Original article

Impact of asymptomatic genu recurvatum on patellar mobility in young males

Impacto do genu recurvatum assintomático na mobilidade patelar em jovens do sexo masculino

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ABSTRACT | BACKGROUND: Genu recurvatum is one of the most commonly presented lower extremity postural malalignments in individuals. Though genu recurvatum and its impact on impaired knee proprioception, anterior cruciate injuries and posterior soft tissue dysfunctions are reported, its association with patellar mobility is scarcely reported and warrants exploration. **OBJECTIVES:** To evaluate the medial and lateral patellar mobility differences in adult young males with genu recurvatum and normal knee alignment. **METHODS:** The ethical approval for this cross-sectional study protocol was obtained and the study was conducted in Research Department of Alva's College of Physiotherapy and Research Centre, Moodubidire, DK, Karnataka, India. The study participants were recruited through an institutional-based musculoskeletal and sports clinic. The estimated sample size for this study was 174. A total of 87 young males with genu recurvatum and 87 young males with normal knee alignment fulfilling the selection criteria were enrolled in two groups. Participants' knee joint was examined by an assessor and individuals with > 5º knee hyperextension were assigned to genu recurvatum group, and individuals with knee extension < 5º from neutral were assigned to the normal knee alignment group. Further, the patellar glide test was performed to examine the presence of patellar hypermobility in both groups. **RESULTS:** The mean age of the participants in genu recurvatum and normal knee alignment group was 22.04 + 1.860 and 21.91 + 1.869, respectively. A significant higher proportion (86.2%) of participants with genu recurvatum identified with patellar hypermobility compared to normal knee alignment. Within the genu recurvatum subjects, 66.66& and 19.54% were observed to have medial and lateral patellar hypermobility. The odds for occurrence of patellar hypermobility in genu recurvatum was estimated to be 13.007 (95%, CI, 5.481 – 30.866), respectively. **CONCLUSION:** The study result suggests that medial patellar hypermobility is more common in individuals with genu recurvatum. Further study investigating on the mechanism contributing towards medial patellar mobility in genu recurvatum populations could validate the present study findings.

KEYWORDS: Patella. Knee. Hypermobility Joint.

RESUMO | INTRODUÇÃO: Genu recurvatum é um dos desalinhamento posturais dos membros inferiores mais comumente apresentado em indivíduos. Embora o genu recurvatum e seu impacto na propriocepção prejudicada do joelho, lesões cruzadas anteriores e disfunções dos tecidos moles posteriores sejam relatados, sua associação com a mobilidade patelar é pouco relatada e merece exploração. **OBJETIVOS:** Avaliar as diferenças de mobilidade patelar medial e lateral em homens adultos do sexo masculino com genu recurvatum e alinhamento normal do joelho. **MÉTODOS:** O protocolo do estudo foi explicado e a aprovação ética para o protocolo do estudo foi obtida e o estudo foi conduzido no Departamento de Pesquisa do Alva's College of Physiotherapy and Research Centre, Moodubidire, DK, Karnataka, India. Os participantes do estudo foram recrutados por meio de clínica musculoesquelética e esportiva de base institucional. O tamanho estimado da amostra para este estudo foi de 174. Um total de 87 jovens do sexo masculino com genu recurvatum e 87 jovens do sexo masculino com alinhamento normal do joelho foram incluídos em dois grupos. A articulação do joelho dos participantes foi examinada por um avaliador e os indivíduos com hiperextensão do joelho > 5º foram designados para o grupo Genu recurvatum, e os indivíduos com extensão do joelho < 5º do neutro foram designados para o grupo de alinhamento normal do joelho. Além disso, o teste de deslizamento patelar foi realizado para examinar a presença de hipermobilidade patelar. **RESULTADOS:** A média de idade dos participantes do grupo genu recurvatum e alinhamento normal do joelho foi 22,04 + e 21,91 + 1,869, respectivamente. Uma proporção significativamente maior (86,2%) de participantes com genu recurvatum identificados com hipermobilidade patelar em comparação com indivíduos com alinhamento normal do joelho. Entre os indivíduos com genu recurvatum, observou-se que 66,66% e 19,54% apresentavam hipermobilidade patelar medial e lateral. Entre aqueles com alinhamento normal do joelho, 44,83% apresentaram hipermobilidade patelar. A razão de chances para ocorrência de hipermobilidade patelar no genu recurvatum foi estimada em 13,007 (95%, IC, 5,481 – 30,866), respectivamente. **CONCLUSÃO:** O resultado do estudo sugere que a hipermobilidade patelar medial é mais comum em indivíduos com genu recurvatum. Um estudo mais aprofundado que investigue o mecanismo detalhado que contribui para a mobilidade patelar medial em populações de genu recurvatum poderia validar os resultados do presente estudo.

