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ORIGINAL ARTICLE

# Are Indian Habits of Cross-legged Sitting and Squatting associated with Anterior Knee Pain?

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## ABSTRACT

**Aim:** To evaluate the association between anterior knee pain (AKP) and traditional Indian habits of cross-legged sitting and squatting which involve deep knee flexion.

**Materials and methods:** A case control study was carried out in 225 patients and 225 age and sex matched controls at a tertiary care university hospital in South India over 3 years. Males and females between 18 and 55 years were evaluated using a clinical proforma of history and musculoskeletal examination. The details of deep knee flexion habits with quantification of duration were noted and participants were categorized into those who sat and did not sit cross legged, and squatters and nonsquatters. Odds ratios and chi-square tests were calculated for both these categorical variables. A subgroup analysis and stratified analysis were also performed.

**Results:** The Odds ratios for cross-legged sitting and squatting were not significant at 0.88 and 0.92 respectively. Sixty-nine point three percentage of the AKP cases and 72% of the controls sat cross legged (p = 0.534) and 67.6% of the AKP cases and 69.3% of controls habitually squatted (p = 0.685). Stratified analysis revealed a protective effect of cross legged sitting in AKP cases with quadriceps muscle tightness.

**Conclusion:** This study did not find an association between AKP and Indian habits of deep knee flexion. More than 65% of all the participants regularly engaged in these habits. Laboratory biomechanical analysis of these positions is suggested in future to understand their effect on knee joint.

**Clinical significance:** These positions are integral to daily habits of many Indians. The advice to AKP patients to avoid them due to their probable AKP association is not supported by the current study. Clinicians can consider the impact on the patient's quality of life before advising against these positions.

**Keywords:** Anterior knee pain, Cross-legged sitting, Indian habits, Squatting,

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## INTRODUCTION

Anterior knee pain (AKP) is a very common condition encountered in general population as well as the athletic population.[1] It is characterized by diffuse pain in the anterior aspect of the knee which worsens with activities like prolonged sitting with flexed knees (movie sign), ascending or descending stairs, squatting and vigorous physical activity.[2,3] Management of these patients remains a challenge with most patients having persistent or recurrent complaints many years after initial presentation.[4–6] Also, a substantial number of patients with patellofemoral osteoarthritis (PFOA) complain of having suffered AKP in their younger age.[7]

There is a lack of consensus in the literature regarding the exact etiopathogenesis of AKP.[8] Various theories have been proposed to explain the origin and presence of this pain. Among these, the most widely accepted theory suggests that the symptoms are the result of excessive patellofemoral joint stress (PFJS) (force/contact area).[9-12] Wallace et al have earlier shown that this PFJS increases with increasing knee flexion angles in squatting and suggested clinicians to advice on limiting this terminal flexion.[13] Other authors have documented increased patellofemoral joint reaction forces (PFJRF) with increasing knee flexion.[11,14] Goudakos et al demonstrated in a cadaver model that the patellofemoral (PF) joint is at risk of high pressures or stress at higher loads like in squatting.[15]

Most of the Indians have traditional practices of squatting like when using an Indian toilet and sitting cross legged on the floor for day to day activities (Figs 1 and 2). These habits involve high knee flexion. Besides complaining of the classical movie sign, Indian patients also complain of worsening of AKP during these traditional positions. It is common for clinicians to advice patients on restriction of these positions. However, whether avoiding these positions henceforth will prevent worsening of the condition in these patients and prevent recurrences is not known. Also, it is not proven that these positions could have contributed to the development of AKP and its pathogenesis. Whether pain-free population without knee complaints can decrease their probability of developing this type of pain by avoiding these positions is not known either. Essentially, there is no literature evaluating the association of these positions with AKP.

**Fig. 1:** Cross-legged sitting

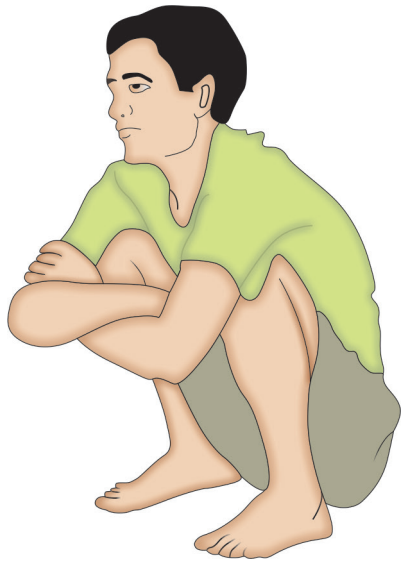

**Fig. 2:** Squatting

Since the Indian population commonly adopts these positions, knowledge of their association with AKP as risk factors is important to know. With the increasing geriatric population in India, prevention of development of PFOA as a result of AKP can be an important preventive health care intervention.

