Volume : 3 | Issue : 1 | Jan 2014 • ISSN No 2277 - 8160

Research Paper | Medical Science

Indian Population Having Squatting Habits- Showing Quadricipital Groove on The Upper End of The Tibia

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ABSTRACT

In India one of the commonest modes of sitting down is squatting position. In squatting there is greater range of flexion at the knee joint. It was observed that this greater range of flexion may affects on the upper end of the tibia due to the increased pressure of the quadriceps tendon against it. The powerful tendon of the ligamentum patellae produces impression on the tibia along its unattached free margin and it also affects the backward tilting of the upper end of the tibia. Humiphrey (1858)[1], Fick (1904)[2], Poirier & Charpy (1926)[3] described the insertion of the ligamentum patellae into the tubercle of the tibia and the upper end of the tibia is deep to the uninserted part of the tendon and Hughes E. S. R. & Sunderland, S. (1946)[4] studied the insertion of the ligamentum patellae. According to them the strongest part of this tendon is inserted into an inverted J-shaped groove which delineates or mark the line along the tubercle of the tibia proximally and on laterally. Titze (1951)[5] had studied the variations of the angle of inclination and retroversion of the upper articular surface of the tibia. The squat is one of the most frequently used exercises in the field of strength and conditioning. Considering the complexity of the exercise and the many variables related to performance, understanding squat biomechanics is of great importance for both achieving optimal muscular development as well as reducing the prospect of a training-related injury. Squatting kinematics and kinetics and their application to exercise performance[6]

KEYWORDS : - ligamentum patellae, vertical groove, knee joint, squatting, angulation, kinematics

INTRODUCTION

The squat is one of the most frequently used exercises in the field of strength and conditioning. It has biomechanical and neuromuscular similarities to a wide range of athletic movements and thus is included as a core exercise in many sports routines designed to enhance athletic performance [8]

It also is an integral component in the sports of competitive weightlifting and power lifting and is widely regarded as a supreme test of lower-body strength[9,10]

Benefits associated with squat performance are not limited to the athletic population. Given that most activities of daily living necessitate the simultaneous coordinated interaction of numerous muscle groups, the squat is considered one of the best exercises for improving quality of life because of its ability to recruit multiple muscle groups in a single maneuver The squatting movement has close specificity to many everyday tasks (such as lifting weight and picking up children), as well as having an indirect correlation to count- less other chores and hobbies. Squats can be performed at a variety of depths, generally measured by the degree of flexion at the knee. Strength coaches often categorize squats into 3 basic groups: partial squats (40° knee angle), half squats (70 to 100°), and deep squats (greater than 100°). However, no standardized measures of quantification have been universally recognized, and terminology can differ between researchers. Other modifying facts associated with the squat involve varying intensity of load, foot placement, speed of movement, level of fatigue, and position of load. When performed properly, squat-related injuries are uncommon[11]

However, poor technique or inappropriate exercise prescription can lead to a wide range of maladies, especially in combination with the use of heavy weights. Documented injuries from squatting include muscle and ligament sprains, ruptured intervertebral discs, spondy-olysis, and spondylolisthesis [12]

The knee joint consists of the tibiofemoral, which carries out sagittal plane movement throughout a range of motion of 0º to approximately 160° of flexion. The tibiofemoral joint can be classified as a modified hinge joint that comprises[13,14,15] the articulation of the tibia and femur. A small amount of axial rotation is also present at the joint during dynamic movement, with the femur rotating laterally during flexion and medially during extension with respect to the tibia. This causes the instant center of rotation at the knee to shift slightly throughout performance of the squat. Assisting the tibiofemoral joint is the patellofemoral joint, a gliding joint in which the patella slides over the trochlear surfaces of the femur during flexion and extension of the knee. This provides additional mechanical leverage in extension because of a greater force arm, as well as reducing wear on the quadriceps and patellar tendons from friction against the intercondylar groove.

The knee is supported by an array of ligaments and cartilage. Of these structures, the ACL is often considered the most important stabilizer of the joint. Its primary role is to prevent anterior tibial translation at the knee, particularly at low flexion angles [16]

It also plays a role in limiting internal and external rotation of the knee and inhibiting varus/valgus motion. The posterior cruciate ligament (PCL) can be considered the counterpart to the ACL. Its primary function is to restrain posterior tibial translation[17]

The medial and lateral collateral ligaments stabilize the knee in the frontal plane, helping to provide resistance to varus/valgus moments.

