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Does Iliopsoas Tightness Affects Synergistic Muscle Activity in Hip Extension During Stance Phase of Gait?

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ABSTRACT

Background and objective: *Iliopsoas stiffness and restricted hip extension ROM affect muscle balance and lumbopelvic alignment. The purpose of this research is study of iliopsoas tightness' effect on electromyographic activity of hip extensor synergists during gait.* ***Methods:*** *In this case-control study 15 adolescents with iliopsoas tightness as experimental group, and 15 healthy adolescents which matched based on age, height, weight, BMI, dominant leg, and sport experience participated voluntarily as control group. Surface electromyographic (sEMG) activity of the gluteus maximus, adductor magnus, and biceps femoris, were measured between groups during stance phase of gait.* ***Results:*** *Individuals with restricted hip flexor muscle length demonstrated more gluteus maximus activation during terminal stance (p=0.001), more biceps femoris activation during mid stance (p=0.002) and late stance (p=0.001) and more adductor magnus activation during mid stance (p=0.04) and late stance (p=0.001).* ***Discussion and conclusion:*** *Adolescent soccer athletes with hip flexor muscle tightness exhibit more biceps femoris and adductor magnus and gluteus maximus activation during stance phase of gait. Thus, individuals with hip flexor muscle tightness appear to utilize different neuromuscular strategies to control lower extremity motion.*

Keywords: Iliopsoas tightness, biceps femoris, adductor magnus, gluteus maximus

INTRODUCTION

The most common cause of disability and long-term pain of musculoskeletal problems in the industrialized world, is muscle stiffness and limited range of motion that is the most common clinical demonstrations after the pain [1]. It is believed that musculoskeletal problems show patterns of muscle imbalance that affects the body and are an important factor in many painful postural conditions. Such a muscle imbalance occurs when the length or strength of one muscle prevents correct function of itself or its antagonistic muscle, for example iliopsoas tightness can limit hip extension ROM and the hip extensor muscles force production [2,3]. According to the length-tension relationship concept, the optimum force production of muscle-tendon unit occurs in the rest length of muscle or neutral position of its joint. If the muscle contract in an increased or decreased length the productive force will be decreased [1]. On the other hand, iliopsoas tightness can alter its antagonist muscles such as gluteus maximus and other hip extensors length tension relationship and decreased their strength or productive force. As per Gibbons, et al., the gluteus maximus muscle acts in its inner range of motion [4] so its force can be decreased with limited hip extension ROM. On the other hand, as mentioned in prior studies, reduced gluteus maximus strength and productive force can lead to synergistic dominancy of its synergist muscles such as hamstrings and adductors [5-7].

From the biomechanical viewpoint, restrictions hip extension range of motion during walking caused a significant functional impairment such as reduced stride length that not only affect the lower limb alignment, but also the ankle biomechanics [8]. Also, limited hip range of motion affect gait cycle in addition to the movement patterns restrictions and posture [9] and is a predictor factor of low back pain [10,11]. To confirm this theory, one can use Sahrmann's movement impairment syndromes theory that reported there is a strong relationship between low back impairment syndrome and the main direction of hip motion limitation [12].

Mills, et al. studied the hip flexor tightness effect on hip extensor muscle activity during deep double leg squat performed in a closed kinetic chain. They find out hip flexor muscle tightness leads to less gluteus maximus activation and lower gluteus maximus: biceps femoris co-activation in a same task [5]. However, it is not clear whether this phenomenon can occur during gait or not. The stance phase of gait can be categorized in closed kinetic chain movements, so we want to study these muscles behaviours during stance phase of gait in presence of iliopsoas tightness. In fact, we want to know whether this neuromuscular strategy known as reciprocal inhibition and synergistic dominance in lower limb can occur in every other closed kinetic chain tasks or not. In addition, in previous study, subjects have limited hip extension ROM so it can be result from all hip one joint or two joint flexor muscles, whereas this study is performed on adolescents who have only one joint hip flexors specially iliopsoas tightness using modified Thomas test and people with two joint hip flexor tightness such as rectus femoris and tensor fasciae latae has been extracted from study using differential tests. In addition, iliopsoas, GM, and adductor magnus (AM) muscles, according to Richardson and Hides play a greater role in activities combined with weight-bearing and take place in the closed kinematic chain [13,14]. Adductor magnus is the biggest adductor muscle of the thigh that constitutes 63% hip adductor muscle volume [15]. This muscle has an extensor portion, which starts from ischial tuberosity and an adductor section that starts from pubic horn. Functional tasks studies showed, AM muscle is active in weight-bearing section of activities such as stance phase of gait [13]. So, it seems investigate the electromyographic activity of these muscles in weight-bearing phase of gait can show the effect of the iliopsoas tightness on the GM activity as well as biceps femoris (BF) and AM activity.

