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Dominant Body Somatotype and its Influence on the Quadriceps and Tibiofemoral Angles of Male and Female Young Adults in South Eastern Nigeria

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Background: Body somatotype reflects an overall outlook of the body and conveys a meaning of the totality of morphological features of the human body.

Objectives: The main purpose of this study was to determine the influence of dominant body somatotype on Quadriceps (Q) and tibiofemoral (TFA) angle of male and female young adults in Southeast Nigeria.

Method: A total of 294 (147 males and 147 females) participants were involved in this study. The research design used was a cross sectional survey and consecutive sampling technique was used to recruit participants. The Heath-Carter Anthropometric Body Somatotyping method was used to measure the body somatotype of each of the participants. A universal plastic goniometer was also used to measure the tibiofemoral and quadriceps angles. Data was analysed with SPSS version 20 and summarized using mean, standard deviation, frequency and percentages. Further analyses were done using two-way ANOVA, two-way MANOVA, Tukey's HSD Post Hoc test and Pearson Correlation with alpha level set at 0.05.

Result: The result revealed no significant difference (p=0.19 Wilkis lambda ∧ =0.961, partial eta squared =0.02) for the two-way MANOVA when explored for an interaction effect between sex difference and dominant body somatotype. There were significant influences using two-way ANOVA when explored for the separate impact of sex differences and dominant body somatotypes on the TFA and Q-angle except for the left tibiofemoral. TFA (Lt=0.16 & Rt=0.01) and Q-angle (Lt=0.02 & Rt=0.00). This study also showed that there was a significant positive correlation between right Q-angle and TFA ($p<0.001$) and left Q-angle and TFA ($p<0.001$) of endomorphic male and female. The most prevalent dominant body somatotype of all the participants was mesomorphy.

Conclusion: This study established the mean quadriceps and tibiofemoral angles of endomorphic, mesomorphic and ectomorphic male and female young adults in south-east Nigeria. Body somatotype was found to influence the quadriceps and tibiofemoral angles.

Keywords: *Dominant somatotype, Biomechanics, quadriceps angle, tibiofemoral angle*

Highlights:

- This study highlighted the importance of quadriceps and tibiofemoral angles on the biomechanics of the knee, since the higher values of both angles increases the chances of associated knee pathologies in the nearest future.
- Dominant body somatotype was found to influence the quadriceps and tibiofemoral angles.

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Introduction

Body somatotype reflects an overall outlook of the body and conveys a meaning of the totality of morphological features of the human body.[1] Somatotypes are morph phenotypic ranges along continua of variation which possess constantly recognizable characteristics and are the functional end products of the whole genetic and developmental complex.[2,3]It is expressed in a three-number rating representing endomorphy, mesomorphy and ectomorphy components respectively, always in the same order.[4] Endomorphy is the relative fatness, mesomorphy is the relative musculoskeletal robustness, and ectomorphy is the relative linearity or slenderness of a physique. For example, a 3-5-2 rating is recorded in this manner and is read as three, five and two. These numbers give the magnitude of each of the three components. Ratings on each component of ½ to 2½ are considered low, 3 to 5 are moderate, and 5½ to 7 are high and 7½ and above are very high.[5] Numerous studies indicate that somatotype components have a strong genetic basis. Familial transmission of these components has also supported this viewpoint.[1]

In a study carried out to determine the influence of dominant body somatotype on Quadriceps angle (Q-angle) and selected skeletal (hip width and femur length) measures of 250 (125 male and 125 female) undergraduate students aged between 18-30 years, dominant body somatotype in both males and females was mesomorphy.[6] Each dominant body somatotype had different values for Q-angle and selected skeletal measures; thus establishing that the dominant body somatotype influences Q-angle and selected skeletal measures.[6]