PALAVRAS-CHAVE: Patela. Joelho. Hipermobilidade Articular.

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1. Introduction

The complexity of the patellofemoral joint with several tissues and varying contact points throughout the knee joint movement often poses challenges in knee rehabilitation for both the athletic and non-athletic populations at all ages. Articular dysfunction, soft tissue lesions, muscular conditions and poor biomechanics are commonly addressed etiologies in individuals consulting the physical therapist. Patellofemoral pain is often caused by hypomobility of the patella and is characterized by one of the two syndromes, global patellar pressure syndrome and excessive lateral pressure syndrome.[1] Mobility dysfunctions of the patella are associated with overuse of the knee joint and associated structures. Retinacular tightness, lesions in the extensor expansion, articular cartilage damage, intra-articular derangement and deformities of the knee joint predispose to hypomobility and abnormal tracking of patella in the intercondylar groove. Abnormal patellar mobility, such as increased or decreased lateral or medial patellar mobility, is considered as possible contributor to patellofemoral pain.[2]

Patellar mobility contributes to knee joint kinematics and kinetics. The patella moves in multiple planes such as, superior/inferior, medial/lateral glide, medial/lateral tilt, medial/lateral rotation. The plane of patellar tracking during tibiofemoral motion largely depends on the contraction force of quadriceps muscle, flexibility of the extensor expansion, geometry of patella and the trochlear groove. Due to the asymmetrical configuration of femoral condyles, the gliding of the patella in frontal plane during flexion and extension of the tibiofemoral joint contributes to normal kinematics of the knee joint. Hypomobility or hypermobility of the patella is reported to be associated with the pathomechanics of the knee joint.[3]

Malalignment of the knee joint alters muscular imbalance and integrity of soft tissues and contributes to instability, pain and other movement dysfunctions. Genu recurvatum is one of the most common postural malalignment condition of the knee joint characterized by hyperextension of the tibia bone beyond 5º [4],and considered as the objective measure of genu recurvatum.[2] Various factors proposed for the etiology of genu recurvatum such as congenital, hormonal, physiological, biomechanical, lifestyle, musculoskeletal, postural and so on.[3] In most individuals, genu recurvatum is often associated with poor posture. The risk factor for developing genu recurvatum is most prevalent during the gross motor development stages in toddlers and in adults it is associated with neuromusculoskeletal conditions of lower extremity.[5]

Studies in the literature[4,6] have reported the influence of genu recurvatum in knee joint structures. In individuals with genu recurvatum, the axis of the femur runs obliquely inferiorly and posteriorly, and tends to increase the ground reaction force anterior to the knee joint. The posterior structures are placed in tension to stabilize the knee joint without quadriceps muscle contraction. Hyperextension of the knee also increases the tensile stress of the anterior cruciate ligament and posterolateral structures and poses a potential risk of injury to those structures. Relatively, abnormal increases in the joint reaction force in anterior tibiofemoral joints are reported in genu recurvatum. Structural changes reported to be associated with kinetic chain distortion effect of genu recurvatum are pseudo patella alta, excessive femoral internal rotation, genu varum, genu valgum, tibial varum, and excessive subtalar joint pronation. Diminished strength of internal and external rotator muscles around the hip joint in individuals with genu recurvatum is also reported in the literature.[7] Pathomechanical changes in genu recurvatum increases tensile stress on the posterior compartment and contact stress on the anterior compartment, necessitating the need for determining, and analyzing the patellar mobility in individuals with genu recurvatum. The main objective of the present study is to assess the patellar mobility in individuals with genu recurvatum and compare it with normal knee alignment subjects. It is hypothesized that patellar mobility differs in individuals with genu recurvatum than those with normally aligned knee joint.

