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Original Research Article

Relationship of incidence of anterior cruciate ligament injuries and body-built Index somatotype in Indian population

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ABSTRACT

Background: Incidence of ACL injuries and physical parameters like age, sex, height, weight and BMI has been studied intensely as a risk factor. Each of them poses as a different risk factor for occurrence of ACL injuries. But body-built index-somatotype considers relative proportions of fatness, muscle mass and skeletal architecture in terms of endomorphy, mesomorphy and ectomorphy in a single individual which neutralises variables like age, sex, BMI.
Methods: 100 patients were included in the study, excluding those with multiligament injuries, associated fractures around knee, mucoid degeneration of ACL and road traffic accident cases. Parameters such as skin fold thickness, circumference and epicondylar, condylar width was taken into consideration. Body built index was calculated in terms of endomorphy, mesomorphy and ectomorphy using the heath-carter anthropometric somatotype manual.
Results: We found that amongst all those have ACL injury, endomorphy was higher grade (5.49), followed by mesomorphy (4.75). Lesser grades of ectomorphs i.e., slender people were having ACL injuries. Though there was low margin of grading between the two, endomorphy was higher in ACL injured people followed by mesomorphy.
Conclusions: Endomorphs and mesomorphs have higher tendancy of ACL injury. Ectomorphs have lesser incidence of ACL injury.

Keywords: ACL tear, Body built type, Somatotypes, Endomorph, Mesomorph, Ectomorph

INTRODUCTION

ACL injuries and associated risk factors have been extensively studied in international literature. Age, sex, height, weight, BMI are the physical variables those have been extensively studied as risk factors for ACL injuries.[1,2,4] Preoperative MRI to look for ACL dimensions like sagittal length, tibial footprint size, femoral footprint size, dimensions of intercondylar notch are the local parameters studied in view of ACL risk factors.[3,5]

Recently advanced measurement like ACL volume, hip abduction muscle strength, sagittal obliquity of ACL on MRI, knee hyperextension, size of lateral femoral condyle, Intercondylar Roof Inclination Angle.[6-9]

When age and the morphological characteristics of the anterior cruciate ligament (ACL) on MRI were compared, Takanori found that, the sagittal ACL area was significantly larger in the young group when compared with the elderly group. Wang et al concluded that men had greater absolute ACL volume and ACL width than women $p<0.001$.[2] Greater body mass index and hip abduction muscle strength can predict ACL injuries in noncontact players.[9] Javad et al in their prospective study have shown that, age, sex, body mass and BMI were strong contributors ($p<0.05$) to structural property of ACL like to elongation, energy at failure, and linear stiffness and load to failure in different proportion. [1]

Indian population is diverse in terms of height, colour, body skeletal structure varying from north Indians being taller than south Indian and eastern Indian population. Index of obesity also varies at different age groups as younger population less than 30 years tend to be more active physically and less obese than population more than 40 years as BMI starts increasing in their sedentary lifestyle. Although this statement can also be confounded by presence or absence of physical activities in the later group.

Similar thought process can be applied to ACL injuries in either of the genders. Female athletes have been proven to be lesser volume of ACL than male athletes leading to higher risk for ACL injury.[10] But that is difficult to be applied to all type of body habitus in the same gender. The type of body built containing different percentage of fat, muscle mass and slenderness can give different results when compared to both sexes.

Somatotyping considers overall body status which includes overall fat content of body, muscle mass and slenderness i.e., skeletal structure of an individual. It has an advantage as it considers all parameters like weight, height, BMI in a single-criteria. Somatotyping is also applicable to all ages and both genders.

Objective of this study is to find the relationship that relates the Indian scenario of mixed culture population using somatotype as parameter and correlate incidence of ACL injury. In a study of 100 patients of ACL tear, Authors have tried to evaluate relation between occurrence of ACL tear and body-built type in Indian nonathletic population. Overweight patients may have different proportion of body fat content and muscle mass content. For example, endomorph obese have more fat than muscle mass whereas mesomorph overweight patients are of stalky built and have more of muscle mass compared to fat content. This factor along with their skeletal architecture contributes to higher overall body weight in mesomorphs and may have different proportion of risk for ACL tears.

METHODS

This was a prospective randomised study. We selected 100 patients between 15 and 50 years coming to OPD having ACL tear confirmed clinically and on MRI in D Y Patil Hospital between 2015 to 2022. Complete ACL injuries less than 6 months old, with and without meniscus tear were selected.

