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Original Research Article

A Study on Lower Extremity Malalignment and Its Correlation to Q-Angle in State Level Athletes of Odisha

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ABSTRACT

Introduction: Q-angle is considered to be the most important variable among the lower extremity alignment variables. The present study was undertaken to determine the anatomical factors, those which have impact on the magnitude of Q-angle and to examine sex differences in lower extremity alignment of state level athletes.
Methods: 100 state level athletes (50 male and 50 female) of age group 18-27 years were selected purposively from various sports academies of Odisha for study. Five anthropometric variables, i.e. height, weight, Body Mass Index, total leg length, lower leg length; and six lower extremity alignment variables, i.e. tibiofemoral angle, femur anteversion, Q-angle, genu recurvatum, tibial torsion, navicular drop were measured on each subject following standard techniques.
Results: The present study depicted that statistically significant differences ($p \leq 0.001$) were observed between male and female state level athletes in anthropometric variables, viz., height, weight, right total leg length, left total leg length, right lower leg length, left lower leg length and; in lower extremity alignment variables, viz., right femoral anteversion, left femoral anteversion, right Q-angle, left Q-angle, right tibial torsion, left tibial torsion. However, statistically significant difference ($p<0.05$) were seen in right tibiofemoral angle, right navicular drop and left navicular drop. Significant positive correlation ($p \leq 0.001$) of right Q-angle was noted with right femoral anteversion, right tibial torsion and right navicular drop.
Conclusion: It may be concluded that femoral anteversion, tibial torsion and navicular drop have significant impact on the magnitude of Q-angle; and the sex difference may influence the static lower extremity alignments.

Keywords: Q-angle, tibiofemoral angle, femoral anteversion, genu recurvatum, tibial torsion, navicular drop.

INTRODUCTION

Lower extremity alignment has been proposed as a risk factor for acute and chronic lower extremity injuries, including patellofemoral syndrome, [1,2] anterior cruciate ligament injuries, [3-6] medial tibial stress syndrome, stress fractures, and plantar fasciitis. [7] It has been suggested that biomechanical changes resulting from abnormal alignment may influence joint loads, mechanical efficiency of muscles, and proprioceptive orientation and feedback from the hip and knee, resulting in altered neuromuscular function and control of the lower extremities. [3, 8] Accounting for the alignment of the entire lower extremity, rather than a single segment, may more accurately describe the relationship between anatomic alignment and the risk of lower extremity injury, because one alignment characteristic may interact with or cause compensations at other bony segments. [9, 10]

Females are generally exposed to a higher risk of lower extremity malalignment due to different anatomical alignments, lower pain thresholds, and lower physical tolerance than males. [11,12] Previous studies found that females are at increased risk of abnormal anterior pelvic tilt, femoral antetorsion, Q-angle, tibiofemoral malalignment, and genu recurvatum. [11,12] It has been suggested that Q-angle is a composite measure of pelvic position, hip rotation, tibial torsion, patella position and foot position. [1,2,13] Regarding the clinical significance of Q-angle, it is observed that changes on this angle are associated with chondromalacia patella, lateral dislocation of the patella, erosion of the patellar cartilage and of the lateral condyle, femoral internal rotation, foot pronation and internal tibial torsion. [14] Q-angles that vary from 15-20◦ are often referred to as excessive. [15] The American Orthopaedic Association defines "excessive" as Q-angles greater than 15◦. Sex-based differences in Q-angle have been reported, with women typically having a larger Q- angle. [16,17] However, literature related to the lower extremity malalignment and Q-angle study is scanty both in normal population and athletes in India, especially in eastern India. Thus the present study was planned to find out the relations and variations among them.

MATERIALS AND METHODS

Participants

The present study was based on the sample of 100 state level athletes (male, n=50 and female, n=50) of age group 18-27 years, selected purposively from various sports academies of Cuttack and Bhubaneswar, Odisha. The age of the subjects was determined from their respective school records. A written consent was obtained from the subjects. The data was collected under natural environmental conditions while maintaining the privacy of the athletes. The study was approved by the institutional ethical committee. The subjects with any history of pain and musculoskeletal problems in the lower extremity in previous 6 months of the commencement of the study, and documented history of trauma in lower extremity that would affect the alignment of the lower extremity joints (i.e. fracture or surgery) were excluded from the study.

Anthropometric Measurements:

Five anthropometric variables, viz. height, weight, BMI (Body Mass Index), total leg length, lower leg length were taken on each subject following standard techniques [18] and were measured thrice with the median value used as the criterion. The height was recorded by using anthropometric rod in centimetres. The body weight was measured by digital standing scales (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. Body mass index (BMI) was calculated from height and weight by the formula: BMI= weight (kg) / height^2 (m^2). Total leg length and lower leg length were measured by steel tape in centimetres.

