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The Effect of Obesity on the Magnitude of Quadriceps Angle and Angle of Foot Progression in Adult Females

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Abstract: Background obesity is a medical condition in which excess body fat has accumulated to an extent that it may have a negative effect on health causing serious diseases, such as type 2 diabetes, heart disease, cancer as well as causing musculoskeletal disorders and biomechanical disturbance of joint angles particularly of lower limbs leading to overuse injuries. The aim of this study was to determine the impact of adolescent girl's obesity on the magnitude of quadriceps angle and angle of foot progression. Methodology cross section study, forty adolescent girls were selected from faculty of physical therapy, Kafrelsheikh University. Their ages ranged from 18 to 22 years old. Group A, 20 girls with body mass index (BMI <25 kg/m2) and group B, 20 obese girls with BMI ranged from 30-40 kg/m2. Both quadriceps angle and angle of foot progression were measured in both group A and B. Result significant increase in quadriceps angle and angle of foot progression among adult obese females (Group B) (P<.05) as compared to normal weight (Group A). Conclusion the study proved that adult females have higher magnitude in both quadriceps angle and foot progression angles compared to non-obese adult females.

Key words: Quadriceps Angle · Foot Progression Angle · Adult Females · Obesity

INTRODUCTION

The prevalence of overweight and obesity has increased dramatically ; Globally, there were more than 300 million adult obese individuals and greater than 115 million individuals suffering from problems related to obesity; including hypertension, diabetes, heart diseases, respiratory diseases, cancers and musculoskeletal disorders, particularly at the lower extremities such as osteoarthritis, which are the most common [1].

Obesity defined as global epidemic disease in which excessive body fat had accumulated in the adipose tissue; Person of body mass index (BMI) higher than 30 kg/m^2 is considered as obese.

It is recognized as serious health problem as its incidence is rapidly increasing at alarming rate [2].

The foot provides stable base of support (BOS) for the body, attenuates impact and rotational forces, provides sensory information, Hennig [3] and combines flexibility and stability for propulsion of the body. Vicenzino *et al*. [4] and Doxey [5] normal weight individual, joints of the lower extremity are exposed to reaction forces nearly three to six times body weight during locomotion (Single leg stance phase). Frankel *et al*. [6] and Felson [7] consequently; obese individuals experience greater absolute loads at these joints than normal weight individuals [8].

Because of overloading on musculoskeletal structures, obesity has well-known association with orthopedic problems, as any mal-alignment in the body is thought to place undue stress and strain on the joints, ligaments and muscles which lead to overuse injuries [9].

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Knee and foot problems are common in adult obese subjects; this may be due to the increased stress placed on the knee and feet through the need to bear excessive mass, Riddiford-Harland *et al.* [10] as well as the interface between body and ground are subjected to high stresses and load [11].

Severe obesity change the biomechanics of ankle and foot joints as it leads to greater rear foot motion which can lead to certain dysmorphism of foot specially flat foot, negative impact on postural stability and alteration in the gait [12-14].

A high Quadriceps angle interferes with the smooth gliding movement between the patella & the knee. Overtime, especially with repetitive activities, this type of micro trauma causes non specific pain to the front of the knee & the cartilage on the underside of the patella begins to wear & thin, eventually knee becomes degenerative & develops osteoarthritis [15].

Both (Q-angle) and (Foot angle) are important indicator of biomechanical function and dysfunction in the lower extremity. There is an effect of excessive foot pronation on the magnitude of Q-angle [16]. Therefor, the aim of this study was to investigate the effect of adult females's obesity on the magnitude of both Q and foot progression angles.

MATERIALS AND METHODS

This study was designed as a Cross sectional study. The institutional review board at the Faculty of Physical Therapy, Cairo University approved this study before its commencement. The study has followed the Guidelines of Declaration of Helsinki on the conduct of human research. The study was conducted between February 2018 and December 2018. The samples of forty females were selected from Faculty of Physical Therapy, KafrElsheikh University, Cairo, Egypt. The females' age ranged from 18 to 22 years old. There were two groups in this study, equal in number; Group A; 20 females with normal body weight and body mass index (BMI <25 kg/m^2); and group B; 20 females, their BMI ranged from 30-40 kg/m^2. Both quadriceps and foot progression angles were measured in both group A and B.

The females who possessed any past or current neurological, musculoskeletal, neuromuscular, physiological disabilities, cardiovascular or neurological illness, orthopedic abnormality, gait problems or pain that might affect or interfere with their walking or had previous surgeries in their lower limbs were excluded from participating in this study.