Those excluded from study were multi-ligament injuries, associated fracture around the knee, mucoid degeneration of ACL. Road traffic accident injuries were also excluded as direct knee trauma automatically eliminates the effect of body architecture effect on incidence of ACL injuries.

Each patient having ACL injury was clinically examined for different parameters like skin fold thickness at triceps, infra-scapular and supra-iliac regions. Circumference of flexed arm and calf level was measured using the measuring tape. Epicondylar and condylar width at elbow and distal femur respectively was measured. Lastly body-built index was calculated in terms of endomorphy, mesomorphy and ectomorphy using the heath-carter Anthropometric somatotype manual.[13] Then associations between independent variable of somatotype with presence of ACL tear was studied.

Permission for the study was requested from and granted by the head of ethical committee at the institution from which patient pool was selected.

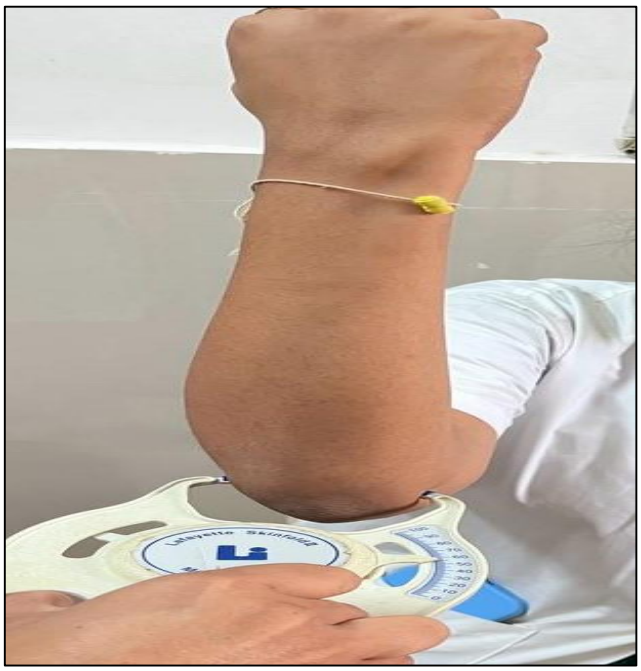

Figure 1: Epinodylar width.

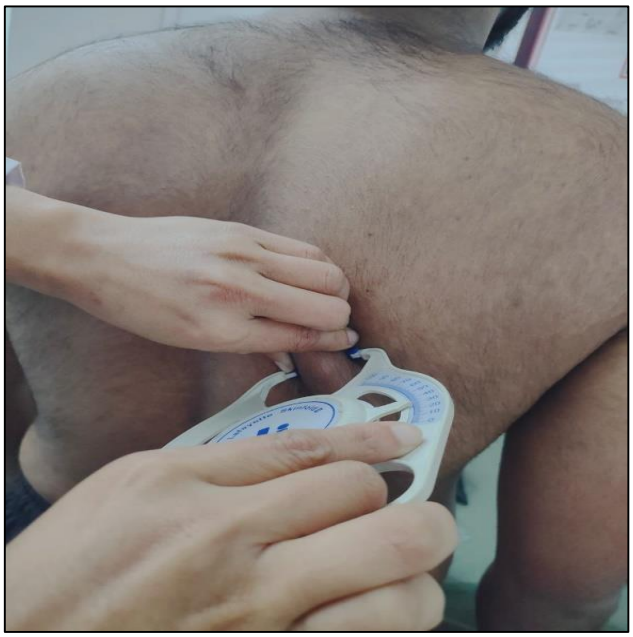

Figure 2: Infra-scapular skin thickness.

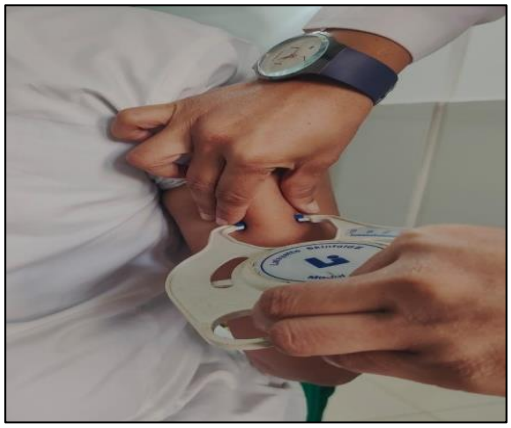

Figure 3: Triceps skin thickness.