In the recent times, increasing research is being specifically performed in the Indian population to study the anatomy of the knee with its clinical implications in view of the ethnic differences to Non-Indians.[16–20] Whereas there is limited literature evaluating AKP risk factors in Indians,[3,21] to the best of our knowledge there is no published literature which has studied the Indian style of squatting and cross legged sitting in AKP patients in India. Moreover, a study of the relationship of these high knee flexion positions with AKP might contribute to the global understanding of the AKP pathogenesis. We hypothesized that Indian habits of sitting cross legged and habitual squatting would be associated with AKP in this population.

## MATERIALS AND METHODS

A case control study was designed to evaluate the association of the risk factors and AKP. A total of 450 participants including 225 cases and 225 controls participated in the study from June 2013 to June 2016. The cases were selected from patients diagnosed with "AKP" in the Outpatient Department (OPD) of Arthroscopy and Sports Medicine and Department of Orthopedics of a tertiary care university hospital in Chennai. Both males and females of ages 18 to 55 years were included in the study provided they met all the criteria.

The inclusion criteria for cases were[3,22]:

- Complaint of anterior or retropatellar knee pain of more than weeks duration, present during or after at least two of the following activities: Prolonged sitting (movie sign), ascending or descending stairs, squatting, kneeling or running
- Insidious onset of symptoms not related to trauma, and
- Positive Zohlen test or pain on palpation of one or both patellar facets.

Age and sex matched controls were chosen from other patients, from attendants of patients and from University staff and students, all of whom did not have any current or past lower limb (LL) complaints in 2 years. Age was matched within +/− 2 years like in an earlier study.[22,23]

Exclusion criteria for both cases and control groups were pregnancy, general illness, inability to lie on one side or back comfortably for testing, tibiofemoral osteoarthritis, past knee surgery or knee trauma, symptoms and signs of knee ligament or meniscal injury, current significant pathology affecting other lower extremity joints, patellar subluxation, medial patellofemoral ligament tear, specific AKP diagnosis like patellar tendinitis, Osgood-Schlatter disease, Hoffa's fat-pad syndrome, etc.[3,9,22]

This study was part of a larger research study on risk factors for AKP. Ethical approval for the same was obtained from the Institutional Ethics Committee. A written informed consent was signed and obtained from all the participants before participation in the study and the study was conducted in accordance with declaration of Helsinki.

A detailed history of the patients and controls was obtained including their demographic information and habitual practices of sitting cross legged and regular squatting. Sitting cross legged was considered a positive risk factor if the participant was doing it for > = 30 minutes on most days of the week before the onset of pain. Regular squatting was considered a positive risk factor if the participant was habitually squatting as

when using the Indian toilet, on most days of the week before the onset of pain. As part of the larger study, the quadriceps flexibility of all the participants was measured in the prone position using a Gollehon Extendable Goniometer with 1° increments (Model 01135 Lafayette Instrument Company, USA). The knee was passively flexed taking care to avoid tilting the pelvis or extending the lumbar spine (LS). With the goniometer at the knee, and the lateral femoral epicondyle, greater trochanter and lateral malleolus as anatomical references, the angle between femur and tibia was measured. An angle of 135° was considered normal.[24]

### Statistical Analyses

A descriptive analysis of the participants was done for the following variables: Age, height, weight, duration of symptoms and activity levels. Odds ratios and chi-square tests were calculated for the discrete variables: Cross legged sitting and squatting. Subgroup analyses were done to evaluate if a higher proportion of bilateral AKP cases had the habits compared to the unilateral. Subgroup analysis was also performed after age grouping. Further, stratified analysis was performed for participants with and without the two habits under evaluation and quadriceps tightness as a risk factor and the odds ratios were calculated. Significance was considered at $p < 0.05$. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS), Version 16 (SPSS Inc, Chicago, IL) and Microsoft Excel 2007 (Microsoft, Seattle, WA, USA).

## RESULTS

There were 117 males and 108 females with AKP who met the criteria and were included in the study. An equal number of age and sex matched controls were included. The mean (standard deviation) age, height and weight of the cases and controls was 29.1 (9.4) years, 1.63 (0.08) metres, 64.5 (12.7) kg and 29.3 (9.6) years, 1.62 (0.09) metres and 61.5 (10.4) kg respectively. Seventy-two cases (32%) had bilateral AKP and 49% of the cases had AKP for at least 1 year. There was no difference in the physical activity levels of both cases and controls with more than 50% of both groups having never engaged in any structured physical activity like exercise or sports.

