International Journal of Research in Orthopaedics
Dey RP et al. Int J Res Orthop. 2025 Nov;11(6):1355-1361
http://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20253412

Original Research Article

Prediction of hamstring tendon autograft dimensions for anterior cruciate ligament reconstruction in the Bangladeshi population

Raju Prasad Dey[1]*, Chowdhury Iqbal Mahmud[1], M. Ali Faisal Liton[1], Mohammad Zahidur Rahman Khan[1], M. Naimur Rahman[2], Neyamul Hasan[1]

[1]Department of Orthopaedics, Bangladesh Medical University (BMU), Dhaka, Bangladesh
[2]US Bangla Medical College and Hospital, Dhaka, Bangladesh

Received: 14 August 2025
Revised: 19 September 2025
Accepted: 04 October 2025

***Correspondence:**
Dr. Raju Prasad Dey,
E-mail: rajudeyctg1982@gmail.com

ABSTRACT

Background: This study aimed to evaluate the predictive value of age, sex, height, weight, and body mass index (BMI) for estimating the length of semitendinosus and gracilis tendons, as well as the total graft diameter, in patients undergoing anterior cruciate ligament (ACL) reconstruction.
Methods: A study was conducted involving 58 patients undergoing ACL reconstruction using hamstring tendon autografts. Preoperative data were collected and intraoperative measurements of semitendinosus, gracilis tendon lengths, and total graft diameter were recorded.
Results: For semitendinosus, longer tendons were associated with greater height (B=89.77, p=0.020) and BMI (B=2.452, p=0.044), while higher weight showed a negative effect (B=-0.841, p=0.047). Males had significantly longer semitendinosus tendons than females (B=1.796, p=0.028). Similar trends were observed for gracilis tendon length, where height (B=113.77, p=0.005), BMI (B=3.245, p=0.012), and sex (B=1.747, p=0.040) were positive predictors, and weight showed a negative association (B=-1.132, p=0.011). Age was not a significant predictor for either tendon length (p>0.5). Regarding total graft diameter, only sex emerged as a significant factor (B=0.295, p=0.049), with male patients having thicker grafts, while age, height, weight, and BMI had no significant effect (p>0.05).
Conclusions: Height and BMI are reliable positive predictors of hamstring tendon length, while weight shows a negative association. Male sex is consistently associated with longer and thicker tendons. Age does not significantly influence graft dimensions.

Keywords: Hamstring tendon autograft, Semitendinosus, Gracilis, Graft diameter, Anterior cruciate ligament

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are among the most common knee pathologies, particularly in athletic populations, and often necessitate surgical reconstruction to restore functional stability and prevent long-term joint degeneration.[1,2] Among available graft options, hamstring tendon autografts-specifically the semitendinosus and gracilis tendons-are widely preferred due to their favorable biomechanical characteristics, reduced donor site morbidity, and lower incidence of anterior knee pain compared to bone-patellar tendon-bone grafts.[3-5] One major concern during ACL reconstruction is graft insufficiency, especially when the harvested tendon is too short or thin to provide adequate strength. Graft diameter less than 8 mm has been associated with significantly higher revision rates, particularly in young, active individuals.[6,7]

This highlights the importance of preoperative prediction of tendon dimensions to improve surgical planning and reduce intraoperative surprises.

Recent studies have identified anthropometric variables-such as height, weight, BMI, and sex-as potential predictors of graft size.[8-10] Height has been shown to positively correlate with tendon length and graft diameter, making it one of the most reliable predictors across populations.[11,12] Similarly, some studies have reported a positive correlation between thigh length and tendon dimensions, suggesting that regional measurements may offer greater predictive value than general body size indicators.[13] However, findings related to BMI and body weight remain inconsistent. While some studies reported that higher BMI may result in longer tendons, others found no significant associations.[8,14] Sex differences also play a notable role in graft morphology, with males typically exhibiting longer and thicker hamstring tendons compared to females.[10,15] Conversely, age has not consistently shown predictive value, with most studies reporting no significant correlation between patient age and tendon size.[9,14,16]

Despite growing research, many existing predictive models are derived from Western cohorts, limiting their applicability to other populations. Recent studies from South Asia have emphasized ethnic differences in anthropometry, calling for population-specific data to improve the accuracy of preoperative graft predictions.[8,14] Incorporating both anthropometric assessments and imaging modalities like MRI may further refine these models and optimize outcomes in ACL reconstruction.[12]

The purpose of this study was to assess the predictive value of age, sex, height, weight, and BMI in determining the total graft diameter and the length of the gracilis and semitendinosus tendons in patients having ACL reconstruction.

