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RESEARCH ARTICLE

Representative values for lower extremity alignment measures in females.

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Abstract

Introduction: Lower extremity alignment has been assumed as a potential risk factor for acute and chronic lower extremity injuries such as patellofemoral syndrome, anterior cruciate ligament injuries, medial tibial stress syndrome, stress fractures, and plantar fascitis. Since, one anatomical alignment has interdependence with the other; this study focuses on finding the relationship with each of the five lower limb alignments. The measurements that would be included in this study would be that of the hip, knee and the ankle i.e Femoral anteversion, Quadriceps angle, Genu Recurvatum, Tibiofemoral angle and Navicular Drop. Additionally, since former researchers have noted sex variance of Quadriceps angle, this study is being conducted on females who have greater Quadriceps angle than male and are a greater risk of Lower Limb injuries than male.
Methods: The study was conducted among 25 participants within Manipal University, Udupi after obtaining ethical clearance from the Institutional Review Board. Preceding the study, the subjects signed the consent form and measurements of the parameters mentioned above were taken according to standard methods.
Results: Once all lower limb alignments and their interdependence were statistically analyzed, it was noted that the tibiofemoral angle, femoral anteversion and genu recurvetum were the most significant predictors to alter the magnitude of Quadriceps angle in females. ($p<0.001$)

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Introduction:-

Lower extremity alignments (LEA) exhibit different normative values for men and women. Among the lower extremity alignments, Quadriceps angle (Q-angle) has been frequently studied and has been identified of having higher values in female.[1] Researchers have also enumerated that females also reveal larger values of other hip, knee and ankle alignments which include Anterior Pelvic Tilt, Femoral anteversion and Genu Recurvetum.[2]

Additionally, anatomical alignments of the hip, knee and ankle has been regarded as the potential risk factor for Lower limb injury.[3]The position of these limbs has been studied by researchers to investigate the relationship of one to another since the position of one segment depends upon the position of another. It has been reported 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.[4]

Considerably, it has been suggested that Q- angle is a composite measure of pelvic position, hip rotation, tibial torsion, patella position and foot position. Therefore, this study focuses whether there is statistical significance between Q-angle and other hip, knee and ankle alignments namely the Femoral anteversion (FA), Genu Recurvetum

(GR), Tibiofemoral angle (TFA)and Navicular drop (ND) in Females and also the reciprocate relationship of each other. Based on anecdotal and published evidence, we presume that there are certain lower extremity alignments in our study that have potential interdependence with each other.

Methods:-

Subjects and Study Design:-

After obtaining ethical clearance from the Institutional Review Board of Kasturba Medical College, Manipal University, this study was conducted. Participants were predominantly college-aged students and had no current injury to the lower extremity or previous history that would affect the alignment of the lower extremity. Exclusion criteria also included students who had undergone orthopedic surgery to the back or lower limb and a history of lower extremity surgical realignment. Prior to participation, subjects read and signed a consent form approved by the Intuitional Review board for protection of human subjects. After which, demographics of age, height, and body mass were recorded for each subject, and five LEA measures were measured on both the left and right sides. These anatomical alignments were measured on the right and left lower extremities of 25 physically active female volunteers of age 23.9 ±1.43and weight 58.08±5.73 kg.

Clinical Measures:-

Measurements took place at the Department of Anatomy, Kasturba Medical College and measurements procedure were based on commonly accepted methods. All standing procedures were done in the anatomical position.

FA was measured using Craig's test, with the participant in prone position with knee flexed to 90°.[7]The greater trochanter was palpated, and the femur was moved passively into internal rotation until the greater trochanter could be palpated at its most lateral position. Femoral anteversion was determined as the acute angle formed by the tibia and an imaginary vertical line.

Q-angle was determined with the volunteer in standing posture and was measured as the acute angle created by a line from the anterior-superior iliac spine to the central point of the patella and from the central point of the patella to the tibial tuberosity in the frontal plane[6].Since contraction of quadriceps will contract the patella, it was necessary for the quadriceps to be in relaxed state.

GR was measured as the angle created in the sagittal plane by the femur (from the central point of the greater trochanter to the central point of the lateral epicondyle) and the shin (from the most lateral point of the proximal joint line of the knee through the lateral malleolus). Each participant was instructed to extend the knee as fully as possible in a weight bearing position.