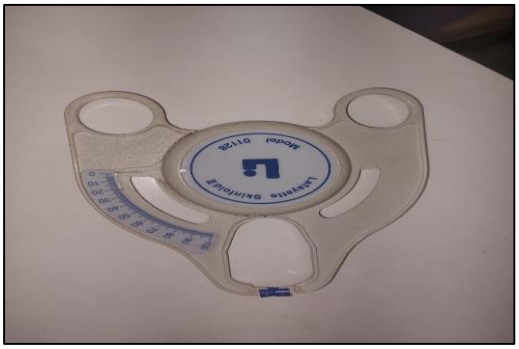

Figure 4: Skin measuring Caliper.

Following formulae were used for calculating somatotype.

Endomorphy=-0.7182+0.1451×Z-0.00068×Z2+ 0.0000014×Z3

Where: Z-triceps skinfold + subscapular skinfold + supra-iliac skin fold

Mesomorphy=0.858 × biepicondylar breadth + 0.601 × bicondylar breadth + 0.188 × corrected arm circumference +0.161×corrected calf circumference-(body height×0.131 +4.5

Where: corrected arm circumference -flexed arm circumference-triceps skinfold, corrected calf circumference- calf circumference-medial calf skinfold;

Ectomorphy=HMR×0.732–28.58 where: HMR=body height/cube root of body mass. If HMR ≤38.25 than 0.1 is assigned. If HMR>40.75 than: ectomorphy =HMR×0.463/17.63

The associations between injury occurrence (dependent variable) and anthropometric-somatotype characteristics (independent variable) was established using the forward conditional logistic regression analysis.

RESULTS

Respondent demographic were shown in Table 1.

Table 1: Physical parameters.

Demographics	Percentage (%)
Gender	
Male	75
Female	25
Age (Years)	
18-35	75
36-49	12.5
50-60	12.5
Body height (cm)	
131-140	12.5
141-150	0
151-160	6.25
161-170	50
171-180	25
181-190	6.25
Body weight (kg)	
50-59	37.5
60-69	31.25
70-79	6.25
80-89	12.5
90-99	12.5
Skin fold thickness (cm)	
Triceps	
10-15	37.5
16-20	50
21-25	12.5

Continued.

Demographics	Percentage (%)
Skin fold thickness (cm)	
Subscapularis	
10-15	37.5
16-20	37.5
21-25	25
Suprailiac	
10-15	37.5
16-20	18.75
21-25	25
26-30	18.75
Calf	
10-15	25
16-20	37.5
21-25	37.5
Circumference (cm)	
Flexed arm	
20-25	12.5
26-30	43.75
31-35	37.5
36-40	6.25
Calf	
26-30	6.25
31-35	37.5
36-40	37.5
41-45	18.75
Breadth (cm)	
Biepi-condyle	
5.0-5.9	12.5
6.0-6.9	56.25
7.0-7.9	31.25
Bicondylar	
8.0-8.9	31.25
9.0-9.9	56.25
10.0-10.9	12.5
Body built (index)	
Endomorphy	
3.0-3.9	12.5
4.0-4.9	37.5
5.0-5.9	12.5
6.0-6.9	25
7.0-7.9	12.5
Mesomorphy	
2.0-2.9	6.25
3.0-3.9	31.25
4.0-4.9	25
5.0-5.9	6.25
6.0-6.9	18.75
7.0-7.9	12.5
Ectomorphy	
0.0-0.9	31.25
1.0-1.9	37.5
2.0-2.9	6.25
3.0-3.9	18.75
4.0-4.9	0
5.0-5.9	0
6.0-6.9	6.25

Table 2: Variables for somatotype.