The Quadriceps angle (Q-angle) is described as the acute angle formed by the vector for the combined pull of the quadriceps femoris muscle and the patellar tendon.[7] It is measured using the anterior superior iliac spine (ASIS) as the proximal landmark.[8] The Q-angle provides an estimate of the vector force between the quadriceps femoris muscle and the patellar tendon.[9] It is formed by the crossing of two imaginary lines.[10] The first line extends from the ASIS to the centre of the patella (CP)[10]. The second line is drawn from the tibial tuberosity (TT) to the CP[10]. The angle formed between these two lines represents the Q-angle.[10] The Q-angle normally varies between 6º and 27º, with a mean value of approximately 15º.[11]

An increase in Q angle beyond the normal range is considered as indicative of extensor mechanism misalignment, and has been associated with patellofemoral pain syndrome, knee joint hypermobility and patellar instability.[12] The clinical tibiofemoral angle (TFA) is the angle defined by the mechanical axis of the femur intersecting the mechanical axis of the tibia.[13] The mechanical axis of the femur is defined as the line from the femoral head center to the femoral intercondylar notch center and the mechanical axis of the tibia is defined as the line from the ankle talus center to the center of the tibial bone.[14] A normal knee will have a tibiofemoral angle approximately 5-7º valgus.[14]

Deviation from this angle leads to a knee joint with a varus or valgus condition. A reduction of this angle is known as genu varum (bowlegs) and an exaggeration of this angle is known as genu valgum (knock-knees).[15] Increased tibiofemoral angle, which represents the valgus or varus angle formed by the anatomical axes of the femur and tibia, tend to move the patella medially relative to the anterior superior iliac spine and the tibial tuberosity laterally thus increasing the Q-angle.[16-18]

Knowledge of the normal limits of the tibiofemoral angle (TFA) in children is an aid in distinguishing physiological from pathological variations.[19]In a study carried out on the correlation among tibiofemoral angle, Q-angle and BMI of secondary school students in Nnewi North Local Government Area of Anambra State, the result showed a significant correlation between BMI, TFA and Q-angle. It also revealed sex differences on the values of TFA and Q-angle with the male participants having greater values than their female counterparts.[20]

Increased Q-angle has been associated with greater incidence of patellofemoral problems such as chondromalacia patella, patellofemoral pain syndrome and recurrent lateral subluxation of the patella and because overweight individuals suffer more of these problems, they have been assumed to have increased Q-angle.[21,22]Increased tibiofemoral angle has also been shown to be associated with knee problems and increases in the shear stress and strain at the surface of the knee cartilage.[17] Despite this assumption, individuals that are moderately built and even slender individuals suffer from this patellofemoral pain syndrome and other knee problems. This study therefore intends to investigate the influence of dominant body somatotype on Q-angle and TFA. It may help to prove whether the size and stature of an individual will affect his/her Q angle and TFA.

Methods

Study design and sample population

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The research design used was cross sectional survey research design. The population for this study were 294 apparently healthy male and female undergraduates of Faculty of Health Science and Technology, of a Nnamdi Azikiwe University South East Nigeria. Consecutive sampling was used to recruit participants. Taro Yamane's formula was used to calculate the sample size. The formula is stated as follows: $n = \frac{N}{1+N(e)^2}$, where n = Sample size, N = Population (1,109), e = Significant level (0.05). Therefore the sample size for the study is 294 participants.

Ethical approval was obtained from the Institutional Review Committee of the Nnamdi Azikiwe University Teaching Hospital before the commencement of the study. The participants were fully informed about the purpose of the study and written consents were obtained before measurements were taken. In collecting data, names of participants and sensitive information were not included in the data collected rather identity numbers were given to identify each participant.

Measurement of body somatotype

The Heath-Carter Anthropometric Somatotype Instruction Manual (2002) was used to categorise the body somatotype of each of the participants[3,4,5,6] The anthropometric method was used in this study to determine the dominant body somatotype of each of the participants. The ten (10) anthropometric dimensions were used to calculate the arthropometric somatotype. They are:

1. Height: This was taken against a height meter with the participant standing straight touching the scale with the heels, back and occiput, looking straight-head. The height of the participants was recorded to the nearest 0.1meters.
2. Weight: This was taken with a weighing scale with the participant in light apparel and standing with shoes off. The weight was recorded in kilograms
3. Triceps skinfold: This was taken using a skinfold calliper.The participant's arm was hanging loosely in the anatomical position, a fold was raised at the back of the arm at a level half way on a line connecting the acromion and the olecranon process.
4. Subscapular skinfold: The subscapular skinfold was raised on a line from the inferior angle of the scapular in a direction that is obliquely downward and laterally at 45 degrees.
5. Supraspinale skinfold: The fold was raised above the anterior superior iliac spine (ASIS) on a line to the anterior axillary border and on a diagonal line going downwards and medially at 45 degrees.
6. Medial calf skinfold: A vertical skinfold on the medial side of the leg at the level of the maximum girth of the calf was raised.
7. Biepicondylar breadth of the humerus (Right): This is the width between the medial and the lateral epicondyle of the humerus with the shoulder and elbow flexed to 90 degrees. The calliper was applied at an approximately dissecting angle at the elbow.
8. Biepicondylar breadth of the femur (Right): This is the width between the medial and lateral epicondyle of the femur, the participants sat with the knee bent at right angle. The greatest distance between the lateral and medial epicondyle of the femur was measured with firm pressure on the cross-bars in order to compress the subcutaneous tissue.
9. Upper limb girth (Right): With the elbow flexed to 45 degrees and tensed, shoulder flexed to 90 degrees and hand clenched, elbow flexors and extensors maximally contracted, measurement of the greatest girth of the arm was taken with a tape.
10. Calf girth (Right): The participants stood with the feet slightly apart. The tape was placed around the calf and the maximum circumference was measured.

The height and girth measurement was read to the nearest metres (m). Biepicondyle diameter to the nearest 0.5mm and the skinfolds to the nearest 0.1mm.

These anthropometric dimensions were used to find the dominant body somatotype using the somatotype rating form.

Calculating the anthropometric somatotype

There are two ways to calculate the anthropometric somatotype:

- Enter the data into equations derived from the rating form;
- Enter the data onto a somatotype rating form .

The second method of obtaining the anthropometric somatotype is by means of equations into which the data are entered.

Endomorphy rating

The measurements for each of the three skinfolds triceps, subscapular, and supraspinale were recorded. The sum of triceps, subscapular, and supraspinale skinfolds was recorded in the sum in the box opposite sum of 3 skinfolds. Corrections for height were made by multiplying the sum by (170.18÷ height in cm). On the table to the right of the sum of 3 skinfolds box, the value closest to the number in the box was circled. The table is read vertically from low to high in columns and horizontally from left to right in rows. "Lower limit" and "upper limit" on the rows provide exact boundaries for each column. These values are circled only when sum of 3 skinfolds are within 1 millimetre of the limit. In most cases the value in the row of "midpoint" was circled. In the row for endomorphy, value directly under the column for the value was circled.

Mesomorphy rating

Height and breadth of upper arm (humerus) and thigh (femur) were recorded in the appropriate boxes. Corrections for skinfold were made before recording girths of biceps and calf. To make the skinfold correction: Triceps skinfold was converted to centimeters by dividing by 10. Converted triceps skinfold was subtracted from biceps girth. Calf skinfold was also converted to centimeters, and subtract from calf girth.

In the height row directly to the right of the recorded value, the height value nearest measured height of the subject was circled (Note: Regard the height row as a continuous scale.)

For each bone breadth and girth,the number nearest the measured value in the appropriate row was circled. (Note: Circle the lower value if the measurement falls midway between the two values. This conservative procedure is used because the largest girths breadths are recorded.)

Columns only were involved, not numerical values for the two procedures below. The average deviation of the circled values for breadths and girths from the circled value in the height column were found as follows:

a. Column deviations to the right of the height column are positive deviations. Deviations to the left are negative deviations. (Circled values directly under the height column that have deviations of zero are ignored.)

b. The algebraic sum of the plus and miss deviations was calculated.

(D). This formula was used: mesomorphy = (D/8) + 4.0.The obtained value of mesomorphy was round to the nearest one half (1/2) rating unit.