The Odds ratios for cross-legged sitting and squatting were 0.88 and 0.92 respectively, which were not statistically significant (Table 1). 69.3% of the cases and 72% of the controls sat cross legged and 67.6% of cases and 69.3% of controls habitually squatted. No significant difference was noted between proportions of bilateral *vs* unilateral cases in these habits (Table 2). There was no significant difference between the two age groups of 18 to 30 and 31 to 55 years either (Table 3). Odds ratios of stratified analysis are in Tables 4 and 5.

## DISCUSSION

Anterior knee pain is a debilitating knee condition affecting predominantly young individuals.[25] It may

**Table 1:** Odds ratios for risk factors

| *Risk factor* | *Odds ratio* | *p-value* | *95% confidence intervals* |
|---|---|---|---|
| Cross-legged sitting | 0.88 | 0.534 | 0.58–1.31 |
| Habitual squatting | 0.92 | 0.685 | 0.61–1.37 |

**Table 2:** Comparison of bilateral and unilateral cases

| | *Bilateral (72)* | *Unilateral (153)* | *p-value* | *Total cases (225)* |
|---|---|---|---|---|
| Cross-legged sitting | 66.7% (48) | 70.6% (108) | 0.5 | 156 |
| Habitual squatting | 68% (49) | 67.3% (103) | 0.9 | 152 |

**Table 3:** Age group analysis

| | *31–55 years (84)* | *18–30 years (141)* | *p-value* | *Total cases (225)* |
|---|---|---|---|---|
| Cross-legged sitting | 71.4% (60) | 68% (96) | 0.6 | 156 |
| Habitual squatting | 69% (58) | 66.7% (94) | 0.7 | 152 |

**Table 4:** Stratified analysis of cross-legged sitting and quadriceps tightness

| *Cross-legged participants (318)* | *Cases (%) (156)* | *Controls (%) (162)* |
|---|---|---|
| Quadriceps tightness +ve (92) | 39.7 | 18.5 |
| Quadriceps tightness –ve (226) | 60.3 | 81.5 |
| OR: 2.9 (1.7, 4.8) | $p < 0.000$ | |
| *Noncross-legged participants (132)* | *Cases (%) (69)* | *Controls (%) (63)* |
| Quadriceps tightness +ve (50) | 53.6 | 20.6 |
| Quadriceps tightness –ve (82) | 46.4 | 79.4 |
| OR: 4.4 (2, 9.6) | $p < 0.000$ | |

**Table 5:** Stratified analysis of squatting and quadriceps tightness

| *Squatting participants (308)* | *Cases (%) (152)* | *Controls (%) (156)* |
|---|---|---|
| Quadriceps tightness +ve (96) | 43.4 | 19.2 |
| Quadriceps tightness –ve (212) | 56.6 | 80.8 |
| OR: 3.2 (1.9, 5.3) | $p < 0.0001$ | |
| *Nonsquatting participants (142)* | *Cases (%) (73)* | *Controls (%) (69)* |
| Quadriceps tightness +ve (46) | 45.2 | 18.8 |
| Quadriceps tightness –ve (96) | 54.8 | 81.2 |
| OR: 3.6 (1.7, 7.6) | $p < 0.001$ | |

persist for years and have long-term sequelae like PFOA. Complaints of worsening of this pain in Indians during traditional habits like sitting cross legged and squatting are common. This apparent clinical association with these positions has never been studied in the Indian population. The current study analyzed AKP and its association with these two factors in a large sample of general population. The mean age of the participants was 29.1 years highlighting the predominance of this condition in younger adults. Forty-nine percentageof the cases complained of AKP for at least 1 year indicating the chronicity of this pain and the need to understand its risk factors.

The pain in AKP has been attributed to the increase in PFJS in AKP patients compared to controls.[10] Also, a reduction of the PFJRF is associated with lessening of pain, further suggesting the role of a high force and stress in etiology.[26] Patellofemoral joint reaction forces, in turn, is known to increase as the knee flexion increases.[26] Biomechanical analyses have calculated the PFJRF during deep knee flexion to be 7–8 times the body weight.[27–29] However, in the current study, there was no significant association between the high knee flexion positions and AKP. Whereas literature has supported the pathogenesis of increased PFJS in AKP,[9–12] the effect of high flexion position on PFJS is debatable (Fig. 3).

The PFJS depends on the PFJRF and the contact area. Magnetic resonance imaging (MRI) measurements and three-dimensional (3D) image postprocessing to study the PF contact areas up to 90° flexion found that an increase in flexion was associated with larger contact surface area in healthy persons in unloaded position.[30–32] Using MRI measurements, Besier et al showed that this contact area also increased in the loaded condition up to 60° flexion and was higher than the unloaded condition.[25] Recently, MRI based measurements have shown increasing PF cartilage contact area until 140° in unloaded position.[33] These increases in contact areas may reduce the PFJS in spite of knee flexion explaining the findings of the current study. However, these studies have only been in healthy persons.

