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Squat Posture Analysis in Various Ethnic Groups in Malaysia

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ABSTRACT

The squat posture is commonly used in an Asian population like Malaysia. Certain positions have been shown to lead to pathologies like osteoarthritis. This study compares the hip, knee, and ankle joint angles in the squat posture among the Chinese, Indian, and Malay ethnic groups. Participants (N = 31) were divided equally into three groups; Chinese, Indian, and Malay (n = 11). The hip, knee, and ankle joint angles were measured during the squat using 2-dimensional motion analysis equipment. Series one-way ANOVA, $p < 0.05$, was used for analysis. Significant differences in the hip angle between the Chinese and Indian groups ($p = 0.020$) were found. There was a significant difference in the frequency of squatting for religious purposes among the different ethnic groups ($p=.000$). There were moderate to high significant differences in the frequency of squatting for religious purposes among the Chinese and Malay groups ($p=.049$), and the Indian and Malay groups ($p=.000$). There were significant interethnic differences in the hip joint and the frequency of squatting for religious activities; however, further research is required to confirm these findings and expand this study's directions.

1. Introduction

The squat posture is defined as the final sitting posture after the descent of the body from an upright position where the hips, knee, and ankles flex until the top of the thigh is approximately parallel with the ground, and the hip joint is at least equal with or slightly below the knee complex [1,2]. The squat is one of the most common exercises in the rehabilitation and sports community, where it is used for improving lower extremity muscular endurance, power, and strength [3]. In addition, the squatting position is vital for the Asian population like Malaysia; as it is used in many components of activity of daily living (ADL) such as toileting, socializing, and religious ceremonies, agricultural activities or for work purposes [4,5].

It has been found that there are differences in lower extremity joint angles in the squat posture that can potentially increase the shear and compressive forces at the ankle, knee, hip joints, and

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lumbar spine, leading to the increased probability of injury and osteoarthritis (OA) in the elderly [6,7]. Schoenfeld [8] also asserts a close relationship between movement at the hips, pelvis, and lumbar spine during higher flexion of squat posture and increased lumbar shear. The author also deduces a higher incidence of potential injury due to habitual heel-off squats under external load.

Toutoungi *et al.,* [9] found a significant increase in forces exerted onto the anterior cruciate ligament (ACL) when squatting is done with feet flat versus heels raised during descent and ascent of squatting. There have also been suggestions linking osteoarthritis and squatting. Liu and Xue [10] attained a relationship between the frequency of squatting and an increase in the prevalence of 40% of men and 68% of women developing tibiofemoral OA in Chinese individuals. Similar research by Tangtrakulwanich *et al.,* [11] concluded that a lifetime of frequent squatting could increase the relative risk of OA. Both these studies looked at the Chinese population.

Malaysia, similar to many parts of Asia, consists of various ethnic groups which possess variations in culture and adopt various religions. There has been some evidence of differences in the squatting habits between different populations. A study by Chokkhanchitcha *et al.,* [12] compared the frequency of squatting among Muslims and Buddhists in Thailand. They ascertained that 81% of Muslims prefer using the squatting latrine in their home, and 45% of Buddhists prefer Western-style latrine. Moreover, Muslims are immensely exposed to frequent squatting from a young age for religious practice. ADLs force greater knee flexion angle due to the constant stretch of surrounding soft tissue. This is one of a few articles claiming that there might be a difference in knee ROM during squat posture among ethnic groups. Besides toileting, the Malay population also uses squatting movement during repeated movements and postures involved in prayer. From standing, the devotee first bows the torso forward and bends the knees preparing for a squat phase, lowering the body into a position where the knees, hands, and forehead rest on the floor [13]. Ghazal [14], also states that rising from this position to continue to other positions involves activities like deep squats.