In the row for mesomorphy, the closest value for mesomorphy obtained was circled. (If the point is exactly midway between two rating points, circle the value closest to 4 in the row. This conservative regression toward 4 guards spuriously extreme ratings.)

Ectomorphy rating

Record weight (kg). Note: 1 Kg = 2.2 pounds

Height was obtained by dividing by cube root of weight (HWR). HWR was recorded in the appropriate box. The closest value in the HWR table to the right was circled. In the row for ectomorphy, the ectomorphy value directly below the HWR was circled. In the row for Somatotype, the circled ratings for Endomorphy, Mesomorphyand Ectomorphy were recorded.

Limitations of the rating form

Although the rating form provides a simple method of calculating the anthropometric somatotype, especially in the field, it has some limitations. First, the mesomorphy table at the low and high ends does not include some values for small subjects, e.g. children, or for large subjects, e.g. heavy weight lifters. The mesomorphy table can be extrapolated at the lower and upper ends for these subjects. Second, some rounding errors may occur in calculating the mesomorphy rating, because the subject's height often is not the same as the column height. If the anthropometric somatotype is regarded as an estimate this second limitation is not a serious problem. Nevertheless, the following procedures described in Carter (1980) and Carter and Heath (1990) can correct these problems[3,4,5,6].

Research Instruments

The following research instruments were used:

i. Height meter (locally made): This was used to measure the heights of the participants in meters.

ii. Bathroom weighing scale (Hana model BR 9001:0-120 Kg: China): This was used to measure the weights of the participants in Kg.

iii. Flexible tape (Butterfly brand: Nigeria): This was used to measure the upper arm and calf girth of the participants.

iv. Sliding Calliper: This was used to measure the biepicondylar breadth of the humerus and femur of the participants.

v. Skin Fold Calliper: This was used to measure the skinfold of the triceps, subscapular, supraspinale and medial calf of the participants.

vi. Plinth: This was used by the participants to lie down while the measurement is being carried out.

vii. Plastic Universal Goniometer: This was used to measure the Q-angle and the Tibiofemoral angle of the participants in degrees.

viii. Venier Calliper: This was used to locate the centre of the ankle which will be marked as the midpoint between the medial and lateral malleoli of the participants.

ix. Felt-tip Marker: This was used to make mark on areas identified for measurement.

Measurement of Q-angle

The bilateral Q-angle of the participants was measured to the nearest degree with a metallic goniometer, with each participant lying supine on a plinth. The anatomical landmarks including the border of the patella, the tibia tubercle and ASIS was located and the centre of the patella marked with a felt-tip marker. The axis of the goniometer was placed on the midpoint of the patella, its stationary arm aligned to the ASIS while the immovable arm was aligned to the tibia tubercle. The angle formed was read as Q-angle.[7,8,10,11]

Measurement of Tibiofemoral angle

The bilateral tibiofemoral angle was measured with the participant lying supine on a plinth with the hips and knees in full extension, with the knees or ankles touching each other. The ASIS was marked with a skin marker pen; the centre of the patella was identified with the aid of concentric circles of increasing diameters and then marked with the pen. The centre of the ankle was marked as the midpoint between the medial and lateral malleoli with the help of a standardized vernier caliper. The goniometer was placed with its hinge at the centre of the patella. The TFA was measured to the nearest degree. The angle formed was read as tibiofemoral angle[14,19].

Data analysis

The data from this study was summarized using descriptive statistics of mean and standard deviation. The Statistical package used was SPSS version 20. The inferential statistics of two-way ANOVA, two-way MANOVA, Tukey HSD Post hoc test and Pearson correlation coefficient were also used to analyse the influence of dominant body somatotype on Q-angle and TFA. Specifically, Two-way ANOVA was used to determine the influence of sex differences on tibiofemoral and quadriceps angles across the different dominant body somatotypes. Two-way MANOVA was used to determine the influence of different dominant body somatotypes on the quadriceps and tibiofemoral angles of male and female participants. Tukey's HSD was used for post hoc analysis to determine the significant differences among the somatotypes. Pearson correlation coefficient was used to determine the Relationship between the quadriceps and tibiofemoral angles across the different dominant body somatotypes.