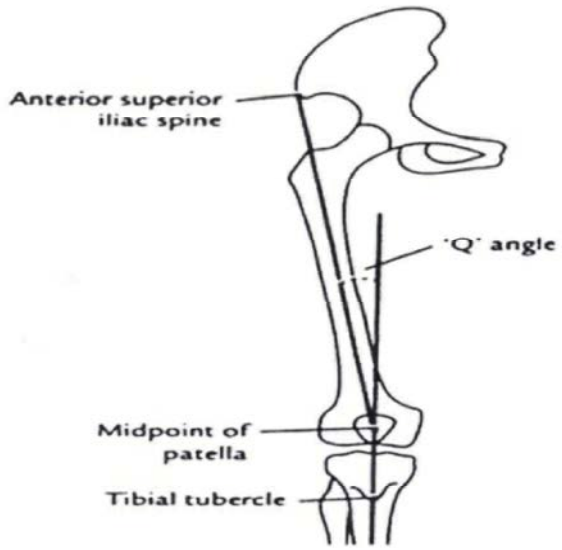

Fig. 1: Measurement of Q-angle

Procedures: quadriceps and foot progression angles were measured for all females in both groups A and B. The measurements were performed by single well-trained examiner.

A-measurement of the Quadriceps Angle: It is the angle between two lines; the first line is line connecting the anterior superior iliac spine (ASIS) to the midpoint of patella and the second line is the line connecting tibial tuberosity to midpoint of patella. It was measured while the girl in standing position. (Figure 1) [9].

The participants were positioned standing barefoot, their knees in total extension and each girl were asked to keep her lower limbs in relaxing status. Afterwards, the same technician took radiographs (A 500 mm A G3 Model, Macrotec®) in anteroposterior positioning using radiological 35 x 91 cm film, comprising a portion of the hip 15 cm below the previously market TAT using a lead film (4 cm2) fixed on the skin with adhesive tape, in order to facilitate the visualization of the TAT after revealing the film (A Kodak® film). The Q angle is formed by the crossing of two imaginary lines: the first line is formed by the (ASIS) to midpoint of patella and the second line is formed by the tibial tuberosity to the midpoint of patella [17]. The Q angle was traced and measured for the right and left knee by the same researcher using a conventional rule, a pen and protractor to prevent study error. The participants were kept in an upright standing position and no trunk - forward or posterior swing was permitted.

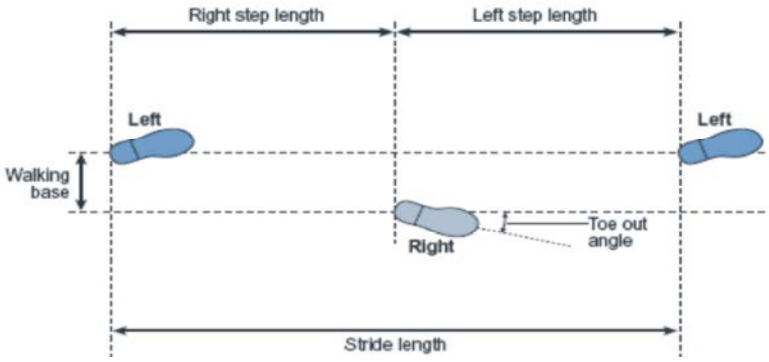

Fig. 2: Measurement of foot progression angle (Degree of toe-out)

Measurement of the Foot Progression Angle: It represents the angle of foot placement. It is the angle between two lines; the first line is line of progression and the second line is line which intersecting the midpoint of heel and second toe. (Figure 2) [9].

The subject was instructed to walk away. From the second footprint, three consecutive footprints were evaluated for the degree of toe out (Foot angle).

Statistical analysis involved the calculation of the means and standard deviations for each of the variables measured. Differences between the values of the Q angle between the participants in the two groups were assessed using the student-t test. A P-value of < 0.05 was taken to represent statistical significance. Data analysis was performed using SPSS software version 16.

RESULTS

The results of this study revealed that there was significant increase in both quadriceps and foot angles among obese females (Group B) (P<.05) as compared to the normal (Group A).

Quadricepse Angle: Right Knee: There was statistically significant increase in participant's Q-angle (P= 0.05), as the mean value of Q-angle was 17.55°± 1.4 at normal girls (Group A), while it was 22.9°±1.3 at obese girls (Group B).

Left Knee: There was statistically significant increase in participant's Q-angle (P=0.05), as the mean value of Q-angle was 17.01°±0.6 at normal girls (Group A), while it was 22.4°±1.5 at obese girls (Group B) (Table 2 & Figure 2).

There were no statistically significant differences in the participant's quadriceps-angle between the right and left knee (P>0.05) at normal girls (Group A) as well as in adolescent obese girls (Group B).

The Foot Progression Angle

Right Foot Angle: There was statistically significant increase in participant's *foot angle* (P= 0.05), as the mean value of *foot angle* was 7.44°±1.3 at normal weight group (A), while it was 9.61°±1.7 in group (B).