The TFA was measured in the standing position with the hips and knees in neutral rotation and the knees or ankles touching each other. The ASIS was marked and the centre of patella was identified .The centre of the ankle was marked as the midpoint between the medial and the lateral malleoli. The goniometer was placed with its hinge at the centre of the patella. Each axis of the goniometer was adjusted such that the tip of the proximal limb touched the ASIS and the tip of the distal limb touched the midpoint of the ankle. The TFA was measured using goniometer. This angle corresponded to the angle suspended by the anatomical axis of the femur with the anatomical axis of the tibia.

ND was measured by a modification of a technique described by Brody.[5] ND is determined as the difference in height of the navicular tuberosity from the floor during weight bearing and non-weight bearing position. Initial measurement was taken with the volunteer seated, both feet on the floor, un-weighted, and in subtalar neutral. The un-weighted navicular position is the distance from the floor to the marked point on the navicular tuberosity. The participant was then instructed to stand with equal weight bearing on both feet. The measurement was noted as the difference between the heights. This difference in the distance was noted as the navicular drop.

Statistical analysis:-

For the data analysis the Statistical Package for the Social Sciences (SPSS, Version 17) was used. All data followed normal distribution patterns and correlations were estimated utilizing the two-tailed Pearson Correlation test.

Results:-

Mean, Standard deviation and median of the five parameters are listed in Table 1. Result of the study for each lower limb alignment measures are listed in Table 2. and Table 3. for right and left side respectively.

Discussion:-

Riegger-Krugh and Keysor[8] has described that the relationships among alignment characteristics can be structural or functional in nature, with the position of one segment depending on alignment deviations of an adjacent segment or resulting from compensatory changes toward more efficient dynamic function.[8] To accurately describe the relationship between anatomic alignment and the risk of lower extremity injury, the entire lower extremity should be considered rather than a single segment because one alignment characteristic may interact with or cause compensations at other bony segments [9,10]. Since hip, knee and ankle alignment is thought to play a key role in the load distribution at the knee, the purpose of our study was to quantitatively assess the relationship between five major lower extremity alignments in females. [11]

A visual inspection may reveal an obvious malalignment, but this should be ruled out with reliable measures to confirm the malalignment and a “normal” range should be defined in literature to prove whether the data obtained is within or beyond the range. All alignment characteristics were measured using techniques that have previously been identified as standard.

Based on anecdotal evidence, we hypothesized that quadriceps angle would alter the other major variables of lower limb since Q-angle is a composite measure of pelvic position, tibial rotation, patella position, and foot position.[9,12,13] The primary finding of our study is that Q-angle has a major correlation with TFA and GR whereas a minimum relation with FA, therefore depicting that the alignment of the lower extremity is associated with the magnitude of the Q- angle. It can also be inferred that the position of the limb can alter the measurement of Q-angle. This finding was similar to the study done by Hassan Daneshmandi et. al.[14]

As Q-angle represents the direction of the quadriceps muscle force vector in the frontal plane, the position of the patella and rotation of the femur will also alter the angle. Abnormal quadriceps forces which causes excessive angulations is thought to predispose individuals to injuries acting at the knee, especially the ACL injury and patellofemoral joints. However, the extent to which excessive Q-angle increases the risk of knee injury remains unclear.[4] An increased femoral internal rotation causes the patella to move medially in respect to the ASIS, as the patella would be moved medially with respect to the ASIS and the tibial tuberosity and would increase the Q-angle. Likewise, femoral external rotation could decrease the Q-angle.[15] As femoral anteversion represents a medial torsion of the femur as the femoral neck is projected forward relative to femoral condyles, excessive femoral anteversion would essentially place the femur into a more medially rotated position, potentially resulting in a medial displacement of the patella.[16] This medial displacement of the patella would result into increase in the Q-angle. Q-angle is also influenced by the rotation of the tibia. Tibiofemoral angle also has the potential to alter the quadriceps angle as increase in it would position the tibial tuberosity more laterally, thus increasing the Q-angle.

Our findings suggest that independent examination of Q-angle for its effects on lower extremity injuries may not be sufficient. Continuing to understand the relationship among alignment may help clinicians effectively to identify those who may be at greater risk for injury and therefore develop intervention strategies to subsequently reduce the risk of a lower extremity injury.