Results

Participants Profile

Two hundred and ninety four (294) participants were involved in this study, out of whom 147 were males and 147 were females. These participants were aged between 18 and 30 years.

The mesomorphy body somatotype was the most prevalent among the male participants and also among the female participants (Table 3). The mean and standard deviations of right and left quadricep angles, and right and left tibiofemoral angles of the male and female participants in relation to the dominant body somatotype (Tables 1 and 2).

Quadriceps and tibiofemoral angles of endomorphic male and female participants

The mean quadriceps angle of the endomorphic male participants were found to be 20.04±4.31º on the right and 19.65±4.12º on the left; those of the female participants were found to be 21.29±3.52º on the right and 20.96±3.93º on the left (tables 1, 2).

The mean tibiofemoral of the endomorphic male participants were found to be 9.26±2.22º on the right and 9.21±2.13º on the left; those of the female participants were found to be 9.50±1.91º on the right and 9.50±1.67º on the left (Table 1,2). The Pearson product moment correlation reveals positive relationships between the angles (table 7, 8).

Table 1: Profile of male participants in relation to the dominant body somatotype

Sex	Dominant Body Somatotype	Right Q-A (º)	Left Q-A (º)	Right TFA (º)	Left TFA (º)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Male	Endomorphy	20.04±4.31	19.65±4.12	9.26±2.22	9.22±2.13
	Mesomorphy	15.04±3.21	15.75±3.40	6.96±1.77	7.38±1.81
	Ectomorphy	17.69±3.38	17.54±3.41	8.00±1.73	7.86±1.71

SD: Standard deviation; Q-A: Quadriceps femoris angle; TFA: Tibiofemoral angle; (º): Degree

Table 2: Profile of female participants in relation to the dominant body somatotype

Sex	Dominant Body Somatotype	Right Q-A (º)	Left Q-A (º)	Right TFA (º)	Left TFA (º)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Female	Endomorphy	21.29±3.52	20.96±3.93	9.48±1.87	9.52±1.63
	Mesomorphy	17.68±3.51	17.89±3.56	7.65±1.81	7.90±1.66
	Ectomorphy	17.44±3.46	17.20±3.75	7.67±1.71	7.84±1.57

SD: Standard deviation; Q-A: Quadriceps femoris angle; TFA: Tibiofemoral angle; (º): Degree

Quadriceps and tibiofemoral angles of mesomorphic male and female particpants

The mean quadriceps angle of the mesomorphic male participants were found to be 15.04±3.23º on the right and 15.75±3.40º on the left; that of the female participants were found to be 17.68±3.50º on the right and 17.89±3.56º on the left (Tables 1 and 2). The mean tibiofemoral of the mesomorphic male participants were found to be 6.96±1.77ºon the right and 7.38±1.81º on the left; those of the female participants were found to be 7.84±1.77º on the right and 8.06±1.60º on the left (Tables 1 and 2). The Pearson product moment correlation reveals positive relationships between the angles (Tables 7 and 8).

Quadriceps and tibiofemoral angles of ectomorphic male and female participants

The mean quadriceps angle of the ectomorphic male participants were found to be 17.69±3.38º on the right and 17.54±3.41º on the left; those of the female participants were found to be 17.44±3.46º on the right and 17.20±3.75º on the left (Tables 1and 2).The mean tibiofemoral of the ectomorphic male participants were found to be 8.00±1.72º on the right and 8.21±1.72º on the left; those of the female participants were found to be 7.73±1.72º on the right and 8.05±1.56º on the left (Tables 1 and 2). The Pearson product moment correlation reveals positive relationships between the quadriceps and tibiofemoral angles (Tables 7).