Wei *et al.,* [15] analyzed the hip, knee, and ankle angle during the squat position in Shanghai, Chinese, whereas Hemmeric *et al.,* [16] analyzed Indians in Chennai. Both studies had differing findings. There have been no concurrent studies collating and contrasting the kinematics of the squat position between ethnic groups. Differences in squatting movements may be associated with various lower extremity abnormalities, specifically those involving the knee joint, because of the altered distribution of biomechanical loading. Due to the lack of comparable studies on the squat posture among the different ethnic groups, it would be informative to have baseline data and the juxtaposition between ethnic groups on the kinematics of the squat, as well as the frequency of the squatting posture, for future assessment and intervention studies. This study aims to fill the existing gap in the literature and identify the differences in angles in the hip, knee, and ankle during squatting among Malaysian Chinese, Indian and Malay.

2. Methodology

This study is a cross-sectional study involving three ethnic groups in Malaysia; the Malays, Chinese, and Indians. Participants were selected through the non-probability sampling method. Participants, both males, and females, who were 19—26 years old, with no knee or hip problems, no lower limb, and spinal deformities, and no fractures of the hip, pelvis, knee, and ankle, were included in the study. Participants were also not active in sports. Thirty-three participants were selected for the study, with 11 participants in each ethnic group. A sample size calculation was based on the published literature. A minimum sample size of 30 was determined to detect at least a 5° angle difference between the three groups, with an alpha (α) value of 5% and a 1-beta (β) value of 80% [16]. The author used G-power statistical software for the sample size was calculated 33, respectively.

The Faculty of Health and Sport Sciences Research Review Committee, MAHSA University, approved this study. All participants gave their informed consent. Recruited participants who met the inclusion and exclusion criteria attended the laboratory session, where a camera was mounted to the camera stand and set on the level concrete surface to reduce contamination of data from outside sources, was placed at a distance of 1.2 m from the platform within the parameters suggested by camera user manual to identify the amount pixelization required. The camera was linked to the Simi® Aktisy software package.

Before testing, participants were given a brief explanation of the research and the equipment and a simple Frequency of Squatting questionnaire to fill in. Surface-mounted tracking targets (SMT) were securely adhered using tape on the right side of participants at the hip (greater trochanter), knee (lateral epicondyle of the femur), ankle (lateral malleolus), and toe (base of the fifth metatarsal), as the reference point for tracking the angle of hip, knee and ankle joints while squatting [17]. They were instructed to stand erect, ensuring that all SMT was facing the camera. Then, they were instructed to descend naturally downward into a squatting pattern according to the researcher's verbal cue. When they reached their final squat posture, there was a static hold for 5 seconds before returning to the upright position. The participants were required to perform the task three times. The initiation of the trial was prompted by the movement of any of the three joints and stopped at the termination of motion of all three joints [15,18].

The first two trials were used to familiarize the subject, and the third trial data was used for analysis. The 2D motion camera record motion of the SMT as a measure of the angles of the hip, knee, and ankle joints at the final squat posture (static hold phase of the trial) [19]. The 2D motion capture of the hip, knee, and ankle angles at squat posture was collected and saved as a file in Simi® Aktisys software. The text files were converted into a spreadsheet with Microsoft® Excel to quickly read and analyze the data. In this phase, the author also collected and tabulated the data from the Frequency of Squatting questionnaires to determine the cumulative frequency of squatting.

3. Results

A series of one-way ANOVA tests were conducted at α=0.05 to compare three ethnicities (Chinese, Malay, and Indian) on angles of hip, knee, and ankle joint at the final squat posture, as well as the cumulative frequency of squatting scores using a Statistical Package of Social Science (SPSS) software (SPSS Version 21. SPSS Inc. Chicago, Illinois, USA, 2011).

The current study investigated the angular differences in the hip, knee, and ankle joints between Chinese, Indian, and Malay people. Table 1 presents a summary of the descriptive statistics of the participants. The mean age of the Chinese participants was (23.50 ± 1.04 years), the Indian participants were (23.4 ± 2.29 years) and the Malay participants were (22.9 ± .70 years). The samples were primarily women across the three ethnic groups. Table 2 displays the mean of hip, knee, and ankle angles during the squat posture adopted by the different ethnic groups.