Navicular drop Test (NDT) measures the sagittal plane displacement of the navicular tuberosity from a neutral position to a relaxed position in standing.[17] NDT is a valid predictor of navicular height, and its height maintain the function and structure of the MLA. High arch foot has been associated with frequent ankle injuries, stress fractures of the fifth metatarsal and iliotibial band friction syndrome while the low arched planus foot exhibit plantar fascitis, patellar tendinitis and knee pain.[18.19] Since ND is also an indicator of foot pronation, excessive ND would result into internal rotation of the lower extremity and therefore result in greater Q-angle.[5]

Our findings implies that volunteers with greater genu recurvatum also had greater navicular drop which supports the evidences of interactive effect between the knee and foot pronation. Greater genu recurvatum is often considered a postural deviation in the sagittal plane, moreover magnetic resonance imaging study suggests that rotational motion also occurs at the tibiofemoral joint as the knee moves from hyperextension to flexion.[20] GR results in medial femoral rotation relative to the tibia as the lateral femoral condyle moves anteriorly relative to the tibia to a greater extent. This medially rotated posture at the knee may increase medial rotational stress at the foot, resulting in greater pronation, a triplanar deviation described as eversion of the calcaneus, adduction, and plantar flexion of the talus and abduction of the forefoot.[21]These biomechanics of the tibiofemoral joint may explain the positive relationships between greater genu recurvatum and navicular drop as noted in the present study.

These relationship established between the postural alignment characteristic will help clinicians effectively identify those that may be at greater risk for injury and therefore help in developing intervention strategies to subsequently reduce the risk of a lower extremity injury.

Table 1. Mean, Standard deviation and median of lower extremity alignments.

Anatomical measures	Mean	Standard Deviation	Median
Tibiofemoral Angle			
Right	13.8	3.84	13
Left	14.5	3.82	14
Quadriceps Angle			
Right	16.94	2.52	17
Left	17.5	2.50	17.5
Genu Recurvetum			
Right	2.816	1.18	3
Left	2.94	1.02	3
Femoral Anteversion			
Right	13.76	3.7	14
Left	14.36	2.91	13
Navicular Drop			
Right	0.84	0.40	0.9
Left	1.02	0.36	0.9

Table 2. Correlations between the variables in the right lower limb

		Tibio_femoral_angle_rt	Quadriceps_angle_rt	Genu_recurvatum_rt	Femoral_anterversion_rt
Tibio_femoral_angle_rt	Pearson Correlation	1	.560	.638	.057
	Sig. (2-tailed)		.001	.000	.970
	N	25	25	25	25
Quadriceps_angle_rt	Pearson Correlation	.560	1	.936	.026
	Sig. (2-tailed)	.001		.000	.001
	N	25	25	25	25
Genu_recurvatum_rt	Pearson Correlation	.638	.936	1	-0.010
	Sig. (2-tailed)	.000	.000		.000
	N	25	25	25	25
Femoral_anterversion_rt	Pearson Correlation	.057	.026	-0.010	1
	Sig. (2-tailed)	.970	.001	.000	
	N	25	25	25	25

Table 3. Correlations between the variables in the left lower limb

		Tibio_femoral_angle_lt	Quadriceps_angle_lt	Genu_recurvatum_lt	Femoral_anterversion_lt
Tibio_femoral_angle_lt	Pearson Correlation	1	.548	.770	.105
	Sig. (2-tailed)		.002	.000	.885
	N	25	25	25	25
Quadriceps_angle_lt	Pearson Correlation	.548	1	.795	.029
	Sig. (2-tailed)	.002		.000	.000
	N	25	25	25	25
Genu_recurvatum_lt	Pearson Correlation	.770	.795	1	-0.027
	Sig. (2-tailed)	.000	.000		.000
	N	25	25	25	25
Femoral_anterversion_lt	Pearson Correlation	.105	.029	-0.027	1
	Sig. (2-tailed)	.885	.000	.000	
	N	25	25	25	25

Conclusion:-

In accordance with the literature and the primary finding of the present study it can be ascertained that more than one anatomical parameter can alter the position of the landmarks to measure Q-angle and thereby altering its magnitude. Therefore, it is concluded that measuring Q-angle alone is not sufficient to identify individuals at risk for knee injury. Rather, it may be the unique combination of alignment characteristics that collectively contribute to the increased risk of knee injury.

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