Whereas the knee ligaments are the main static stabilizers of the joint, the knee musculature assumes a dominant role in dynamic joint stabilization [18]

During the squat, the primary muscles acting about the knee are the quadriceps femoris (vastus lateralis, vastus medialis, vastus intermedius, and rectus femoris), which carry out concentric knee extension, as well as eccentrically resisting knee flexion. The quadriceps tendon and patellar tendon facilitate action of the knee extensors, allowing for optimal pull on the tibia during dynamic movement.

The hamstrings (biceps femoris, semitendinosus, semimembranosus) are technically antagonists of the quadriceps, opposing knee extensor moments. In closed-chain exercise, however, they behave paradoxically and co-contract with the quadriceps. This synergistic action has

important implications for enhancing the integrity of the knee joint in squatting. Specifically, the hamstrings exert a counter regulatory pull on the tibia, helping to neutralize the anterior tibiofemoral shear imparted by the quadriceps and thus alleviating stress on the ACL[19] deep squats, citing an increased potential for injury to soft tissue structures in the knee during high flexion [20] Although it is true that shear forces tend to increase with increasing knee angles, forces on the ACL and PCL actually decrease at high flexion. According to Li et al, knee structures are highly constrained at angles greater than 120°, resulting in much less anterior and posterior tibial translation and tibial rotation in comparison with lesser flexion angles. This constraint apparently is caused by impingement between the posterior aspect of the upper tibia with the superior posterior femoral condyles or the compression of soft tissue structures including menisci, posterior capsule, hamstrings fat, and skin[21,22]Because compressive forces peak at high degrees of knee flexion [23] the greatest risk of injury during deep squatting would appear to be to be to the menisci and articular cartilage, which are placed under increased stress at high flexion angles[24] .Unfortunately, currently, no guidelines exist to determine at what magnitude of force injury occurs. There also may be a susceptibility to patellofemoral degeneration given the high amount of patellofemoral stress that arises from contact of underside of the patella with articulating aspect of femur and lateral side friction on tibia during high flexion This can lead to disorders such as chondromolacia, osteoarthritis, vertical groove on lateral side tibia and osteochondritis. It is therefore essential to consider an individual's pathologic condition in determining optimal squat depth. Muscular forces at the knee are largely produced by the quadriceps. Quadriceps activity tends to peak at approximately 80° to 90° of flexion[25] remaining relatively constant thereafter. This suggests that squatting past 90° might not result in further enhancements in quadriceps development.

MATERIAL AND METHOD

100 Indian Tibias (50 paired from both right and left side) were collected from locally. 10 pictures of European tibia have been taken and presumed that they were from non-squatters. The region under the course of the ligamentum patellae of every tibia was carefully examined and studied for the presence or absence of a groove and when present its characteristics were noted. The angles of inclination and retroversion of the upper articular surface of the tibia were measured with the help of a parallelograph according to the method described by Maiartin, R. (1958).[26] The maximum lengths of all the tibia were also measured to find out if there was any correlation between the above mentioned angles and the lengths of the bones. Dissections were carried out on acutely flexed knees of local adult cadavers to confirm the site of maximum pressure of ligamentum patellae against the tibia and also to see its angulation against the upper end of the bone.

Lateral view radiographs of this region of 20 living adults in squatting position were taken to see and verify the bending of the ligamentum patellae across the upper end of the tibia.

OBSERVATIONS

On careful examination of the collection in 100 tibia from squatters, in85tibia there was a shallow but distinct vertical groove deep to the course of ligamentum patellae (Fig. 1 a & b). This groove, which shows a tendency to have a lateral lip, extends proximally in a vertical direction from the superolateral aspect of the inverted J-shaped groove (junction of its vertical and horizontal parts) described by Hughes & Sunderland (1946).[4]