The increase in contact area is attributed to both a cartilage deformation and a change in patellar orientation

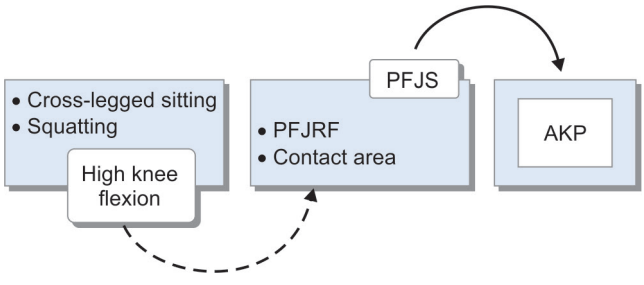


**Fig. 3:** Relationship between high knee flexion and anterior knee pain

to the femur.[25] Thus, if only the lateral facet was in contact in a particular position, both medial and lateral facets may contact with change in knee angle due to a patellar shift. AKP is very often of multifactorial origin with abnormal patellar tracking being one of the factors.[34] It is possible then that in AKP patients with hypo or hyper mobile patella, this contact area of approximation is not same as the healthy people and hence, the flexion positions would lead to a different outcome than normal population. A decrease in contact surface area with increasing flexion in PF malalignment patients has been proposed.[26] But an MRI study found an increasing total contact area in AKP patients from 30 to 45°.[35] Another study evaluated contact areas in AKP patients in full knee extension only and found it lesser than controls.[12]

However, all the studies measuring the contact areas did not measure the PFJRF in the participants. Concomitant increases in PFJRF may lead to higher PFJS values in spite of higher contact areas in both AKP patients and controls. On the contrary, Wallace et al demonstrated an increase in PFJRF, but they did not measure the contact areas in their participants.[13] They used areas from a cadaver study to measure PFPS in their participants.

Bandi researched the PFJR forces with concomitant hip and knee flexion and concluded that associated hip and knee flexion reduces the PFJRF as against knee flexion alone.[26] The increasing knee flexion brings the quadriceps tendon and the intercondylar notch in more contact.[36] This wrapping effect is proposed to enhance the load distribution and force transfer in the knee. The thigh calf soft tissue contact is another factor proposed to contribute to reduction of knee forces as shown in a free body diagram and finite element analysis model.[27] This study proved that maximal knee forces do not correspond with maximal knee flexion as measured at 155°. The finite element model computed that the thigh calf contact reduced the knee compressive forces from 4.89 to 2.9 times body weight at 155°. These could be reasons that no significant association was found between AKP with cross-legged sitting and full squatting.

However, most of these biomechanical and MRI studies explain the patellofemoral biomechanics in healthy participants rather than AKP patients. Chen et al compared the PFJRF in patients and controls during movements like running, walking and stairs and found lower values in patients. They proposed that the patients may be employing strategies that minimize the loading of the joint.[37]

There are no studies in literature which have studied cross legged sitting, to compare our study results with. Although it can be considered similar to squatting as regards the knee angles, it is a non-weight bearing

position and would experience different forces on that account. We carried out a stratified analysis of participants who sat and did not sit cross legged for an AKP risk factor—quadriceps tightness. A substantially lower odds ratio in the cross legged cases implies a probable protective role of cross legged sitting in cases with quadriceps tightness. Although the odds ratio in squatters was also lower, it was only marginally low. A subgroup analysis was carried out to explore the probability of higher proportion of the proposed risk factors in the bilateral cases. We did not find a higher proportion of these habits in bilateral as compared to unilateral cases. There was no significant difference between younger and older adults either in the frequencies of cross-legged sitting and habitual squatting.

## CONCLUSION

The Indian habits of regular cross-legged sitting and squatting were not found to be directly associated with AKP in spite of them involving high knee flexion. There was found to be a probable protective effect of cross legged sitting against AKP in certain situations. Wrapping effect, thigh-calf soft-tissue contact and increasing PF contact areas could be probable reasons for this. This study is among the first large studies on AKP in Indians and the first to evaluate association of traditional Indian practices as risk factors with AKP.

## CLINICAL SIGNIFICANCE

These traditional sitting and squatting positions evaluated are integral to daily lifestyle of many Indians across all ages. The advice often given to AKP patients to avoid them due to their probable AKP association is not supported by the current study. Based on findings of this study, the clinicians can consider the impact on the quality of life of the patient before advising against these positions. Also, it would be useful to study these habits under laboratory conditions through 3D biomechanics for their effects on the patellofemoral biomechanics to structure preventive advice for healthy people too.

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