Table 3 shows the differences in the hip angle between the three ethnic groups. There is a statistically significant difference in the angle of the hip joint in squat posture between the Chinese and Indians (p = .020). However, there were no significant differences in the hip joint angle between the Chinese and Malay (p =. 378) and Indian and Malay (p =. 296) groups. Tables 4 and 5 show the difference in knee and ankle angles between the ethnic groups. The interethnic comparisons of the knee and ankle angles in the squat posture showed no significant differences in both knee and ankle joint angles between the three ethnic groups.

Table 1
Characteristics of Participants

Group (Ethnicity)	n (%)	Sex	Mean age ± *SD* (years)
Chinese	3 (27.3)	Male	23.5 ± 1.04
	8 (72.7)	Female	
Indian	2 (18.2)	Male	23.4 ± 2.29
	9 (81.8)	Female	
Malay	4 (36.4)	Male	22.9 ± .70
	7 (63.6)	Female	

Table 2
Mean Hip, Knee and Ankle Angle of Ethnic Groups

Ethnicity	Hip (Mean ± SD (º)	Knee (Mean ± SD (º)	Ankle (Mean ± SD (º)
Chinese	98.61 ± 7.54	130.52 ± 10.48	-11.50 ± 9.29
Indian	79.94 ± 21.29	121.78 ± 18.16	-4.09 ± 12.38
Malay	89.82 ± 13.68	124.81 ± 14.66	-1.71 ± 10.91

Table 3
Difference in Mean Hip Angle between Ethnic Groups

Ethnicity		Difference in Mean Hip Angle (º)	p-value
Chinese	Indian	18.67*	0.020
	Malay	8.79	0.378
Indian	Chinese	-18.67*	0.020
	Malay	-9.88	0.296
Malay	Chinese	-8.79	0.378
	Indian	9.88	0.296

Table 4
Difference in Mean Knee Angle between Ethnic Groups

Ethnicity		Difference in Mean Hip Angle (º)	p-value
Chinese	Indian	8.74	0.360
	Malay	5.74	0.640
Indian	Chinese	-8.74	0.360
	Malay	-3.03	0.881
Malay	Chinese	-5.71	0.640
	Indian	3.03	0.881

Table 5
Mean Ankle Angle between Ethnic Groups

Ethnicity		Difference in Mean Hip Angle (º)	p-value
Chinese	Indian	-7.41	0.266
	Malay	-9.79	0.107
Indian	Chinese	7.41	0.266
	Malay	-2.38	0.867
Malay	Chinese	9.79	0.107
	Indian	2.38	0.867

As for the frequency of squatting, the mean number of squats per day by the different ethnic groups is shown in Table 6. There was no significant difference in the frequency of squatting (p=.389) between the three groups. An analysis was also done by dissecting the 'Frequency of Squatting' questionnaire into its four main derivative questions; (1) frequency in using the squatting latrine, (2) frequency of squatting as a resting position, such as while outdoors to avoid sitting on the ground, (3) frequency of squatting indoors and (4) frequency of squatting for religious purposes. Table 7

shows that there was only a significant difference (p=.000) in the frequency of squatting for religious purposes and ethnic groups. Tukey's post hoc test showed a moderate to highly significant difference in the frequency of squatting for religious purposes among Chinese and Malay (p = .049) and Indian and Malay (p = .000), respectively. However, there were no significant differences between Chinese and Indian (p=.115). The other three questionnaire items had no significant differences between ethnic groups.

Table 6
Frequency of Squatting

Ethnicity	Mean Number of Squats / Day (±SD)
Chinese	5.64 ± 2.01
Indian	4.55 ± 2.11
Malay	4.45 ± 2.58

Table 7
Differences in Frequency of Squatting for Religious Purposes Between Ethnic Groups

Ethnicity		Difference in Frequency of Squatting for Religious Purposes	p-value
Chinese	Indian	0.46	0.115
	Malay	-0.55*	0.049
Indian	Chinese	-0.46	0.115
	Malay	-1.00*	0.000
Malay	Chinese	0.55*	0.049
	Indian	1.00*	0.000

* indicates a significant main effect, p<.05

4. Discussion

There have been only a few published kinds of literature regarding the kinematics of hip, knee, and ankle joints during a squat posture from which to compare and contrast data, as far as our knowledge. Our findings were not consistent with the results of previous literature, which may be attributed to the alterations in methodology or the differences in the physical attributes of the population as the majority of these studies were conducted in different countries with a population of different sociodemographic [15,16]. This study found that the mean angles of the hip, knee, and ankle angles for the Chinese group were 98.61 ± 7.54°, 130.52 ± 10.48° and -11.50 ± 9.29° respectively, whereas Wei *et al.,* [15] discerned the angles at 107.3 ± 16. 5°, 150.4 ± 8.2° and 31.4 ± 10.7°, respectively.