METHODS

This cross-sectional observational study was conducted in the department of orthopaedics, arthroscopy arthroplasty unit, Bangladesh medical university over a defined period from 01 July 2024 to 30 June 2025, involving patients scheduled for primary ACL reconstruction using hamstring tendon autografts. A total of 58 patients who met the inclusion criteria were enrolled consecutively. Inclusion criteria comprised skeletally mature individuals undergoing ACL reconstruction with semitendinosus and gracilis autografts. Patients with prior knee surgery, multiligamentous injuries, or systemic musculoskeletal disorders were excluded. Preoperative demographic and anthropometric data, including age, sex, height, weight, and BMI, were recorded. BMI was calculated using the standard formula: weight (kg) divided by height (m^2). All surgeries were performed by experienced orthopedic surgeons using a standardized arthroscopic technique. Intraoperatively, the lengths of the semitendinosus and gracilis tendons were measured immediately after harvest using a sterile ruler. The total graft diameter was recorded following quadrupling of the tendons and measurement with a graft-sizing block in 0.5 mm increments. Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize demographic variables. Linear regression analysis was conducted to evaluate the predictive relationship between the independent variables (age, sex, height, weight, BMI) and the dependent variables (semitendinosus length, gracilis length, total graft diameter). Statistical significance was set at $p<0.05$. This study was conducted in accordance with the declaration of Helsinki, and ethical approval was obtained from the institutional review board. Informed written consent was obtained from all participants prior to enrolment.

RESULTS

Demographic of the study population

The age group distribution shows that the majority of ACL reconstruction patients were between 26-30 years (n=20), followed by 21-25 years (n=14), indicating that ACL injuries are most common in young adults. The number of cases declines steadily with age, with very few patients above 40 years, suggesting that younger individuals, likely due to higher physical activity levels, are more prone to ACL injuries requiring surgical intervention.

The sex distribution reveals a significant male predominance, with 56 out of 58 patients (96.6%) being male and only 2 (3.4%) females. This suggests that ACL injuries requiring reconstruction are far more common among males, likely due to greater participation in high-risk physical activities or sports.

The height summary shows that the average height of the patients is 1.70 meters, with a moderate range from 1.55 meters to 1.85 meters, indicating a relatively homogeneous population in terms of height.

The weight summary reveals an average weight of 74.03 kg, with a broad spread from 49 kg to 100 kg, suggesting variability in body weight among the participants.

The majority of patients fall into the overweight (25.0-29.9) category (30 patients), followed by normal (18.5-24.9) weight (20 patients), indicating that most of the cohort has a BMI above the healthy range. Only 2 patients were classified as underweight, and 6 were in obese class I, with no patients in obese class II, suggesting that the population tends to be overweight or normal weight.

Linear regression analysis identified several significant predictors of semitendinosus tendon length. Height (B=89.77, p=0.020) was positively associated, indicating that taller individuals tend to have longer tendons. Conversely, weight (B=-0.841, p=0.047) was negatively associated, suggesting that heavier individuals have shorter tendons. BMI (B=2.452, p=0.044) and sex (B=1.796, p=0.028) were also significant, with higher BMI and male sex associated with longer tendons. Age, however, was not a significant predictor (p=0.506).

Linear regression analysis revealed that height (B=113.77, p=0.005), weight (B=-1.132, p=0.011), BMI (B=3.245, p=0.012), and sex (B=1.747, p=0.040) were significant predictors of gracilis tendon length. Taller individuals and those with higher BMI tend to have longer gracilis tendons, while greater weight is associated with shorter tendon length. Sex also had a significant influence on tendon length. Age, however, was not a significant predictor (p=0.652). Linear regression analysis showed that sex was the only significant predictor of total graft diameter (B=0.295, p=0.049), indicating that graft diameter varies by sex. Age, height, weight, and BMI were not significant predictors, with all p values greater than 0.05.