Fig 1 a :- Right tibia arrow showing lateral lip of vertical groove

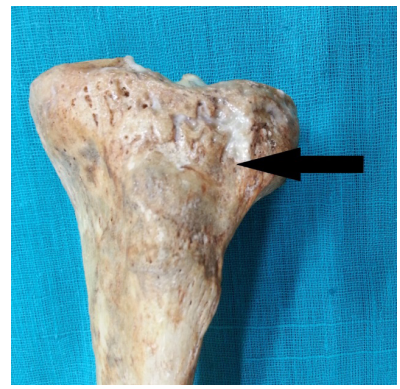

Fig 1 b :- Left tibia arrow showing lateral lip of vertical groove

Extending proximally, this groove reaches the anteromedial margin of the articular surface of the lateral condyle of the tibia. The groove is 2-4 cm. long and 0·5-1·0 cm. broad. Seen from above its presence almost invariably produces a notch on the anterior margin of the lateral condyle in its anteromedial part (Fig. 2). It has shown that a groove on tibia deep to the ligamentum patellae is a clearly established on 85 tibia belongs to squatters being present, The tibia of Europeans (pictures) had no groove (non-squatters) Fig 3 & 4. The very small number of squatters tibia (i.e5) in which the groove was absent.

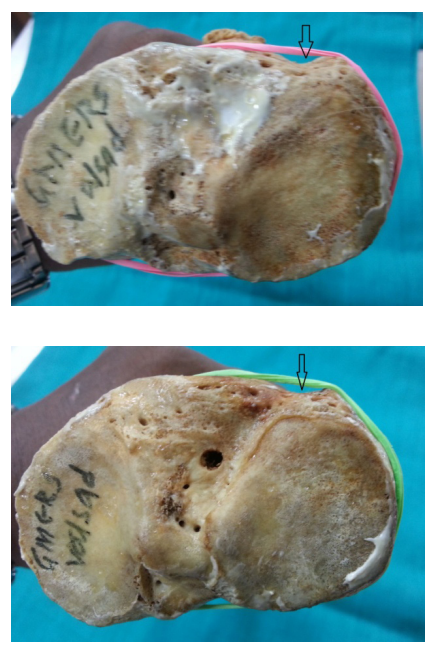

Fig.2 Showing right tibia with notch on anterior border

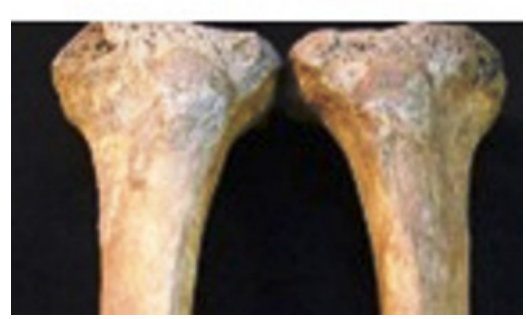

Fig 3

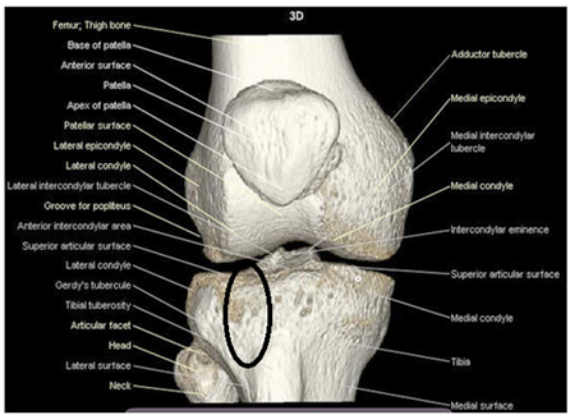

Fig 4

Figure 3 Showing picture of British Tibia- not showing vertical groove on lateral side of Tibia

Figure 4 Showing picture of British Tibia with labels - not showing vertical groove on lateral side of Tibia-circular marked area is area of vertical groove where no such groove can seen

The dissections on acutely flexed knees clearly showed that in this position the ligamentum patellae is bent at an angle over the anterior margin of the upper end of the tibia.

The radiographs of the flexed knees of living persons also confirmed the angulation of the ligamentum patellae over the same region (Fig. 5).

Fig. 5. Radiograph showing the shadow of the tendon exerting pressure on the tibia.