Lower extremity alignment variables:

Standing Q-angle was measured with the subject in a standing, relaxed position with a standard goniometer in degrees. [19] Q-angle represents the angle formed by a line from the anterior superior iliac spine to the patella centre and a line from the patella centre to the tibial tuberosity. [20]

Tibiofemoral angle is the angle formed in the frontal plane by the anatomical axes of the femur and tibia. [21] It was measured in degrees by standard goniometer with the goniometer axis (modified with an extension piece on the stationary arm) over the knee centre (midpoint between the medial and lateral joint line in the frontal plane), the stationary arm was aligned along a line from the knee centre to a proximal landmark (midpoint between the anterior superior iliac spine and the most prominent aspect of the greater trochanter), and the movable arm was aligned along a line from the knee centre to a distal landmark (midpoint between the medial and lateral malleoli).

Femoral anteversion was measured using the Craig's test with the subject prone and the knee flexed to 90°. [22] The angle between the vertical line and the shaft of the tibia was measured using a standard goniometer in degrees.

Genu recurvatum was measured with the subject in supine and a bolster positioned under the distal tibia. The goniometer axis was positioned over the lateral joint line, the stationary arm aligned with the greater trochanter, and the movable arm aligned with the lateral malleolus. The measurement was recorded in degrees while the examiner applying a posteriorly directed force to the anterior knee until passive resistance had achieved. [12]

Tibial torsion was measured using a modified technique with the subject in supine and the knees extended, the subject had rotated the leg until the line between the femoral epicondyles was parallel to the table. [23] In this position the axis of the goniometer was aligned at the midpoint along the line between the medial and lateral malleoli. The angle formed by the line bisecting the bimalleolar axis and the vertical axis was measured using a standard goniometer in degrees.

Navicular drop was measured using a modification of a technique described by Brody. [24] The navicular tubercle was palpated and marked with the subject in a bilateral stance. Navicular height was measured with a straight edge ruler, with the subject in subtalar joint neutral, the position in which the medial and lateral aspects of the talar head would be equally palpable on both sides. Then the subject was instructed to relax the stance, and the difference in centimetres between the height of navicular in subtalar joint neutral and relaxed stances was recorded.

Statistical analysis

Descriptive statistics (mean ± standard deviation) were determined for the directly measured and derived variables. Student's t-test was applied to compare the data between male and female athletes. To understand the dimension of relationship of right Q-angle as dependent variable with set of right lower extremity variables, Karl Pearson's moment correlation coefficients were calculated. All the data were determined using SPSS (Statistical Package for Social Science) version 20.0. A 5% level of probability was used to indicate statistical significance.

RESULTS

Table 1 showed the descriptive statistics of various anthropometric variables of female and male state level athletes. Female athletes had higher mean value in BMI and lesser mean values in height, weight, right total leg length, left total leg length, right lower leg length and left lower leg length than their male counterparts. However, statistically significant differences ($p \leq 0.001$) were found in height, weight, right total leg length, left total leg length, right lower leg length, and left lower leg length between them.

Table 2 showed the descriptive statistics of Q-angle and other lower extremity alignment variables of female and male state level athletes. Female athletes had greater mean values in right tibiofemoral angle, left tibiofemoral angle, right femoral anteversion, left femoral anteversion, right Q-angle, left Q-angle, right genu recurvatum, left genu recurvatum, right tibial torsion, left tibial torsion, right navicular drop and left navicular drop than their male counterparts. However, highly significant differences ($p \leq 0.001$) were seen in right femoral anteversion, left femoral anteversion, right Q-angle, left Q-angle, right tibial torsion and left tibial torsion and statistically significant difference ($p < 0.05$) were seen in right tibiofemoral angle, right navicular drop and left navicular drop between them.

Table 3 showed the correlation coefficients of right Q-angle with other right side lower extremity alignment variables of female and male athletes. In the athletes, significant positive correlations ($p \leq 0.05$-0.001) were seen in right tibiofemoral angle, right femoral anteversion, right genu recurvatum, right tibial torsion and right navicular drop.

Table 1: Descriptive statistics of the anthropometric variables of female and male athletes

	Female athletes (n=50)		Male athletes (n=50)			
Variables	**Mean**	**SD**	**Mean**	**SD**	**t-value**	**p-value**
Height (cm)	156.10	5.68	168.88	6.12	-10.83	**<0.001**
Weight (kg)	53.64	6.71	61.90	9.42	-5.051	**<0.001**
BMI (kg/m^2)	22.01	2.46	21.64	2.58	0.723	0.471
Right total leg length (cm)	82.24	4.12	89.42	3.67	-9.203	**<0.001**
Left total leg length (cm)	82.24	4.12	89.44	3.68	-9.216	**<0.001**
Right lower leg length (cm)	38.40	1.97	40.38	2.42	-4.493	**<0.001**
Left lower leg length (cm)	38.40	1.97	40.34	2.51	-4.298	**<0.001**

Table 2: Descriptive statistics of the lower extremity alignment variables of female and male athletes