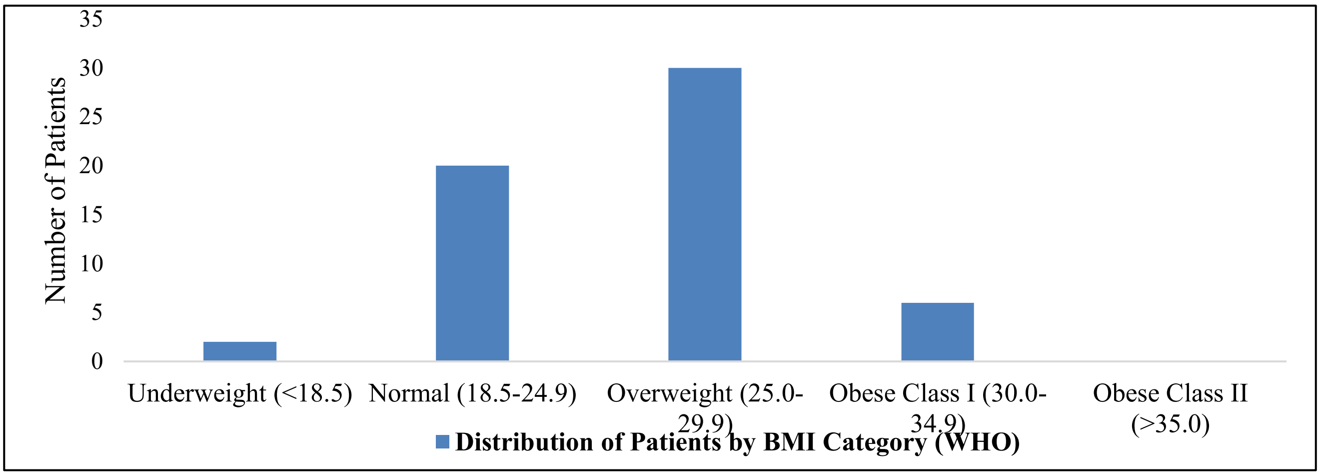

Figure 1: Weight distribution according to BMI categories (WHO classification).

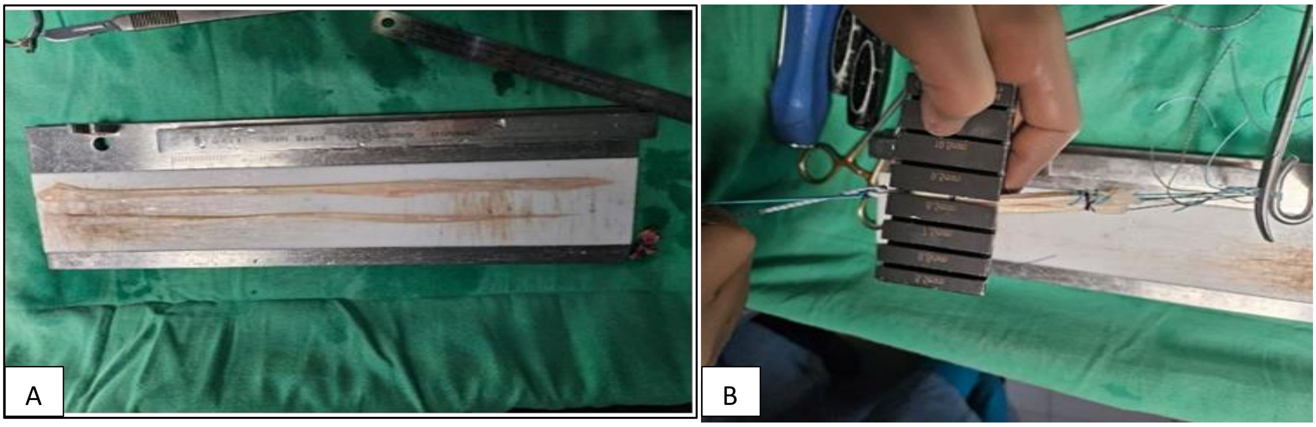

Figure 2 (A and B): Length and diameter measurement after quadruple strand. A-Semitendinosus and gracilis length measurement. B-Quadrupled hamstring diameter measurement.

Table 1: Age group distribution of the study population, (n=58).

Age group (in years)	N
21-25	14
26-30	20
31-35	8
36-40	6
41-45	0
46–50	4

Table 2: Sex distribution of the study population, (n=58).

Sex	N	Percentage (%)
Male	56	96.6
Female	2	3.4
Total	58	100

Table 3: Height summary (in meters) of the study population, (n=58).

Statistics	Value
Count	58
Mean	1.70
Std Dev	0.064
Min	1.55
Median	1.68
Max	1.85

Table 4: Weight summary (in kg) of the study population, (n=58).

Statistics	Value
Count	58
Mean	74.03
S. D.	12.39
Min	49
Median	72
Max	100

Table 5: Weight distribution according to BMI categories (WHO classification).