Variables	Mean	SD	Min	Max
Height (cm)	167.24	13.89	137.16	187.9
Weight (Kg)	68.03	14.98	50	95.9
Skin fold thickness				
Triceps	17.06	3.79	10	24
Infrascapular	17.88	3.56	13	24
Suprailiac	18.94	5.93	11	30
Calf	19	3.52	13	25
Circumference (cm)				
Calf	36.25	3.88	28	42
Flexed arm	30.19	3.69	23.5	36
Breadth (cm)				
Bicondylar	9.22	0.64	8	10.5
Epicondylar	6.43	0.62	5.2	7.4
Body built index				
Endomorphy	5.49	1.15	3.89	7.69
mesomorphy	4.75	1.53	2.51	7.2
ectomorphy	1.78	1.62	0.1	6.15

Ratings on each component of ½ to 2½ are considered low, 3 to 5 are moderate, 5 to 7 are high, and 7 and above are very high. The rating is phenotypical and was applicable to both genders from childhood to old age. We found that amongst all those have ACL injury, endomorphy was higher grade (5.49), followed by mesomorphy (4.75). Lesser grades of ectomorphs i.e., slender people were having ACL injuries. Though there was low margin of grading between the two, endomorphy was higher in ACL injured people followed by mesomorphy.

DISCUSSION

The technique of somatotyping is used to evaluate different body shape and composition. The somatotype is the quantification of the body shape and composition of the human body. It is expressed in endomorphy, mesomorphy and ectomorphy components. Endomorphy is the relative fatness, mesomorphy is the relative musculo-skeletal robustness, and ectomorphy is the relative linearity or slenderness of a physique.[11-13]

As discussed in introduction, ACL injuries and associated risk factors have been extensively studied in international literature. Age, sex, height, weight, BMI are the physical variables those have been extensively studied as risk factors for ACL injuries.[1,2,4] Anatomical factors localised to knee joint studied are preoperative MRI to look for ACL dimensions like sagittal length, tibial footprint size, femoral footprint size, dimensions of intercondylar notch width.[3,5]

Javad et al in their prospective study have shown that, age, sex, body mass and BMI were strong contributors ($p<0.05$) to structural property of ACL like to elongation, energy at failure, and linear stiffness and load to failure in different proportion. ACL length is not significant contributor to any structural property.

ACL minimal area and ACL volume had significant correlation with ACL elongation, energy at failure, and linear stiffness ($p<0.05$). Wang et al concluded that men had greater absolute ACL volume and ACL width than women ($p<0.001$).[3]

When BMI is considered as risk factor, patient-reported outcome measures were similar for patients with BMI above and below 25 kg/m^2, but there is evidence that obese patients have lower IKDC scores.[4]

Indian population is diverse in terms of height, colour, body skeletal structure varying from north Indians being taller south Indian and eastern Indian population. Somatotyping considers overall body status which includes overall fat content of body, muscle mass and skeletal structure of an individual. It has an advantage as it considers all parameters like weight, height, BMI in a single-criteria. Somatotyping is also applicable to all ages and both genders.

We hypothesised that Indian scenario of mixed culture population using somatotype as parameter to correlate incidence of ACL injury. Overweight pts may have different proportion of body fat content and muscle mass content. For example, endomorph overweight patients have more fat than muscle mass whereas mesomorph overweight patients are of stalky built and have more of muscle mass compared to fat content. This factor along with their skeletal architecture contributes to higher overall body weight in mesomorphs.

The correlation between somatotype and lower limb injuries has been studied in 1997 by Diana Hoper in high performance netball players. They used Heath-Carter somatotype scale to measure dependent somatotype variables. None of the three variables were associated with incidence of injury. But mesomorphy and ectomorphy

were significantly associated with the playing position of the athlete.

One more study that has taken body-built index somatotype into consideration was done by Zaletel. Important finding in their study was somatotype types was specifically related to the injuries at 3 locations (ankle, foot and toes).[11]

Kim et al found a positive association between body-fat measures and foot injury occurrence in ballet dancers. An endomorphic somatotype component having more fatness and roundness of the body had higher ankle-injury prevalence.[14] Though our study population didn't contain athletes, similar biomechanics can be applied to Indian population in terms of incidence of knee injuries. Though there was low margin of grading between the two, endomorphy was higher in ACL injured people followed by mesomorphy.

Ectomorphism or slenderness has been associated with higher foot injuries due to longer dimensions of foot in plyers. But no correlation was found with incidence of knee injuries.[15] In our study, ectomorph grading was lesser compared to the other two, which means ectomorphs or slender people are associated with low incidence ACL injuries.

Limitations

The main limitation of this study was that we didn't evaluate the mechanism of injury in these population. Though we had excluded high velocity direct trauma to the knee as the confounding factor because it can cause injury in all categories of somatotpyes i.e., endomorphs, mesomorphs and ectomorphs. Also sample size should have been more and multicentric study would give more conclusions and be more powerful. So, a larger scale of study with large sample size and multicetric study could throw more insight into this hypothesis.