Table 1. Showing angles on the two sides (100 tibia)

Side	Angle of inclination	S.D.	Angle of retroversion	S.D.
Right	5·6	7·8	7·7	7·0
Left	12·5	6·5	20·8	7·1
Both sided tibia	10.8	6.9	14.30	8.1

The average length of the Indian tibia was found to be 32·30 cm, the left being longer, i.e. 34·70 cm, than the right, i.e. 31·70 cm. The average length of the European tibia was 36·70 cm. No definite correlation could be established between the length and the angles.

DISCUSSION

Table2:- The angles of inclination and retroversion compared with different countries

Source	Average angle of inclination	S.D.	Average angle of retroversion	S.D.
Indian(Present study)	10.8	6.9	14.30	8.1
(a) Indian(By kate[28]) (b) European	11·75 9·4	7·0 3·5	15·64 13·5	8·34 4·5
French (Paris)	6·5	---	9·5	--
Red Indian	10·2	--	13·7	--
German	4-8	---	8-1	--
Swiss	5·3	---	7·6	--
Prehistoric	15·17	----	20·0	--

The averages of the angles of inclination and retroversion of the upper articular surface of the tibia studied are given together with Martin's figures (1958) for comparison in Table 2. The range for angle of inclination was between -8° and + 25° and for the angle of retroversion was between -3° and +30°. The reverse angle of retroversion, i.e. angle of anteversion, was present in 5 tibia. The range of this angle was between -10 and -8°. The angle of inclination was also negative in these tibia. The incidence of anteversion reported by Titze (1951) was 1% and the maximum angle reported by him was -5°.

It has shown that a groove on tibia deep to the ligamentum patellae is a clearly established on 85 tibia belongs to squatters being present, The tibia of non-squatters (Europeans) had no groove. The very small number of squatters tibia (i.e-5) in which the groove was absent may belonged to weak or flabby individuals with poorly developed muscles unable to produce impressions on bones. The groove in squatters tibia obviously results from tendinous pressure. In complete flexion of the knee joint the ligamentum patellae is found both by dissections on cadavers and by radiographic study of the living to be bent posteriorly at an angle over the upper end of the tibia. Consequently during movements of the knee either just before reaching the stage of maximum flexion or at the commencement of extension of a fully flexed knee the upper end of the tibia acts as a fulcrum for the ligamentum patellae and while performing this role it is subjected to constantly recurring and powerful backward pressure during all acts of sitting down and standing up. One result of this pressure is the production of this groove. The tendency of the groove to have a lateral lip is due to the ligamentum patellae also exerting a slight lateral pressure due to lateral angulation between the femur and the tibia at the knee and this lipping incidentally also is a factor in preventing lateral displacement in addition to the vastus medialis which by correcting the axis of pull of the quadriceps muscle during the last 15° of flexion prevents patellar displacement as pointed out by Watson Jones (1943)[27] The second result of the pressure by the ligamentum patellae is to increase the backward tilting of the upper end of the tibia. This is shown by the angles of inclination and retroversion of the upper articular surface being significantly greater for the squatters' tibia than those for non-squatters as per Table 1 The upper end of the tibia which at birth is considerably bent posteriorly should normally undergo a straightening out process as the age advances. Titze A Von (1951)[5] has shown that the angle of inclination lessens from 27° at birth to 4° at 19 years. According to him the greater angle at birth is due to acute flexion of the knees of the foetus in the limited space within the uterine cavity. In squatters the same factor of increased range of flexion of the knee joint and the pressure of the ligamentum patellae against the upper end of tibia discussed above appear to help in the retention of a primitive character by hindering the normal straightening out process and thereby results in the angles being greater than those of non-squatters.

The finding of the groove described above and the presence of greater degrees of angles of inclination and retroversion should be a valuable guide in identifying tibia as belonging to squatters. The position of the groove should also be an aid in determining the side to which the tibia belongs specially if only fragmentary remains are required to he identified. These findings would be of great value in medico-legal and anthropological work and it would not be inappropriate to name it as 'the quadricipital groove'.[28]

SUMMARY

1 A quadricipital groove on the upper end of the tibia produced by ligamentum patellae is described. Out of the 100, 85 tibia of squatters, showed the presence of this groove. It was in the area of contact of the ligamentum patellae.

2 The medico-legal and anthropological importance of the groove is mentioned.

3 The angles of inclination and retro version of the upper articular surface were measured and were found to be greater than those of the non-squatters.

4 A few tibia, i.e. 5 %, showed anteversion [28]

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