BMI category (WHO) (kg/m^2)	N
Underweight (<18.5)	2
Normal (18.5-24.9)	20
Overweight (25.0-29.9)	30
Obese class I (30.0-34.9)	6
Obese class II (≥35.0)	0

Association of the independent variables with dependent variables

Table 6: Association of age, sex, height, weight and BMI with length of semitendinosus.

Coefficients[a]					
Model	**Unstandardized coefficients**		**Standardized coefficients**	**T**	**Sig.**
	B	**Std. error**	**Beta**		
(Constant)	-127.513	62.901		-2.027	0.048
Age (in years)	-0.021	0.031	-0.081	-0.670	0.506
Height (cm)	89.765	37.352	2.903	2.403	0.020
Weight (kg)	-0.841	0.413	-5.271	-2.033	0.047
BMI (kg/m^2)	2.452	1.187	3.984	2.066	0.044
Sex	1.796	0.794	0.257	2.262	0.028

*a-Dependent variable: semitendinosus length

Table 7: Association of age, sex, height, weight and BMI with length of gracilis.

Coefficients[a]					
Model	**Unstandardized coefficients**		**Standardized coefficients**	**T**	**Sig.**
	B	**Std. error**	**Beta**		
(Constant)	-167.127	65.703		-2.544	0.014
Age (in years)	-0.015	0.032	-0.057	-0.454	0.652
Height (cm)	113.773	39.016	3.650	2.916	0.005
Weight (kg)	-1.132	0.432	-7.045	-2.622	0.011
BMI (kg/m^2)	3.245	1.240	5.230	2.618	0.012
Sex	1.747	0.829	0.248	2.107	0.040

*a-Dependent variable: Gracilis length.

Table 8: Association of age, sex, height, weight and BMI with total diameter of graft.

Coefficients[a]					
Model	**Unstandardized coefficients**		**Standardized coefficients**	**T**	**Sig.**
	B	**Std. error**	**Beta**		
(Constant)	14.114	11.606		1.216	0.229
Age (in years)	-0.006	0.006	-0.111	-1.004	0.320
Height (cm)	-4.014	6.892	-0.643	-0.582	0.563
Weight (kg)	0.089	0.076	2.766	1.167	0.249
BMI (kg/m^2)	-0.270	0.219	-2.170	-1.231	0.224
Age (in years)	0.295	0.146	0.210	2.017	0.049

*a-Dependent variable: total Dia.

DISCUSSION

This study explored the association between anthropometric parameters and hamstring tendon autograft dimensions in a Bangladeshi population undergoing ACL reconstruction. The findings demonstrate that height and BMI are significant positive predictors of both semitendinosus and gracilis tendon length, while weight has a negative association. Sex also emerged as a consistent predictor across tendon length and graft diameter, with male patients showing longer and thicker tendons. These results align with recent studies highlighting the predictive value of body habitus in estimating graft morphology prior to ACL reconstruction.[17-19]

Height has been repeatedly validated as a reliable predictor of graft length due to its correlation with limb and muscle size, which supports our findings.[20,21] Interestingly, although body weight alone negatively correlated with tendon length, BMI had a positive relationship, echoing prior observations that overall body composition rather than mass alone plays a crucial role in tendon morphology.[22] The finding that male sex significantly predicted longer and thicker tendons is consistent with broader anatomical differences reported in the literature, where men typically exhibit more robust soft tissue structures.[23,24] Notably, age did not significantly predict tendon length or graft diameter, reinforcing prior studies that found little to no correlation between age and graft size in skeletally mature individuals.[25,26] The only significant predictor for total graft diameter was sex, suggesting that while height and BMI may influence tendon length, sex-based anatomical factors likely play a dominant role in tendon cross-sectional area.[27] This highlights the importance of patient sex as a practical preoperative consideration when anticipating graft adequacy and planning surgical strategy.

The clinical significance of these findings is substantial, as hamstring grafts below 8 mm in diameter have been associated with increased rates of failure and need for revision surgery.[27] Given that the study population was predominantly male and overweight, it provides valuable insight into regional norms and graft suitability in South Asia. Additionally, using simple anthropometric measures can be especially useful in resource-constrained settings where advanced imaging may be unavailable or cost-prohibitive. From a biomechanical standpoint, understanding the interplay between body size and tendon morphology also helps optimize graft preparation techniques, such as selecting between quadruple and five-strand constructs for sufficient diameter.[26] Despite the strong correlations found, anthropometric data alone may not fully capture the variability in tendon morphology. Future studies could incorporate muscle cross-sectional area measurements or utilize ultrasound/MRI to enhance predictive accuracy. Long-term clinical outcome correlation, such as graft retear rates or functional scores based on predicted vs. actual graft size, would also be valuable in validating the practical utility of these models. A multicentric approach involving different ethnic groups within the region could further strengthen the external validity of these findings.

