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Simplified methods to measure patellar anatomical and biomechanical variables in state level runners

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Abstract
The endeavour of the present study was to establish simplified methods to measure Patellar anatomical and biomechanical variables. 100 state level runners (50 males and 50 females) of age group 18-27 years were selected purposively from various sports academies of Odisha for this study. All the variables were recorded thrice and median value considered as criterion to eradicate error. Selected variables such as patella length, patella breadth, patellar tendon length, patella to patellar tendon ratio, patellar medial to lateral glide, patellar lateral to medial glide, patellar cephal to caudal glide and patellar caudal to cephal glide were measured on each subject following standard techniques. The Results showed highly significant differences ($p<0.001$) in right patella length, right patella breadth, right patellar tendon length, and statistically significant difference ($p<0.05$) was seen in right patellar cephal to caudal glide on the right patellar side. However, in the left patellar side highly statistically significant differences ($p<0.001$) were seen in left patella length, left patella breadth, left patellar tendon length, left patellar cephal to caudal glide.

Keywords: patella length, patella breadth, patellar tendon length, patella to patellar tendon ratio

Introduction
The patella, also known as the kneecap or kneepan, is a thick, cicular-triangular bone which articulates with the femur and covers and protects the anterior articular surface of the knee joint. In human, the patella is the largest sesamoid bone in the body. The upper three-quarters of the patella articulate with the femur and are subdivided into a medial and a lateral facet by a vertical ledge which varies in shape. Most commonly the medial articular surface is smaller than the lateral [1].

Patellar glide test is done to assess tightness of parapatellar structures. The normal excursion is 1cm. As per the patellar stabilization compression test patella may be divided into four major landmarks, i.e. superior mid-patellae, inferior mid-patellae, medial mid-patellae and lateral mid-patellae. All these land marks are necessary during gliding test of patella [2].

Patello femoral pain syndrome (PFPS), which is known to be the most common of knee joint injuries, is a disease with the primary complaint of pain in the front of the knee, and is one of the most common in the knee complaint of young age groups [3]. PFPS is a disease that has intrinsic, external and internal factors; that is, potential and external risk factors of PFPS are said to be present in sports activities or sports training habits, problems of surrounding environments, and through incorrect use of appliances, etc. as well as internal potential risks due to individual physical characteristics and psychological tendencies [4]. PFPS is associated with various biomechanical characteristics of the lower extremity, and potential risk factors are: abnormal form of the feet; functional weakness of hamstring and quadriceps muscle of the thigh and the gastrocnemius; shortening of the iliotibial tract; generally weakened joints; excessive quadriceps angle; patellar compression or tilting; and abnormal reaction velocities of the vastus lateralis and vastus medialis oblique [2].

Patellofemoral dysfunction is more common in females in the age range of 16-26 years and is more often found in athletes. The term "Chondromalacia patella" was previously used to describe patellofemoral dysfunction.

The position of the patella in the vertical plane has great clinical relevance. A high-riding patella, or patella Alta, is considered a predisposing factor to the development of patellofemoral pain. It also is associated with recurrent dislocation of the patella, chondromalacia patellae, and joint effusion. Therefore, assessment of patellar position is essential in evaluation of the anatomic alignment of the knee, especially in patients with anterior knee pain. Several methods are used to determine the presence of patella alta. Insall and Salvati (1971) were the first to describe a method of establishing patellar height on the basis of the ratio of the length of the patellar tendon to the diagonal length of the patella on lateral radiographs. [5] In the modified Insall-Salvati ratio, patellar bony length is replaced with patellar articular cartilage length. The Insall-Salvati index, however, is the most widely accepted method because of its lack of dependence on the degree of knee flexion and its established MRI criteria [6].

MRI has shown that abnormal contact between the patella and the femur due to superior displacement of the patella can produce malalignment of the patellofemoral joint. [6] Lower extremity malalignment (Caused by abnormalities such as an increased standing Q-angle, pesplanus, or subtalar pronation) often has been implicated as a cause of PFPS.