Left Foot Angle: There was statistically significant increase in participant's *foot angle* (P=0.05), as the mean value of *foot angle* was 7.23°±1.5 at normal weight group (A), while it was 9.81°±12 at group (B) (Table 1 & Figure 1).

There were no statistically significant differences in the participant's foot angle between the right and left knee (P>0.05) at normal girls group (A) as well as in adult obese females group (B).

Table 1: Mean ± SD values of Q angle for participants at normal females (Group A) and adolescent obese females (group B)

	(group A)		*(group B)*	
Q- *angle*	*Right Q angle*	*Left Q angle*	*Right Q angle*	*Left Q angle*
Mean	17.55º	17.01o	22.9o	22.4º
±SD	± 1.4	±0.6	±1.3	± 1.5
p. value	0.05			
Significance	*S*			

**SD: Standard Deviation, P. value: probability value, S: Significant*

Table 2: Mean ± SD values of foot progression angle for participants at normal females (group A) and adolescent obese females (Group B)

	(Group A)		*(Group B)*	
Foot progression angle	*Right foot angle*	*Left foot angle*	*Right foot angle*	*Left foot angle*
Mean	*7.44°*	*7.23°*	*9.61°*	*9.81°*
±SD	*±1.3*	*±1.5*	*±1.7*	*±12*
p. value	0.05			
Significance	*S*			

*SD: Standard Deviation; P. value: probability value; S: Significant.

DISCUSSION

Following the analysis of the results, it is possible to view the difference in the Q angle and the angle of foot progression of normal weight adolescent girls (Group A) and adolescent obese girls (Group B). Our study proved that there was significant increase in quadriceps angle and angle of foot progression among adult obese girls (Group B) (P<.05) as compared to normal weight adult girls (Group A).

Several studies have shown differences in plantar pressure [18] foot structures [19] and foot mechanics in obese compared with normal weight individuals [20]. Other studies have revealed a strong link between body mass index and osteoarthritis [21, 22]. Collectively, these studies showed that obese individuals are more likely to suffer from musculoskeletal pain and disorders. Scientific observations also showed beneficial effects of a moderate weight loss on knee pain, mobility and on the percentage of joint surgeries associated with osteoarthritis [23].

The obese subjects have changes in spatiotemporal parameters such as cadence, walking speed, stride length and the stance and swing phases duration. Differences in kinematic parameters also have been reported as higher dorsiflexion and lesser plantar flexion magnitude in ankle movement for the overweight compared with the normal weight subjects [24].

Concerning our results about increasing the foot angle in obese girls; also the study of Harris [25] stated that during the erect standing position with obese persons, there is flatness of the longitudinal arch, which is usually accompanied by out-toeing and excessive foot pronation which leads to shortening of tendo-achilles and instability at subtalar joint and increasing the foot angle.

Biomechanically, if the foot functions in constant pronation the entire leg undergoes excessive internal rotation. The internal rotatory stress or position of excessive internal rotation of the leg may result in several possible problems around the knee, including excessive angulation of the patellar tendon and excessive pressure of the lateral patellar facet [26].

From biomechanical point of view, the pronated foot may be the result of functional leg length inequality if the problem is asymmetrical. This is because pronation of the foot can lower the ankle joint axis and result in a slight reduction in overall limb length. Lowering the arches also tenses the plantar ligaments and the plantar fascia. Prolonged stress on these structures can result in a cycle of microtears, pain and inflammation [27, 28].

Poor foot alignment may cause pain at other body joints, for example excessive subtalar joint pronation has been thought to contribute to leg, knee and back pain [29]. Shortening of tendo-achilles cause eversion of the calcaneus which leads to increasing the foot angle and degree of toe out due to contracture of the gastrocnemius and soleus [30]. This results matching with the result of our research which proved that, there is significant increase in the foot angle among adult obese girls as compared to normal weight girls (Group A).

The same result proved by Chang *et al*. [31] who concluded that the toe out gait loads the medial foot and increases pressure and mechanical force on the medial foot which leads to increases the severity of the valgus foot.

Many studies [32, 33] come in agreement with our study and revealed that obese subjects always suffer from tight gastrocnemius and tightness of tendoachilles which leads to toe out gait due to increasing in the foot angle. This is likely to place strain on structures associated with the longitudinal arch as weight is transferred from heels to toes.

Several Studies [12-14] were matched with the results of our research and have showed that, severely obese females have significantly greater rear foot motion and foot angle values than normal weight females which can lead to certain dysmorphism of foot especially flat foot, negative impact on balance and alteration in the gait.

The study of Prakash *et al*. [34] showed that there is significant positive correlation between BMI & Q-ANGLE which come in agreement with the results of our study.

CONCLUSION

The study proved that adolescent obese adult females have increasing in both of quadriceps and foot angles compared to normal weight adult females.

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