2. Methods

The study methodology followed STROBE checklist guidelines for reporting cross-sectional studies. The study protocol was approved by the Institutional Ethical Committee (ACP/OP/2022/OL52) of Alva's College of Physiotherapy and Research Centre, Moodbidri, Dakshina Kannada, Karnataka, India. The sample size was estimated using epi info (version 7.2.5.0) stat calc software for Windows, with the following parameters obtained from a previous study by Ota et al.[4], two-sided confidence level (95%), power (80%), ratio participants in each group (1), percent of controls exposed (10.4%). The estimated sample size was 174 allocated equally in genu recurvatum (n = 87) and normal knee alignment (n = 87) groups. The study population was all the students pursuing paramedical professional courses from Alva's Education Foundation, Moodbidri, Dakshina Kannada, Karnataka, India. A total of 317 individuals were screened for selection criteria. The inclusion criteria of this study protocol include males aged from 18 to 27 years; with no deficits in hip, knee and ankle joint range of motion; individuals identified with knee extension range greater than 5 degrees were assigned to the genu recurvatum group and individuals with knee extension range lesser than 5 degrees were assigned in the control group. Females and male athletes were excluded in both groups. Unilateral genu recurvatum is considered for exclusion in the genu recurvatum group. Deformities such as genu valgum, genu varum, limb length discrepancy, spinal deformities, congenital conditions, neuromusculoskeletal conditions, generalized joint hypermobility, past surgical procedures in the lower limb, trauma, osseus deformity or damage, growth plate lesions of bone, Osgood schlatter disease, and prolonged immobilization were considered as exclusion for assigning subjects in both the groups. Male participants in the control group considered for exclusion if they had a history of surgical procedures, immobilization of lower limb and soft tissue injuries or pain in the knee joint. The study objective and protocol was explained to the individuals fulfilling the study protocol and their consent was obtained for participation.

The study was conducted in Research Department of Alva's College of Physiotherapy and Research Centre, Moodubidire, Dakshina Kannada, Karnataka – 574227, India. Demographic data such as age in years, height measured in centimeters (cm) with a 1cm approximation, weight in kilogram (kg) with a 1kg approximation, and the body mass index in kilogram/meter square (kg/m^2) were collected. Patellar gliding test was performed in supine position to identify the patellar mobility in individuals with genu recurvatum and normal knee alignment.

2.1 Screening for genu recurvatum

Genu recurvatum was measured as the angle formed in the sagittal plane by the femur and tibia. Participants were instructed to stand with full extension of the knee joint to the maximum available range. The fulcrum of the universal goniometer is placed at the level of the joint line, the stationary arm of goniometer is positioned parallel to the line connecting the central point of the greater trochanter to the central point of the lateral epicondyle of the femur, and the mobile arm of the goniometer is positioned parallel to the line connecting central point of the proximal joint line to the central point of the lateral malleolus.[8,9]

Screening for genu recurvatum is performed by a qualified, senior physical therapist specialized in musculoskeletal physical therapy with 10 years' experience. The assessor is blinded from the patellar mobility outcomes.

2.2 Patellar mobility

The medial–lateral patellar gliding is performed to assess the mobility of the patella. In a supine lying position, the participant's dominant side knee is positioned with 20 to 30 degrees of flexion. The patella is divided into 4 quadrants and the patella is passively moved in the medial and lateral direction to end range of movement. Lateral gliding of 3 or more than 3 quadrants of patella represents lateral restraint incompetency (laxity) or lateral patellar hypermobility and medial gliding of 2 or more than 2 quadrants represent medial patellar hypermobility.[10,11]

The patellar glide test to evaluate patellar mobility was performed by an experienced clinical physical therapist with more than 10 years' expertise in the rehabilitation of knee joint related musculoskeletal conditions from a knee specialty clinic.