The term ‘anterior knee pain’ refers to pain within the anterior aspect of the knee including chondromalacia patellae, intra-articular patellar chondropathy, patellar arthralgia, runner’s knee, jumper’s knee and possible referred pain from the hip or the saphenous nerve. Patients with a clinical presentation of anterior knee pain could be diagnosed with PFPS, excluding those patients with anterior knee pain resulting from intra-articular pathologies, patellar tendinopathy, peripatellar bursitis, plica syndrome, Sinding Larsen Johanson’s and Osgood Schlatter’s lesions, Hoffas disease and other rare pathologies [6].

McConnell identified four components of the patella that need to be evaluated i.e. glide, medio-lateral tilt, antero-posterior tilt and rotation. The medio-lateral displacement test is a good and reliable clinical test to determine the mobility of the patella. With the subject’s quadriceps muscles relaxed, and the knees in extension, the clinician can apply a maximal manual medial or lateral force to the patella. If this medial or lateral displacement is smaller than 12 mm in girls and 10 mm in boys, this can be classified as a hypomobile medial glide (Tight lateral retinaculum). The displacement is recorded in millimetres in the coronal plane with a measuring rod [7].

The patellofemoral joint comprises the patella and the femoral trochlea. The patella acts as a lever and also increases the moment arm of the patellofemoral joint, the quadriceps and patellar tendons. Contact of the patella with the femur is initiated at 20 degrees of flexion and increases with further knee flexion, reaching a maximum at 90 degrees. Stability of the patellofemoral joint involves dynamic and static stabilizers, which control movement of the patella within the trochlea, referred to as “patellar tracking.” Patellar tracking can be altered by imbalances in these stabilizing forces affecting the distribution of forces along the patellofemoral articular surface, the patellar and quadriceps tendons, and the adjacent soft tissues.

Forces on the patella range from between one third and one half of a person’s body weight during walking to three times body weight during stair climbing and up to seven times body weight during squatting [8].

Materials and Methods

Participants

The present study was based on the sample of 100 state level runners (male, n=50 and female, n=50) of age group 18-27 years, selected purposively from various sports academies of Odisha. The age of the subjects was determined from their respective academy records. A written consent was obtained from the subjects. The data was collected under natural environmental conditions while maintaining the privacy of the subjects.

Patellar anatomical and biomechanical variables

For all the measurements, skin around and above the patella was stretched by examiner’s thumb. All the starting measurement points on patella were marked by permanent marker pen.

1. **Patellar length:** It measures the straight distance between the superior mid-patella and inferior mid-patella by using steel tape. Then for confirmation divider compass is used to join the points and the distance is measured on regular 15cm scale. Superior mid-patella is the highest point on the base of the patella on the mid-sagittal plane. Inferior mid-patella is the lowest point on the tip of the apex on the mid-sagittal plane. Subject was in supine lying with 20˚ knee flexion and the examiner took the measurement in cm.
2. **Patellar breath:** It measures the straight distance between the medial mid-patellae and lateral mid-patellae by using steel tape. Then for confirmation divider compass is used to join the points and the distance is measured on regular 15cm scale. Medial mid-patella is the most prominent point on the medial margin of the patella. Lateral mid-patella is the most prominent point on the lateral margin of the patella. Subject was in supine lying with 20˚ knee flexion and the examiner took the measurement in cm.
3. **Patellar tendon length:** Subject was in supine lying with knee flexed to 20˚. Examiner located the inferior mid-patellar prominent point, marked it and measurement was taken up to tibial tuberosity, where the patellar tendon is inserted in cm on regular 15cm scale by the help of divider compass.
4. **Patella to patellar tendon ratio:** It was calculated by dividing patellar length by patellar tendon length.
5. **Medial to lateral glide:** The subject was supine with knee flexed to 20˚ flexion over the examiner’s knee. The examiner’s thumbs were placed against the medial edge of the patella, and a force was applied to the side of the patella, with the fingers used for stabilization. The reading was taken in cm on regular 15cm scale by the help of divider compass by keeping the marked superior mid-point of the patella as the starting point for glide.
6. **Lateral to medial glide:** The subject was supine with knee flexed to 20˚ flexion over the examiner’s knee. The examiner’s thumbs were placed against the lateral edge of the patella, and a force was applied to the inner side of the patella, with the fingers used for stabilization. The reading was taken in cm on regular 15cm scale by the help of divider compass by keeping the marked superior mid-point of the patella as the starting point for glide.
7. **Cephal to caudal glide:** The subject was in supine