Although the findings resonate with previous international studies, they are especially valuable in the South Asian context, where population-specific data are sparse. Anthropometric norms differ significantly across ethnicities, and predictive models developed in Western populations may not generalize well to this region.[28] This study thus contributes important region-specific data to the evolving global understanding of ACL graft planning. This study is limited by its small sample size, particularly the underrepresentation of female patients, which may affect the generalizability of sex-based findings. Additionally, being a single-center study, the findings may not reflect anthropometric variations across different regions or ethnic groups within Bangladesh. The cross-sectional design also restricts causality interpretation, and the absence of imaging data such as MRI prevents comparison with radiological predictors of graft size.

CONCLUSION

Height, BMI, weight, and sex are significant predictors of hamstring tendon autograft dimensions in the Bangladeshi population undergoing ACL reconstruction. Age does not significantly influence graft morphology. These anthropometric variables can serve as useful tools for preoperative estimation of graft adequacy, especially in resource-limited settings. Further large-scale, multicentric studies incorporating imaging and functional outcomes are recommended to enhance the robustness of predictive models and their clinical applicability.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Spragg L, Chen J, Mirzayan R, Love R, Maletis G. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. Arthroscopy. 2012;28(4):526–531.
2. Bouras T, Lianou I, Filippopoulos A, John L, Dimitrios N. Use of anthropometric data for the prediction of four-strand hamstring graft size in white Caucasian population. J Clin Med. 2025;14(3):825.
3. Joseph B, Mammu S, Hussain N, Pawaskar S. Anthropometric predictors of hamstring graft size in anterior cruciate ligament reconstruction. Int J Res Orthop. 2024;10:1231-8.
4. Garcia-Lopez E, Ghanta RB, Halvorson RT, Feeley B. Generation of 5-Strand Hamstring Autograft for Anterior Cruciate Ligament Reconstruction-A Technical Note. Arthrosc Tech. 2023;12(11):e1873-e1877.
5. Panigrahi T, Maharaj R, Nanda D. Anthropometric measurements of hamstring tendon graft and its predictors in ligament reconstruction surgeries of knee: an observational study. Int J Recent Surg Med Sci. 2023;9:S80-3.
6. Mariscalco MW, Flanigan DC, Mitchell J, Pedroza AD, Jones MH, Andrish JT, et al. The influence of hamstring autograft size on patient-reported outcomes and risk of revision after anterior cruciate ligament reconstruction: a Multicenter Orthopaedic Outcomes Network (MOON) Cohort Study. Arthroscopy. 2013;29(12):1948-53.
7. Conte EJ, Hyatt AE, Gatt CJ Jr, Dhawan A. Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. Arthroscopy. 2014;30(7):882-90.
8. Islam MS, Ahmed AMFU, Goni MO, Islam MR, Rahman MM, Bari SU, et al. Anthropometry in predicting Semitendinosus and Gracilis graft diameter for arthroscopic ACL reconstruction among the Bengali population. Medicine (Baltimore). 2023;102(40):e35402.
9. Purohit S, Pol SP, Bhosle S, Karwande N, Panghate AN, Jadhav D, et al. ACL reconstruction: a retro-prospective observational study to predict graft length and graft diameter using anthropometric parameters in a western Indian population. J Orthop Rep. 2025;4(2 Suppl):100606.
10. Movahedinia, M., Movahedinia, S., Hosseini, S. et al. Prediction of hamstring tendon autograft diameter using preoperative measurements with different cut-offs between genders. J Exp Ortop. 2023;10:1-6.
11. Nepal S, Gupta M, Panthee R, Kafle G, Sah R. Correlation of anthropometric measurements with hamstring graft size in anterior cruciate ligament reconstruction in Nepalese population: a prospective observational study. J Karnali Acad Health Sci. 2023;6:26-30.
12. Xu Y, Wang J, Zhang H. Comparing ultrasound and MRI evaluations of the hamstring tendon cross-sectional area for ACL reconstruction. Orthop J Sports Med. 2024;12(1):23259671241248187.
13. Shrestha P, Singh Thapa S, Mahara DP, Paudel S, Lamichhane A, Saud T. Prediction of Hamstring Autograft sizes for Anterior Cruciate Ligament Reconstruction using Preoperative Magnetic Resonance Imaging. J Nepal Health Res Counc. 2023;21(1):34-39.
14. Tuman JM, Diduch DR, Rubino LJ, Baumfeld JA, Nguyen HS, Hart JM. Predictors for hamstring graft diameter in anterior cruciate ligament reconstruction. Am J Sports Med. 2007;35(11):1945-9.
15. Lazarides AL, Alentorn-Geli E, Vinson EN, Hash TW, Samuelsson K, Toth AP, et al. Advanced Patellar Tendinopathy Is Associated With Increased Rates of Bone-Patellar Tendon-Bone Autograft Failure at Early Follow-up After Anterior Cruciate Ligament Reconstruction. Orthop J Sports Med. 2018;6(11):2325967118807710.
16. Ma CB, Keifa E, Dunn W, Fu FH, Harner CD. Can pre-operative measures predict quadruple hamstring graft diameter? Knee. 2010;17(1):81-3.
17. Mayr MF, Siegel M, Taghizadeh E, Obid P, Schmal H, Izadpanah K. Prediction of the Hamstring Graft Size for ACL Reconstruction Using Different Axial Layers in Preoperative MRI J Pers Med. 2024;14(6):582.
18. Mardani-Kivi M, Karimi-Mobarakeh M, Mirbolook A, Keyhani S, Saheb-Ekhtiari K, Hashemi-Motlagh K, et al. Predicting the Hamstring Tendon Diameter Using Anthropometric Parameters. Arch Bone Joint Surg. 2016;4(4):314-7.
19. Frodl A, Mayr M, Siegel M, Meine H, Taghizadeh E, Bendak S, Schmal H, et al. Predicting the Hamstring Graft Size for ACL Reconstruction Using a 3D Tendon Model in Preoperative MRI. J Clin Med. 2025;14(6):2128.
20. Takenaga T, Yoshida M, Albers M, Nagai K, Nakamura T, Fu FH, et al. Preoperative sonographic measurement can accurately predict quadrupled hamstring tendon graft diameter for ACL reconstruction. Knee Surg Sports Traumatol Arthrosc. 2019;27(3):797-804.
21. Hollnagel K, Johnson BM, Whitmer KK, Hanna A, Miller TK. Prediction of Autograft Hamstring Size for Anterior Cruciate Ligament Reconstruction Using MRI. Clin Orthop Relat Res. 2019;477(12):2677-84.
22. Goyal T, Paul S, Das L, Choudhury AK. Correlation between anthropometric measurements and activity level on length and diameter of semitendinosus tendon