Influence of dominant body somatotype on the quadriceps and tibiofemoral angles of male and female participants

A two way multivariate analysis of variance(two-way MANOVA) was conducted to explore the impact of sex difference and dominant body somatotype (two independent variables) on the four dependent variables of quadriceps angles (left and right) and the tibiofemoral angles (left and right). There was no statistically significant interaction effect between sex difference and dominant body somatotype on the tibiofemoral and quadriceps angles F(4,1.39;p=0.19) Wilkis lambda ᴧ = 0.96; partial eta squared =0.02. When results for the dependent variables were considered separately, the only difference to reach statistical significance using the bonferroni adjusted alpha level of 0.013 was the right quadriceps angle (p=0.005, partial eta squared = 0.04); while the left quadriceps angle (p=0.021, partial eta squared = 0.03), left tibiofemoral angle (p=0.16,partial eta squared = 0.01), right tibiofemoral angle (p=0.04, partial eta squared = 0.02) were insignificant. The post hoc comparison using Tukey HSD test indicates that the mean scores for the endomorphs is significantly different from mesomorphs and ectomorphs. The ectomorphs did not differ significantly from the mesomorphs (Table 5).

A two-way between group analysis of variance (two-way ANOVA) was conducted to explore the impact of sex difference and dominant body somatotype separately on the quadriceps angle (Left & Right) and the tibiofemoral angles (Left & Right) to split the samples into groups according to dependent variables. The values as obtained for the effect on the left quadriceps angle for the three groups of endomorphs, mesomorphs and ectomorphs reveal statistical significance, F(2,288)=3.63; p=0.03 for the interaction effect between sex difference and dominant body somatotype. There was statistically significant main effect for dominant body somatotype, F (2,288) =16.34; p=0.00, however the effect size was small (partial eta squared=0.03). Post hoc comparisons using the Tukey HSD test indicated that the mean score for the endomorphs is significantly different from mesomorphs and ectomorphs. The ectomorphs did not differ significantly from the mesomorphs. The main effect for the sex difference is (1,288) 4.94 p=0.03 (Tables 4 and 6).

Table 3: Frequencies and percentages of the dominant body somatotype of male and female participants

Sex	*Dominant Body Somatotype*	*Frequ-encies*	*Percentages (%)*
Male	Endomorphy	23	15.6
	Mesomorphy	56	38.1
	Ectomorphy	68	46.3
Female	Endomorphy	24	15.3
	Mesomorphy	71	48.3
	Ectomorphy	52	35.4

Exploring the impact of sex difference and dominant body somatotype on the right quadriceps angle

The interaction effect of sex difference and dominant body somatotype on the right quadriceps angle was statistically significant, F (2,288) =5.25; p=0.01. There was a statistically significant main effect for the dominant body somatotype, F (2,288) =26.11; p< 0.01.However the effect size was small (partial eta squared=0.03). Posthoc comparison using the Tukey HSD test indicated that the mean score for the endomorphs is significantly different from mesomorphs and ectomorphs. The main effect for sex difference is F (1,288) =7.26; p=0.01 (Tables 4 and 6).

Exploring the impact of sex difference and dominant body somatotype on the Left tibiofemoral angle

The interaction effect of sex difference and dominant body somatotype on the Left tibiofemoral angle was statistically insignificant, F (2, 288) =1.78; p =0.17. There was a statistically significant main effect for the dominant body somatotype, F (2,288) =15.70; p=0.00. However the effect size was not very small (partial eta squared =0.1). Post hoc comparisons using the Tukey HSD test indicated that the mean scores for the endomorphs are significantly different from mesomorphs and ectomorphs. The ectomorphs did not differ significantly from the mesomorphs. The main effect of sex difference is F (1,288) =1.50; p=0.22 (Tables 4 and 6).

Exploring the impact of sex difference and dominant body somatotype on the right tibiofemoral angle.

The interaction effect of sex difference and dominant body somatotype on the right tibiofemoral angle was statistically significant, F (2,288) =3.11; p=0.04. There was a statistically significant main effect for the dominant body somatotype, F (2,288) =20.63; p=0.00. However, the effect size was not very small (partial eta squared =0.13). Post hoc comparison using the Tukey HSD test indicated that the mean scores for the endomorphs is significantly different from mesomorphs and ectomorphs. The ectomorphs did not differ significantly from the mesomorphs. The main effect of sex difference is F (1,288) =1.48 p=0.23 (Tables 4 and 6).