2.3 Statistical analysis

Statistical analysis was conducted in SPSS (version 26.0 for Windows; SPSS Inc, Chicago, IL). Descriptive statistics was performed for demographics such as age, height, weight, and body mass index. Inferential statistics such as chi square test performed to identify the outcomes of patellar mobility in genu recurvatum and normal knee alignment groups. Logistic regression is performed to estimate the odds ratio (strength of association) for patellar mobility in genu recurvatum and normal knee alignment group. Odds ratio measures demonstrate the strength of outcome associated with exposure. The larger the odd ratio higher the outcome is associated with exposure. Small odds ratio implies least possibility of outcome occurring with exposure. The crude odds ratio or unadjusted ratio estimates the relative risk of outcomes associated with exposure. The adjusted odd ratio estimates the absolute risk of outcome associated with exposure.

3. Results

A total of 174 participants were included in this cross-sectional study. The mean age, height, weight and body mass index of the participants did not differ significantly in both groups. The mean age of the participants enrolled in this study was 21.98 years (SD 1.86), and the majority of the participant's age ranged from 22 to 24 years (n = 90; 51.7%). The mean weight of the study participants was 66.63 kilograms (SD 10.07) and 36.2% (n = 63) was in 61–70 kilograms of weight category range. The mean height of the participants was 168.24 centimeters (SD 6.50) and 92% (n = 160) was from 150–175 centimeter category. The normal body mass index range was observed in 67.8% of the participants (n = 118) (Table 1).

Table 1. Descriptive statistics of variables associated (chi square test) with patellar mobility

Variables	Category	Frequency (n)	Percentage (%)	Patellar mobility			Chi square test (X^2)	Significance (p value)
				Normal	Medial hypermobility	Lateral hypermobility		
Age (years)	18 – 21	71	40.8	29	25	17	7.076	0.132
	22 – 24	90	51.7	30	35	25		
	25 - 27	13	7.5	1	9	3		
Weight (kilogram)	50 - 60	52	29.9	20	15	17	7.737	0.460
	61 – 70	63	36.2	21	29	13		
	71 - 80	47	27.0	15	21	11		
	81 – 90	8	4.6	2	4	2		
	91 - 100	4	2.3	2	0	2		
Height (centimeters)	150 – 175	160	92	59	63	38	23.849	0.002**
	176 - 200	14	8	1	6	7		
Body mass index (kg/m²)	Normal category	118	67.8	36	46	36	10.834	0.028*
	Overweight category	50	28.7	19	23	8		
	Obesity type I category	6	3.4	5	0	1		
Knee alignment	Genu recurvatum	87	50	59	63	38	6.770	0.34
	Normal knee alignment	87	50	1	6	7		

* significant if P value < 0.05
** highly significant if P value < 0.01
Source: the authors (2023).

3.1 Patellar mobility

The reported patellar hypermobility was higher in participants with genu recurvatum - 86.21% (n = 75) - compared to the normal knee alignment group - 44.83% (n = 39). In genu recurvatum group, medial and lateral patellar hypermobility was reported in 66.66% (n = 58) and 19.54% (n = 17) of the individuals. Normal knee alignment group participants differed from genu recurvatum group in the commonly reported type of hypermobility. Among the patellar hypermobility individuals in normal knee alignment group, 32.18% (n = 28) had lateral hypermobility and 12.64% (n = 11) were identified with medial hypermobility. A majority of 55.17% (n = 48) of participants in normal knee alignment group demonstrated normal patellar gliding range, whereas it was lesser, with 13.79% (n = 12) in genu recurvatum group (table 2).