	Female athletes (n=50)		Male athletes (n=50)			
Variables	**Mean**	**SD**	**Mean**	**SD**	**t-value**	**p-value**
Right tibiofemoral angle (degree)	9.72	1.82	8.78	1.52	2.807	**0.006**
Left tibiofemoral angle (degree)	8.76	1.78	8.08	1.91	1.839	0.069
Right femoral anteversion (degree)	23.26	3.28	18.74	2.64	7.597	<0.**001**
Left femoral anteversion (degree)	21.78	2.76	17.78	2.61	7.445	**<0.001**
Right Q-angle (degree)	21.56	1.72	16.28	2.36	12.807	**<0.001**
Left Q-angle (degree)	20.62	1.83	15.62	2.04	12.909	**<0.001**
Right genu recurvatum (degree)	8.82	2.30	8.40	1.34	1.115	0.267
Left genu recurvatum (degree)	8.12	2.01	7.74	1.55	1.060	0.292
Right tibial torsion (degree)	19.40	1.84	17.44	2.25	4.766	**<0.001**
Left tibial torsion (degree)	18.32	2.42	16.62	1.69	4.074	**<0.001**
Right navicular drop (cm)	0.86	0.16	0.79	0.15	2.405	0.018
Left navicular drop (cm)	0.82	0.17	0.71	0.15	3.127	**0.002**

Table 3: Correlation coefficients of right Q-angle with right lower extremity alignment variables of state level athletes

	Athletes (n=100)	
Variables	**r-value**	**p-value**
Right tibiofemoral angle (degree)	0.240	**<0.016**
Right femoral anteversion (degree)	0.719	**<0.001**
Right genu recurvatum (degree)	0.310	**<0.002**
Right tibial torsion (degree)	0.511	**<0.001**
Right navicular drop (cm)	0.522	**<0.001**

DISCUSSION

Athletics is a game of endurance as well as strength. It is a collection of sporting events that involve competitive running, jumping, throwing, and walking. The most common types of athletics competitions are track and field, road running, cross country running, and race walking.

Lower extremity is the most important part of the body used excessively during a sporting event. The anatomical, anthropometric and biomechanical relationship of the lower extremity alignments are most important area to be studied frequently for diagnosing the faulty alignments and preventing future injuries which may occur during various athletic events. For the holistic development of the athletics, the purpose of this study was fully justified. The anthropometric profile of an athlete plays an important role in determining his or her potential for success within the sport. For the general assessment of the absolute size and shape of the individual, height and body mass are two inter-related characteristics.

The findings of our study indicate that female athletes have higher mean value in BMI and lesser mean values in height, weight, right total leg length, left total leg length, right lower leg length, and left lower leg length than their male counterparts. The findings of lower extremity alignment variables in the study indicate that female athletes have higher mean values in right tibiofemoral angle, left tibiofemoral angle, right femoral anteversion, left femoral anteversion, right Q-angle, left Q-angle, right genu recurvatum, left genu recurvatum, right tibial torsion, left tibial torsion, right navicular drop and left navicular drop than their male counterparts. In this direction, Daneshmandi et al. recorded significantly higher values in Q-angle, femoral anteversion and tibiofemoral angle in female athletes. [25] McKeon and

Hertel reported that women demonstrate greater Q-angle, genu recurvatum, anterior pelvic tilt and femoral anteversion as compared to men and; no sex difference in tibial varum and navicular drop. [11] Woodland and Francis stated that the Q-angle value can suffer changes due to muscle imbalance, tibial torsion, femoral anteversion and a high or low patella. [16] Nguyen and Shultz reported that for both the right and left lower extremities, females had greater mean values than males for pelvic angle, femoral anteversion, quadriceps angle, tibiofemoral angle, and genu recurvatum. Males and females were not different on navicular drop or tibial torsion. [10] Mathew and Madhuri (2013) reported significant correlation between the standing height, thigh length, length of the lower limbs and the tibio femoral angle of south Indian children. [26] Our study showed right Q-angle had significantly positive correlation with right tibiofemoral angle, right femoral anteversion, right genu recurvatum, right tibial torsion and right navicular drop in the athletes.

CONCLUSION

The study includes normative values, descriptive statistics and correlations among lower extremity alignment variables and Q-angles in female and male athletes.

In athletes, lower extremity plays a vital role in performance. Thus identifying the postural factors that influence Q-angle, excessive stress and potential injury is of considerable importance. The results of this study would be implicated for pre-season screening as well as clinical diagnosis and treatment of athletes or patients. Various corrective exercise programs would be started as preventive measures in case of any malalignment persisting before and can be modified, which would prevent future injuries. Moreover, in rehabilitating stage of an injured player, regular checking of lower extremity would provide proper information towards treatment strategy. With the findings of the present study, coaches may arrange supportive devices and corrective exercises for the athletes as per their lower extremity alignment for performance enhancement and educate the sports persons to avoid various types of sports injuries. Proper training programs would be formulated and implemented for both male and female athletes separately, which would enhance their performance. And also the gender difference alignment findings would help to correlate the injury patterns and prior planning for their prevention.

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SUGGESTIONS

Further studies can be done on athletes of other states and ethnicity with more sample size. Studies on different age groups will be more fruitful and can be compared with normal population. Few more parameters like anterior pelvic tilt, genu valgum, genu varum, patellar tilt, etc. can be studied additionally.

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