Discussion

This study established that the most prevalent dominant body somatotype for both male and female participants was mesomorphy. This was in line with a previous works which also found the dominant body somatotype to be mesomorphy using the same age group.[6,20] Reference values for the quadriceps and tibiofemoral angles in relation to their various body somatotypes were also established. The quadriceps angle values for the females were greater than those of males. This finding is in line with other works. [9,11,15,21,23,25] This study also revealed that dominant body somatotype significantly influenced the quadriceps and tibiofemoral angles of male and female young adults in southeast Nigeria.

The normative values for tibiofemoral angle and quadriceps angle across various age groups in Nigeria have already been established and suggested a relationship between tibiofemoral angle and quadriceps angle.[19,23,26,27,28] However, these works did not specify in details the nature of the relationship. Post hoc comparison using the Tukey HSD test in all the angles indicated that the mean scores for the endomorphs were significantly different from mesomorphs and ectomorphs. The ectomorphs did not differ significantly from the mesomorphs.

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Table 4:Two-way ANOVA showing the influence of dominant body somatotype on Q-angle and TFA of males and females

Variables	*Dominant Body Somatotype*	*Mean ± SD (^{0})*	*F-value*	*p-value*
LTQ-A	Endomorphy Mesomorphy Ectomorphy	20.32 ± 4.04 16.95 ± 3.63 17.39 ± 3.55	3.63	0.03*
RTQ-A	Endomorphy Mesomorphy Ectomorphy	20.04 ± 4.31 16.52 ± 3.61 17.58 ± 3.40	5.25	0.01*
RTTFA	Endomorphy Mesomorphy Ectomorphy	9.38 ± 2.05 7.46 ± 1.82 7.88 ± 1.72	3.11	0.04*
LTTFA	Endomorphy Mesomorphy Ectomorphy	9.36 ± 1.89 7.76 ± 1.73 8.14 ± 1.65	1.78	0.17

RTQ-A: Right quadriceps angle; LTQ-A: Left quadriceps angle; RTTFA: Right tibiofemoral angle; LTTFA: Left tibiofemoral angle; SD: Standard deviation; (º): Degree; *: Significance at α< 0.05

Table 5: Two—way MANOVA Tukey HSD Post Hoc Test showing comparison among endomorphic, mesomorphic and ectomorphic males and females

Variables	*Mean Difference*	*p-value*
RTQENDO VS RTQMESO	4.16	0.000*
RTQENDO VS RTQECTO	3.10	0.000*
RTQMESO VS RTQECTO	-1.07	0.044*
LTQENDO VS LTQMESO	3.37	0.000*
LTQENDO VS LTQECTO	2.93	0.000*
LTQMESO VS LTQECTO	0.44	0.600
RTTFAENDO VS RTTFAMESO	1.93	0.000*
RTTFAENDO VS RTTFAECTO	1.50	0.000*
RTTFAMESO VS RTTFAECTO	-0.43	0.070
LTTFAENDO VS LTTFAMESO	1.61	0.000*
LTTFAENDO VS LTTFAECTO	1.22	0.000*
LTTFAMESO VS LTTFAECTO	-0.39	0.183

RTQ: Right quadriceps angle; Ecto: Ectomorphy; LTQ: Left quadriceps angle; Meso: Mesomorphy; RTTFA: Right tibiofemoral angle; *: Significance at α< 0.05; LTTFA: Left tibiofemoral angle; Endo: Endomorphy

Table 6: Two-way ANOVA Tukey HSD Post Hoc Test comparison among endomorphic, mesomorphic, ectomorphic males and females