Table 2. Patellar glide test results in individuals with genu recurvatum and normal knee alignment

Group	Normal mobility, n (%)	Hypomobility, n (%)	Medial patellar hypermobility, n (%)	Lateral patellar hypermobility, n (%)	Total hypermobility
Genu recurvatum (n = 87)	12 (13.79%)	0 (0%)	58 (66.66%)	17 (19.54%)	75 (86.21%)
Normal knee alignment (n = 87)	48 (55.17%)	0 (0%)	11 (12.64%)	28 (32.18%)	39 (44.83%)

Source: the authors (2023).

Regression analysis was performed with potential variables such as age, height, weight, body mass index and knee alignment. In univariate analysis age, weight, height and body mass index were not significantly associated with patellar hypermobility. In multivariate analysis, individual weight category ranging from 71 to 80 and overweight body mass weight category demonstrated significant association with patellar hypermobility. Age and weight variables remained protective for patellar hypermobility. Genu recurvatum is reported to by extremely significant in both univariate and multivariate regression analysis (Table 3).

Table 3. Univariate and multivariate analysis of independent variable in patellar hypermobility

Variables	Category	Patellar hypermobility		Univariate		Multivariate	
		No	Yes	Crude odd ratio (95% confidence interval)	Significance	Adjusted odd ratio (95% confidence interval)	Significance
Age (years)	18 – 21	28	43	1 (Ref)		1 (reference)	
	22 – 24	30	60	1.302 (0.682 – 2.487)	0.424	1.285 (0.565 – 2.925)	0.549
	25 - 27	1	12	7.814 (0.962 – 17.478)	0.054	9.038 (0.920 – 18.838)	0.059
Weight (kilogram)	50 - 60	20	9	1 (reference)	0.077	1 (reference)	
	61 – 70	21	55	1.250 (0.581 – 2.688)	0.568	1.228 (0.437 – 3.450)	0.697
	71 - 80	14	46	1.473 (0.637 – 3.407)	0.365	**5.713*** (1.486 – 15.958)	0.011*
	81 – 90	2	4	1.875 (0.344 – 5.213)	0.467	2.664 (0.246 – 5.858)	0.420
	91 - 100	2	1	0.625 (0.081 – 4.797)	0.651	3.055 (0.062 – 5.429)	0.575
Height (centimeters)	150 – 175	59	101	1 (reference)		1 (reference)	
	176 - 200	1	13	7.392 (0.943 – 17.960)	0.057	11.089 (0.922 – 33.369)	0.058
Body mass index (kg/m²)	Normal category	36	82	1 (reference)		1 (reference)	
	Overweight category	19	31	0.716 (0+.358 – 1.432)	0.345	**0.257*** (0.081 – 0.811)	0.021*
	Obesity type I category	4	2	0.220 (0.038 – 1.253)	0.088	0.091 (0.007 – 1.151)	0.064
Knee alignment	Genu recurvatum	12	75	**8.503**** (3.975 – 18.191)	0.000**	**13.007**** (5.481 – 30.866)	0.000**
	Normal knee alignment	48	39	1 (reference)		1 (reference)	

* significant if P value < 0.05
** highly significant if P value < 0.01
Source: the authors (2023).

The statistical analysis results indicate that patellar hypermobility is associated with genu recurvatum and the odds for occurrence of medial hypermobility is greater than lateral hypermobility in individuals with genu recurvatum. Out of 87 normal knee alignment individuals, a moderate proportion of 44.83% (n = 39) was identified with patellar hypermobility and in those individuals lateral patellar hypermobility reported was 32.18% (n = 28), which is greater than the medial hypermobility (12.64%, n = 11).

4. Discussion

The purpose of this study was to assess the patellar mobility in active male adults with genu recurvatum and normal knee alignment. The preliminary findings of this study suggest that medial patellar hypermobility is significantly associated with genu recurvatum in young males. The study result accepts the hypothesized statement that patellar mobility differs in individuals with and without genu recurvatum and hence the null hypothesis is rejected. Patellar hypomobility is often reported as a risk factor for developing patellofemoral pain and knee dysfunctions at any ages. Previous studies[12-14] have reported that tight lateral retinaculum and lateral extensor expansion soft tissue as most common etiology for patellofemoral pain. Contrastingly, the present study revealed that medial-lateral patellar hypermobility was more prevalent in genu recurvatum individuals. The present study included only males for evaluating patellar mobility due to the hormonal and physiological changes associated with joint laxity and varied level of flexibility in female populations.