position with the knee slightly flexed. The examiner then placed one hand over the subject's patella so that the pisiform bone rested over the base of the patella. Then the examiner applied a caudal force to the base of the patella. Reading was taken in cm on regular 15cm scale by the help of divider compass by keeping the marked medial mid patella point as the starting point for glide.

8. **Caudal to cephal glide:** The subject was in supine position with the knee slightly flexed. The examiner then placed one hand over the subject's patella so that the pisiform bone rested over the inferior pole of the patella. Then the examiner applied a cephalic force to the inferior pole of the patella. Reading was taken in cm on regular 15cm scale by the help of divider compass by keeping the marked medial mid patella point as the starting point for glide.

Image 1: Divider Compass

Image 2: Permanent Marker Pen

Image 3: 15cm Regular Scale

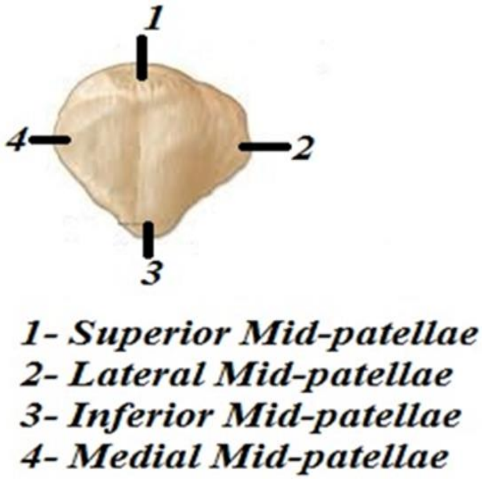

Image 4: Marked Points on Patella

Statistical analysis

Descriptive statistics (Mean ± standard deviation) were determined for the directly measured and derived variables. All the data were determined using SPSS (Statistical Package for Social Science) version 22.0. A 5% level of probability was used to indicate statistical significance.

Results

Table 1 showed the descriptive statistics of right Patellar anatomical and biomechanical measurement variables of the female and male athletes. Female athletes had greater mean values in right patellar medial to lateral glide (0.96cm), right cephal to caudal glide (0.79cm), right caudal to cephal glide (1.11cm), right patella to patellar tendon ratio (0.998), and lesser mean values in right patella length (5.01cm), right patella breadth (5cm), right patellar tendon length (5.01cm) and right patellar lateral to medial glide (1.336cm) than their male counterparts.

Table 1: The descriptive statistics of right Patellar anatomical and biomechanical measurement variables of the female and male athletes

Variables	Female Athletes (N=50)		Male Athletes (N=50)		t value	p value
	Mean	SD	Mean	SD		
Right patellar length (cm)	5.01	0.38	5.53	0.43	-6.430	<0.001
Right patellar breadth (cm)	5.00	0.33	5.50	0.49	-6.018	<0.001
Right patellar tendon length (cm)	5.01	0.37	5.53	0.43	-6.495	<0.001
Right patella medial to lateral glide (cm)	0.96	0.17	0.92	0.23	0.982	0.328
Right patellar lateral to medial glide (cm)	1.33	0.18	1.34	0.21	-0.102	0.919
Right patellar cephal to caudal glide (cm)	0.79	0.17	0.71	0.15	2.483	0.015
Right patellar caudal to cephal glide (cm)	1.11	0.14	1.09	0.12	0.679	0.499
Right patella to patellar tendon ratio	0.998	0.03	0.994	0.02	0.740	0.461