These differences could be attributed to the heel procedure of squat posture, as all the participants were not instructed on how to squat. This is evident with the high standard deviations associated with angles of all three lower joints in the squat posture. In this study, the mean hip flexion angle at squat posture for the Indian group was the lowest compared to the Chinese and Malay. This is parallel with the findings of previous study, that state that the Indian population has a compensatory increase in lumbar lordosis, and that can be the explanation for lower hip flexion angle [16]. This was also seen in the Indian participants for this study.

The results of statistical analysis revealed that there were significant differences only in the hip joint angle between the ethnic groups. The discrepancies in the width and foot placement angles may result in angular differences in the hip angle. Lorenzetti *et al.,* [20], found that the narrower the stance width and smaller foot angle during a squat were associated with a higher hip flexion angle in the sagittal plane. A wider stance width and larger foot placement angle were seen with higher knee

flexion angles. This may explain the higher hip flexion angle in the squat posture among the Chinese group because the participants were observed to prefer a narrower stance with a slightly smaller foot angle when compared to the Indians and Malays. The author also noticed variations in the type of squat with the ankle plantarflexed (heel-off squat) and heel firm on the ground (foot-flat squat).

There may not have been any differences in knee angles between ethnic groups due to the participants' various body mass indexes (BMI). Farooque and Hussain [21] found a moderate negative correlation between the degree of knee flexion with BMI, stating that a smaller BMI stipulates lesser surrounding soft tissue to restrict the motion of the knee complex in deep flexion. Parikh and Arumugam [22] also showed that the soft tissue contact between the thigh and calf contributes to knee angle reduction. Thus, these contrasting factors may negate the potential differences in knee angles among ethnic groups.

With regards to the frequency of squatting between ethnic groups, there were no significant differences; however, on breaking down the items, there was a significant difference in the frequency of squatting for religious purposes between the Chinese and Malays; and the Indians and Malays, with the Malay group having the highest frequency score. The results show that 72.7% of Malay participants use squatting for prayers more than one time per day compared to Chinese and Indian participants, who tend to only on holy days or once per day.

There were no significant differences in the frequency of squatting in using the squat-type latrine and squatting indoors and outdoors as there is a purposed aspect of acculturation and social interaction between ethnicities. According to Abidin *et al.,* [23], due to the acculturation of cultures, where the ethnic groups develop the tendency to accept; as well as integrate the culture and lifestyle of the dominant community. As such, the habits concerning squatting may be customary and shared among the ethnic groups in Malaysia.

This study has shown us that there may not be many differences between the ethnic groups in Malaysia regarding squatting. This then allows us to direct future research into the kinematics of squats in activities of daily living (ADL) and links to pathologies such as osteoarthritis. This study utilizes the 2D camera analysis, which means that the rotational components of the hip and tibia are not analyzed. Future studies should also utilize 3D methods of capture and analysis and a force plate to determine ground reaction forces. Prospective investigations could also examine the association of BMI, type of squat (heel-off, foot-flat), and subjects with pain and various joint kinematics.

The system used for assessment and analysis here was easy to use, and fairly portable, and this may pave the way for technologies such as these that can be easily used in the clinical setting for practical uses.

5. Conclusion

In conclusion, this study's results indicate significant differences in the hip angle during a squat amongst ethnic groups but no significant differences in the knee and ankle angle between ethnic groups. The Malay ethnic group seemed to have an increased frequency of squatting compared to the other ethnic groups during daily religious activities. Further research is required to investigate other factors influencing the squatting posture.

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