In this study, the frequency of medial patellar hypermobility was higher than the lateral patellar hypermobility in males with genu recurvatum. The arthrokinematics of knee joint in genu recurvatum could be a biomechanical factor contributing for medial patellar hypermobility in individuals with genu recurvatum. Biomechanical analysis of closed chain, flexion to extension movement in hyperextended knee reports, altered arthrokinematics of femur in relation to tibia. Accessory joint play rolling of femur on tibia is disrupted in the end ranges of extension in individuals with hyperextended knee.[15] This is due to deviation of joint axis from the normal alignment, the joint axis in genu recurvatum runs obliquely inferiorly and posterolaterally creating more tensile force posterolaterally and compressive force anteromedially.[16] The compression of anterior tibiofemoral joint especially, the anterior horn medial meniscus and the association of hoffa's syndrome or infrapatellar fat pad impingement with genu recurvatum are evident from the reports of the previous studies.[10,15,17-19] The excessive compression of anteromedial structures in genu recurvatum might contributed for laxity in the anteromedial soft tissues permitting excessive medial patellar gliding.

The present study results revealed that majority of normal knee alignment individuals had normal patellar mobility and the remaining proportion of individuals in their group demonstrated lateral patellar hypermobility than the medial hypermobility. This result is similar to the comparative study findings of Ota et al.[4], in which the authors concluded no significant differences exist in medial and lateral patellar mobility in asymptomatic individuals. It is also reported in the literature[20-23] that, either excessive or reduced mobility of the patella could contribute to patellofemoral pain.

The first limitation of this present study was instrumentation for measuring patellar mobility. Patellofemoral arthrometer or radiological methods to evaluate patellar mobility might provide more accurate results than patellar gliding test. The second limitation was the amount of manual force applied by the assessor for pushing the patella in medial and lateral directions. The force applied by the assessor is not quantified in this study. The third limitation was regarding the end feel resistance in patellar gliding test. The end feel resistance felt by the assessor is not documented. The fourth limitation was resting position of patella. The resting position of patella is not evaluated while performing the patellar glide test. The fifth limitation of this study is non-availability of match-suitable characteristic pairs for genu recurvatum individuals, and also difficulty existed in determining the most appropriate variables to match pairs in the groups. Matching individuals based on characteristics could have controlled variability, confounding factors and improved statistical power of the study. Based on these limitations, future study designs investigating patellar mobility in different populations and both genders could contribute added knowledge to the findings of the present study.

The strength of the present study highlights the difference in anteromedial structure biomechanics in individuals with and without genu recurvatum. The result of this study could assist physical therapists in evaluating and intervening medial patellar hypermobility in individuals with genu recurvatum. Anatomical and biomechanical predispositions associated with knee hyperextension were suggested to be the contributing factors for medial patellar hypermobility in individuals with genu recurvatum. The outcome of medial and lateral patellar hypermobility associated with genu recurvatum deserves further study with matched participants and control of confounding variables to validate the present study findings.

5. Conclusion

The study results conclude that young adult males with genu recurvatum demonstrate increased medial patellar mobility. Medial patellar hypermobility in the coronal plane is associated with Genu recurvatum. The study findings provide insight for screening patellar mobility in asymptomatic genu recurvatum individuals for preventing and managing the symptoms associated with patellofemoral mobility dysfunctions.

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Authors' contributions

Vavachan N and Ravichandran H conceived and designed the data collection tools. Shetty KS and Janakiraman B monitored the data collection and wrote the statistical analysis plan. Vavachan N and Janakiraman B analysed the data. Vavachan N, Ravichandran H, Shetty KS drafted the manuscript and Janakiraman B revised the article.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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