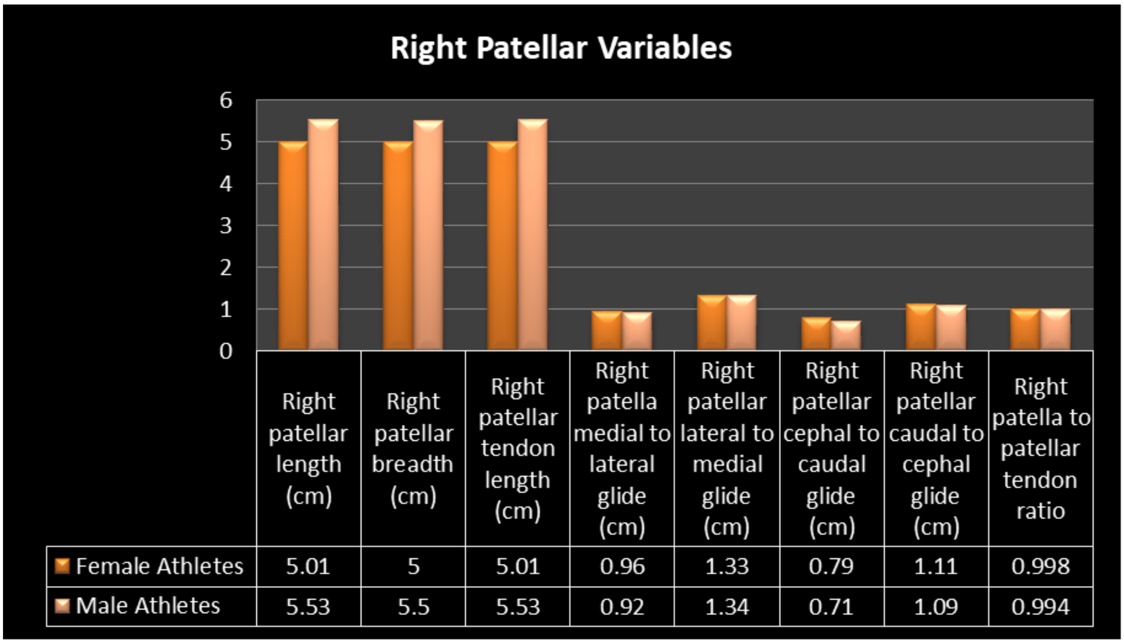

Fig 1: Showed the graphical representation of right patellar anatomical and biomechanical measurement variables of the female and male athletes

Table 2 showed the descriptive statistics of left Patellar anatomical and biomechanical measurement variables of the female and male athletes. Female athletes had greater mean values in left patellar medial to lateral glide (0.91cm), left cephal to caudal glide (0.73cm), left caudal to cephal glide (1.05cm), left patella to patellar tendon ratio (0.998), and lesser mean values in left patella length (5.01cm), left patella breadth (5cm), left patellar tendon length (5.01cm) and left patellar lateral to medial glide (1.25cm) than their male counterparts.

Table 2: The descriptive statistics of left Patellar anatomical and biomechanical measurement variables of the female and male athletes

Variables	Female Athletes (N=50)		Male Athletes (N=50)		t value	p value
	Mean	SD	Mean	SD		
Left patellar length (cm)	5.01	0.38	5.53	0.43	-6.430	<0.001
Left patellar breadth (cm)	5.00	0.33	5.50	0.49	-6.018	<0.001
Left patellar tendon length (cm)	5.01	0.37	5.53	0.43	-6.495	<0.001
Left patella medial to lateral glide (cm)	0.91	0.17	0.88	0.21	0.624	0.534
Left patellar lateral to medial glide (cm)	1.25	0.15	1.26	0.18	-0.299	0.766
Left patellar cephal to caudal glide (cm)	0.73	0.11	0.64	0.13	3.66	<0.001
Left patellar caudal to cephal glide (cm)	1.05	0.14	1.03	0.11	0.647	0.519
Left patella to patellar tendon ratio	0.998	0.03	0.994	0.02	0.740	0.461

