of ND between the two groups:

For FFF group, the mean right and left foot ND was (12.75±1.58 and 12.88±1.46) respectively. For normal group, the mean right and left ND was (5.63±0.92 and 6.38±0.92) respectively. There was a significant increase in the right and left foot ND in the flatfoot group compared with normal group ($p < 0.05$).

Comparison of Thomas test between the two groups:

Table 1 shows descriptive statistics of both right and left Thomas test as well as the significant level of comparison between groups. There were statistically significant differences in both right and left Thomas test between FFF and normal controls ($p < 0.05$).

Table 1. Mean Thomas test for FFF and normal groups

Thomas test	Flatfoot group (mean±SD)	Normal group (mean±SD)	MD	p-value
Right Thomas test	9.88± 8.79	-17.38± 4.00	27.25	0.00**
Left Thomas test	11.5± 9.83	-19.13± 1.36	30.63	0.00**

SD, standard deviation; MD, mean difference; p-value, level of significance; ** significant

Discussion

The purpose of this study was to evaluate the influence of bilateral FFF on iliopsoas flexibility. The results showed a significant decrease in iliopsoas flexibility in subjects with bilateral FFF compared to subjects with normal foot alignment.

A significant decrease in iliopsoas flexibility that has been observed in FFF subjects may be due to the maintained changes in hip and pelvis posture during weight bearing activities. On standing, subjects with FFF ,according to the principles of closed kinetic chain, have excessively pronated feet that are associated with internal rotation of tibia[27,28], that leads to internally rotated femur[6.29,30], with increased pelvic anteversion[5,31], and lumbar hyperlordosis[5,32,33]. As the hip joint is maintained in flexion (as the pelvis moves anteriorly on a fixed femur) and internal rotation, the hip flexors and internal rotators are maintained in a shortened position. Animal studies have shown that when a muscle is subjected to maintained changes in length, it undergoes anatomical, biochemical, and physiological changes that are not immediately obvious. Those length-associated changes can be induced by postural mal-alignment[34]. Muscles maintained in a lengthened position add sarcomeres associated with a decrease in the length of the sarcomeres[35] and test stronger at its new extreme length but weaker in a standard muscle test position (stretch weakness)[34], while muscles maintained in a shortened position lose sarcomeres with an increase in sarcomere length[35]and become weak and infiltrated with connective tissue (tight weakness)[34]. From Janda's point of view standing with increased anterior pelvic tilt with an associated increase in lumbar lordosis leads to the pelvic crossed syndrome[36,37], in which there is tightness and facilitation of the iliopsoas and rectus femoris (hip flexors) and thoracolumbar extensors (trunk extensors), while there are weakness and inhibition of the abdominal muscles (trunk flexors) and gluteus maximus and medius (hip extensors)[7].

Subjects with FFF walk with a decreased plantar flexion moment during push off phase of gait[38,39]. The normal strategy for the swing phase of gait is one in which the primary source of momentum is from the plantar flexion moment that takes place during the push off phase. This phase contributes to knee flexion, which stretches the rectus femoris, a hip flexor muscle. This stretching helps initiate hip flexor muscular activity during the swing phase of gait. When the push off is greatly diminished, the motion is generated at the hip for the swing phase "*hip flexorstrategy*"[40]. The emphasis on hip flexor muscular activity can be a contributing factor to shortness of the hip flexors which may be followed by their weakness[9].

The reduction of iliopsoas flexibility that has been found in FFF subjects may be a contributing factor in the development of LBP and lower limb injuries. This may occur because muscle tightness creates a cascade of events that lead to injury. The tightness of a muscle reflexively inhibits its antagonist, creating muscle imbalance. This muscle imbalance leads to joint dysfunction because of unbalanced forces. Joint dysfunction creates poor movement patterns and compensations, leading to early fatigue. Finally, overstress of activated muscles and poor stabilization lead to injury[7]. Janda believed that there are three important factors in muscle tightness: muscle length, irritability threshold, and altered recruitment. Muscles that are tight usually are shorter than normal and display an altered length-tension relationship. Also, tightness leads to a lowered activation threshold, which means that the muscle is readily activated with movement. Movement typically takes the path of least resistance, and so tight and facilitated muscles often are the first to be recruited in movement patterns[41].Structural modifications of muscle length that lead to displacement of the length-tension curve can decrease the muscles' capability to generate or dissipate energy predisposing to injury[11].

There is a growing evidence displaying the mechanical interdependence between hip muscles function and foot function[21,42] which is supported by the results of this study.

Limitations

This study was limited by the small sample size. Another limitation is the reduced ability to ascertain a cause and effect relationship within a case-control design. However our FFF group is thought to develop flat foot deformity early in their lives (as determined from their history), therefore, it appears that the decrease iniliopsoas flexibility was a consequence of the foot misalignment. Also, the lack of postural evaluation of spine and pelvis is from the limitations of this study.

Conclusion

Reduction of iliopsoas flexibility was observed in subjects with bilateral FFF when compared to normal controls. Our results support the interdependence between hip muscles function and foot alignment.

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