autograft in knee ligament surgery: A prospective observational study. SICOT J. 2020;6:23.
23. Alkhalaf FNA, Hanna S, Alkhaldi MSH, Alenezi F, Khaja A. Autograft diameter in ACL reconstruction: size does matter. SICOT J. 2021;7:16.
24. Treme G, Diduch DR, Billante MJ, Miller MD, Hart JM. Hamstring graft size prediction: a prospective clinical evaluation. Am J Sports Med. 2008;36(11):2204-2209.
25. Roach R, Anil U, Bloom DA, Pham H, Jazrawi L, Alaia MJ, et al. Bone-Patellar Tendon-Bone Autograft Thickness Is a Risk Factor for Graft Failure. A Case-Control Analysis. Bull Hosp Jt Dis (2013). 2021;79(2):72-7.
26. Krishna L, Tan X, Wong K, Lin F, Toh S. A 5-Strand Hamstring Autograft Achieves Outcomes Comparable to Those of a 4-Strand Hamstring Autograft With a Graft Diameter of 8 mm or More in Anterior Cruciate Ligament Reconstruction. Orthop J Sports Med. 2018;6:232596711876081.
27. Familiari F, Palco M, Russo R, LaPrade RF, Simonetta R. How to Avoid Common Complications in Hamstrings Harvest for Anterior Cruciate Ligament Reconstruction: A Practical Guide. Arch Bone Joint Surg. 2023;11(7):458-64.
28. Ho SW, Tan TJ, Lee KT. Role of anthropometric data in the prediction of 4-stranded hamstring graft size in anterior cruciate ligament reconstruction. Acta Orthop Belg. 2016;82(1):72-7.

Cite this article as: Dey RP, Mahmud CI, Liton MAF, Khan MZR, Rahman MN, Hasan N. Prediction of hamstring tendon autograft dimensions for anterior cruciate ligament reconstruction in the Bangladeshi population. Int J Res Orthop 2025;11:1355-61.