Variables	*Mean Difference*	*p-value*
RTQENDO VS RTQMESO	4.16	0.000*
RTQENDO VS RTQECTO	3.09	0.000*
RTQMESO VS RTQECTO	-1.06	0.44
LTQENDO VS LTQMESO	3.37	0.000*
LTQENDO VS LTQECTO	2.93	0.000*
LTQMESO VS LTQECTO	0.44	0.600
RTTFAENDO VS RTTFAMESO	1.93	0.000*
RTTFAENDO VS RTTFAECTO	1.50	0.000*
RTTFAMESO VS RTTFAECTO	-0.43	0.152
LTTFAENDO VS LTTFAMESO	1.61	0.000*
LTTFAENDO VS LTTFAECTO	1.22	0.000*
LTTFAMESO VS LTTFAECTO	-0.36	0.982

RTQ: Right quadriceps angle; Ecto: Ectomorphy; LTQ: Left quadriceps angle; Meso: Mesomorphy; RTTFA: Right tibiofemoral angle; *: Significance at α< 0.05; LTTFA: Left tibiofemoral angle; Endo: Endomorphy

Table 7: Pearson's Product Moment Correlation showing the relationship among body somatotypes, Tibiofemoral angle and Quadriceps angle of the male and female participants (N=294)

Sex	Body Somatotype	Variables	r-value	p-value
Male	Endomorphy	RTQ vs RTTFA	0.86	0.000*
		LTQ vs LTTFA	0.86	0.000*
	Mesomorphy	RTQ VS RTTFA	0.87	0.000*
		LTQ VS LTTFA	0.88	0.000*
	Ectomorphy	RTQ VS RTTFA	0.71	0.000*
		LTQ VS LTTFA	0.77	0.000*
Female	Endomorphy	RTQ vs RTTFA	0.730	0.000*
		LTQ vs LTTFA	0.729	0.000*
	Mesomorphy	RTQ VS RTTFA	0.742	0.000*
		LTQ VS LTTFA	0.778	0.000*
	Ectomorphy	RTQ VS RTTFA	0.706	0.000*
		LTQ VS LTTFA	0.770	0.000*

RTQ: Right quadriceps angle; LTQ: Left quadriceps angle; RTTFA: Right tibiofemoral angle; LTTFA: Left tibiofemoral angle; *: Significance at $\alpha < 0.05$

This study showed that there was a significant positive relationship between the tibiofemoral angle and the quadriceps angle of both knees and could be due to the fact that the tibiofemoral angle, which represents the valgus angle formed by the anatomical axes of the femur and tibia, would move the patella medially relative to the anterior superior iliac spine (as the femur is in an adducted position) if too high and the tibial tuberosity laterally (as the tibia is in an abducted position) thus affecting the Q angle.[16,17,18] The findings of this study agrees with the theoretical proposal of some authors who suggested that the values of quadriceps angle are as important as those of tibiofemoral angle[14]. This may serve as a prognostic value during the management of associated disorder of the knee joint involving tibiofemoral or quadriceps angle. Therefore as the value of tibiofemoral angle increases, the value of quadriceps angle increases.[25]

A normal knee will have a tibiofemoral angle approximately 5-7^{o} valgus.[14] Deviation from this angle leads to a knee joint with a varus or valgus condition. A reduction of this angle is known as genu varum (bowlegs) and an exaggeration of this angle is known as genu valgum (knock-knees).[15] This implies that endomorphic male and females have high chances of coming down with genu valgus as a result of their increased tibiofemoral angles.

This study was motivated by dearth of studies between dominant body somatotype and tibiofemoral angle. The mean value of tibiofemoral angle in this study when compared with the studies of other authors were slightly lower.[19,27] The differences could be as a result of numerous methodological variations, sample or population difference, ethnic, and racial differences which may translate into considerable discrepancies. The study also revealed that the quadriceps angle value in female are higher than that of the male as shown in various studies conducted on quadriceps angle.[6,14]

Conclusion

The study established that dominant body somatotype could influence the quadriceps and tibiofemoral angles. It also established reference values for the quadriceps and tibiofemoral angles in relation to their various body somatotypes. Tibiofemoral angle was found to have a significant relationship with quadriceps angle across various body somatotypes. The study also revealed that the quadriceps angle in females was higher than those of the males as shown in various studies conducted on quadriceps angle.

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