CONCLUSION

Risk factors for ACL injuries have been extensively studied. Obesity, Female gender, High BMR have been proven to be associated with higher risk for ACL injuries but, Body built Index i.e, somatotype which considers relative of proportion of fitness, muscle mass and skeletal architecture can be another predictive variables. In our study endomorph and mesomorph were found to be at higher risk for ACL injuries, whereas multicentric study with higher sample size may throw more light on this hypothesis.

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Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Hashemi J, Mansouri H, Chandrashekar N, Slauterbeck JR, Hardy DM, Beynnon BD. Age, sex, body anthropometry, and ACL size predict the structural properties of the human anterior cruciate ligament. J Orthop Res. 2011;29(7):993-1001.
2. Iriuchishima T, Ryu K, Fu FH. Evaluation of age-related differences in anterior cruciate ligament size. Knee Surg Sports Traumatol Arthrosc. 2019;27(1):223-9.
3. Wang HM, Shultz SJ, Ross SE, Henson RA, Perrin DH, Schmitz RJ. ACL Size and Notch Width Between ACLR and Healthy Individuals: A Pilot Study. Sports Heal. 2020;12(1):61-5.
4. DiSilvestro KJ, Jauregui JJ, Glazier E, Cherkalin D, Bennett CH, Packer JD et al. Outcomes of Anterior Cruciate Ligament Reconstruction in Obese and Overweight Patients: A Systematic Review. Clin J Sport Med. 2019;29(4):257-61.
5. Park YB, Ha CW, Kim HJ, Park YG. Preoperative prediction of anterior cruciate ligament tibial footprint size by anthropometric variables. Knee Surg Sports Traumatol Arthrosc. 2017;25(5):1638-45.
6. Ayerza MA, Múscolo DL, Costa-Paz M, Makino A, Rondón L. Comparison of sagittal obliquity of the reconstructed anterior cruciate ligament with native anterior cruciate ligament using magnetic resonance imaging. Arthroscopy. 2003;19(3):257-61.
7. Saita Y, Schoenhuber H, Thiébat G, Ravasio G, Pozzoni R, Panzeri A et al. Knee hyperextension and a small lateral condyle are associated with greater quantified antero-lateral rotatory instability in the patients with a complete anterior cruciate ligament (ACL) rupture. Knee Surg Sports Traumatol Arthrosc. 2019;27(3):868-74.
8. Samora W, Beran MC, Parikh SN. Intercondylar Roof Inclination Angle: Is It a Risk Factor for ACL Tears or Tibial Spine Fractures? J Pediatr Orthop. 2016;36(6):e71-4.
9. Shimozaki K, Nakase J, Takata Y, Shima Y, Kitaoka K, Tsuchiya H. Greater body mass index and hip abduction muscle strength predict noncontact anterior cruciate ligament injury in female Japanese high school basketball players. Knee Surg Sports Traumatol Arthrosc. 2018;26(10):3004-11.
10. Wang H-M, Sandra JS, Scott ER, Robert AH, David HP, Robert AK et al. Sex Comparisons of *In Vivo* Anterior Cruciate Ligament Morphometry. J Athl Train. 2019;54(5):513-8.
11. Zetel P. The association between body-built and injury occurrence in pre-professional ballet dancers-saperated analysis for the injured body locations. Int J Occup Med Envir Heal. 2017;30(1):151-9.
12. Diana M. Somatotype in high performance female netball players may influence player position and the incidence of lower limb and back injuries. Hopper Br J Sports Med. 1997;31:197-9.

13. Carter JEL. The Health Carter Anthropometric Somatotype Instruction Manual. 2002;1-26.
14. Kim JH, Jung ES, Kim CH, Youn H, Kim HR. Genetic associations of body composition, flexibility and injury risk with ACE, ACTN3 and COL5A1 polymorphisms in Korean ballerinas. J Exerc Nutrition Biochem. 2014;18(2):205-14.
15. Bowerman E, Whatman C, Harris N, Bradshaw E, Karin J. Are maturation, growth and lower extremity alignment associated with overuse injury in elite adolescent ballet dancers? Phys Ther Sport. 2014;15(4):234-41.

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