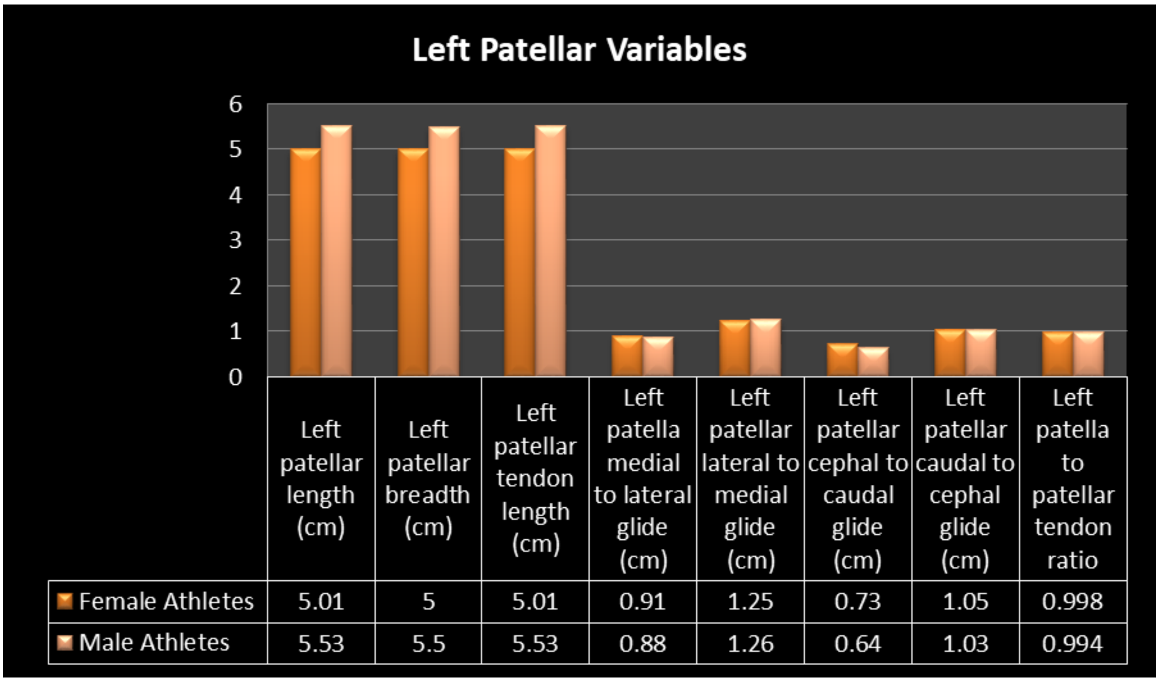

Fig 2 Showed the graphical representation of left Patellar anatomical and biomechanical measurement variables of the female and male athlete

Discussion

Puniello (1993) conducted a study to investigate the relationship between iliotibial band tightness and medial glide of the patella in patients with patellofemoral dysfunction. Stretching the iliotibial band has been advocated in the literature to treat patellofemoral dysfunction, but there is little written about the mechanism of its influence on the patella. Anatomy and biomechanics were reviewed, with emphasis on the lateral retinaculum of the knee and the attachment of the iliotibial band to the patella. In study 17 patients with patellofemoral dysfunction were evaluated. All patients presented with lateral tracking of the patella on knee flexion and extension. Medial glide of the patella was tested manually, and Ober's Test was performed to test flexibility of the iliotibial band. 12 of 17 patients exhibited a tight iliotibial band with hypomobility of medial glide of the patella. Three patients demonstrated normal patella mobility with a normal result on Ober's Test. Two patients had hypomobile patellae with a normal Ober's Test. The study demonstrated a strong relationship between iliotibial band tightness and decreased medial glide of the patella [9].

In the present study highly significant differences (p<0.001) were seen in right patella length, right patella breadth, right patellar tendon length, and statistically significant difference (p<0.05) was seen in right patellar cephal to caudal glide on the right patellar side. However, in the left patellar side highly statistically significant differences (p<0.001) were seen in left patella length, left patella breadth, left patellar tendon length, left patellar cephal to caudal glide.

Conclusion

Though there are various radiological methods available for measuring patellar anatomical variables, there is no simplified manual method to determine them. This study would help therapists for easy and quick assessment of patella with non-expensive instruments.

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