So, the aim of this study is comparison of hip extension synergistic muscle activity between adolescents with Iliopsoas tightness and their healthy counterparts. The main hypothesis of this study was that people with limited hip flexors compared with those with normal Iliopsoas muscle length, have decreased activity of GM and increased activity of BF and AM muscles during gait.

METHODS

In this case-control study 15 adolescents with Iliopsoas tightness as experimental group, and 15 healthy adolescents which matched based on age (mean range=12.5 ± 1.4), height (mean range=148.24 ± 5.7) weight (mean range=37.73 ± 3.3), BMI (mean range=17.22 ± 0.030), dominant leg and sport experience participated voluntarily as control group. The subjects selected from the available community, using non-probability sampling method by the results of a pilot study to determine the sample size were selected based on the variance of the parameters studied on 5 people. It should be noted that all study procedures were explained to subjects before all tests. Written informed consent was obtained from parents and participants filled voluntary participation form.

Inclusion criteria were iliopsoas tightness of dominant leg determined with limited hip extension range of motion using modified Thomas test and universal goniometer. All participants played soccer at least for one year, had no history of surgery in the leg or lower back, any injury or disease of the lower extremities or back pain in the past month, any hip pain or neurological problems that will not allow range of motion measurement and the use of anti-inflammatory drugs or anaesthesia in the past 72 hours.

To measure the hip extension range of motion, subject sitting on the edge of the examination table then lie supine so that the tail was at the end of the table. Subjects opposite leg kept in full flexion (this help to maintain posterior pelvic tilt and flattened lower back and is essential to avoid stress on the spine) [2,16]. To assess, the center of goniometer fixed on the center of greater trochanter of the hip, fixed arm was parallel to axillary line of trunk and movable arm placed parallel with the longitudinal line of femur toward lateral femoral epicondyle [2,16]. The angle was less than 180 degrees indicating iliopsoas shortness, the values were between 180 and 190 in the persons has normal Iliopsoas length. Before measuring the hip extension angle differential tests were used to reject the rectus femoris and tensor fascia latae shortness according to Kendal, et al. [2]. The dominant leg was defined as the leg the participant use almost to kick the soccer ball. Our pilot study showed inter-rater reliability for this method of hip extension rom assessment was good (ICC (2.1)=0.89-0.92 and SEM=3-2.1°).

Surface electromyographic (SEMG) activity of the GM, AM, and BF, were measured between groups during stance phase of gait. After standard skin preparation including hair removal and cleaning the site with 70% alcohol a surface electromyography (SEMG) system (ME6000, Megawin, 8 channels, made in Finland): inter-electrode distance=20 mm; 20 Hz to 450 Hz band pass filtering; input impedance >1015//0.2 w//pf; sampling frequency=1000 Hz) was used to record activity from the GM and BF using SENIAM protocol [17]; for AM muscle the electrodes was placed middle distance between the pubic tubercle and the medial femoral epicondyle over the bulk of the adductor muscles [13].

Prior to recording EMG activity during gait round force sensing resistors (FSR 402, 18.28 mm in diameter; made in Japan) were used to determining the stance phase of gait. The sensors were placed under the heel, first metatarsal bone, and thumb of dominant leg. From the moment of heel contacts until the toes contact the ground was considered as early stance phase, from the moment between toes touch the ground to lift the heel off the ground was considered as the mid stance and the time between lifting the heel off from the ground and toe off was considered as late stance [18]. RMS of three steps for events early stance, mid stance and late stance phase of gait extracted using MATLAB R2016a 9.0 software Raw EMG signals normalized using maximal volitional isometric contractions (MVIC) in 5 seconds for each muscle.

Shapiro-Wilk test results showed that the distribution of variables was normal; therefore, independent t-test was used to compare the GM, BF, and AM activity during stance phase of gait between two groups in significant level of 0.05 using SPSS (version 20) software.

RESULTS

Table 1 shows descriptive information of subjects including age, height, weight, and BMI. Independent t-test showed no significant difference of anthropometric variables between groups ($p \geq 0.05$).

Table 1 Mean and standard deviation (X ± SD) of demographic variables

Variables	Iliopsoas tightness	Healthy
Age (years)	12.5 ± 1.4	12.5 ± 1
Height (cm)	148.24 ± 5.7	149.50 ± 4.9
Weight (kg)	37.73 ± 3.3	37.76 ± 4.6
Body mass index (kg/m^2)	17.22 ± 0.30	17.00 ± 0.76

Table 2 shows mean and standard deviation of variables as well as the results of independent t test to compare the group's average.

Table 2 RMS the gluteus maximus, biceps femoris and adductor magnus during different events of stance phase in people with and without iliopsoas tightness

Variables		Healthy people	Iliopsoas tightness	t	p-value
Early stance	Biceps Femoris	0.18 ± 0.15	0.16 ± 0.19	-0.207	0.82
	Adductor Magnus	0.14 ± 0.16	0.11 ± 0.12	0.68	0.21
	Gluteus Maximus	0.14 ± 0.21	0.11 ± 0.15	1.121	0.27
Mid stance	Biceps Femoris	0.04 ± 0.06	0.12 ± 0.22	3.574	0.002*
	Adductor Magnus	0.14 ± 0.16	0.14 ± 0.28	-0.58	0.04*
	Gluteus Maximus	0.14 ± 0.16	0.13 ± 0.27	-2.029	0.04*
Late stance	Biceps Femoris	0.09 ± 0.10	0.06 ± 0.28	5.185	0.001*
	Adductor Magnus	0.13 ± 0.15	0.07 ± 0.21	1.375	0.001*
	Gluteus Maximus	0.06 ± 0.14	0.08 ± 0.32	4.224	0.001*
* indicates significant differences					

DISCUSSION

This is the first study to investigate the impact of Iliopsoas muscle tightness on activity of the hip extensor muscles during gait. The results showed that the RMS of the GM, BF and AM muscles in the middle stance and late stance during gait significantly was more than healthy counterparts.

It was expected that iliopsoas tightness will lead to decreased GM activity and that will be compensated with increased activity of synergistic muscles such as BF and AM. Whereas RMS of all three muscles of adolescents with iliopsoas tightness was more than healthy counterparts in middle and late stance phases of gait. This indicates decreased efficiency of hip extensors in adolescents with iliopsoas tightness, so in a given task GM as the primary hip extensor and hamstring and AM as the secondary hip extensors in demonstrate more activity in adolescents with iliopsoas tightness in comparison with healthy counterparts. This finding is consistent with Mills, et al. They showed weak people demonstrate more muscular activity than stronger ones in the same task [5]. Hence it can be said restrictions of iliopsoas length disrupt the length-tension relationship of hip extensor muscles and causing weakness in this muscle. On the other hand, take a closer look to RMS of GM and BF in Table 2 can be find out that the GM/BF ratio during early stance and is lower in people with iliopsoas tightness. Whereas this ratio is not significant in mid stance or late stance; it seems that, motor control strategies have been most affected by iliopsoas tightness in the early stance. In the early stance phase of gait GM acts to increase stability in sacroiliac joint and has role in forward propulsion of trunk [4,19], it seems in people with iliopsoas tightness due to reciprocal inhibition and decreased activity of GM the activity of secondary hip extensors such as BF increased. But this was not happened for AM.

AM muscle ability in adduction and hip extension increase its activity in stance phase of gait as weight-bearing phase helps stabilize the hip joint. Increased activity of BF and AM can be a risk factor for strain injury in people with iliopsoas tightness because it exerts too much biomechanical stress on muscle tissue. In addition, increased these muscle activities in patients with iliopsoas tightness can expose them to fatigue in sport. So that increased load on the adductor muscles over activate them in a similar Task and increase the risk of strain and groin pain in soccer players. On the other hand, the hamstrings are the main muscle in controlling anterior tibial translation and shear forces and finally ACL protection [20]. Hamstring fatigue can lead ACL loading and injury in people with iliopsoas tightness. In conclusion, these findings suggest that people with short iliopsoas may be at risk of hamstring or ACL injury. So, improving hip extension range of motion through stretching or manual techniques with the aim of increasing the hip flexor muscles, especially iliopsoas, length can improve length-tension relationship in the extensor muscles and improve their efficiency.

One of the limitations of the present study was to research the young soccer players aged 11 to 14 so that it is not clear it can be extended to other groups. In addition, this study was limited to stance phase of gait therefore its extension to other functional tasks needs and researches.

CONCLUSION

It can be said that the younger soccer players with a short iliopsoas have increased activity of the biceps femoris, adductor magnus and gluteus maximus in stance phase of walking compared to normal counterparts during stance phase of gait. The GM/BF activity ratio in people with iliopsoas tightness was lower than healthy counterparts in early stance phase of gait. Whereas GM/AM activity ratio did not differ between two groups.

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