



Cross-sectional Study

# Patellar height measurement in Indonesian normal adult population

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## ABSTRACT

**Background:** Patellar height is the distance formed by the patella and the length of the patellar tendon. Patellar height measurement can predispose to various abnormalities in the knee joint. Patellar height can be measured using several sizes, such as the Insal-Salvati ratio (IS), Modified Insal-Salvati ratio (MIS), Caton-Deschamps index (CD), and the Blackburne-Peel (BP) index. In Indonesia, no data on the value of patellar height is available. This study aims to determine the patellar height value in Indonesians and compare if there are differences with the standard values commonly used by other countries.

**Materials and methods:** This study is descriptive with 136 research subjects aged 20–40. Data were taken from December 2021 to February 2022. The results of patellar X-ray were measured using the Insal-Salvati, Modified Insal-Salvati, Caton-Deschamps, and Blackburne-Peel methods.

**Results:** In the measurement of patellar height, the longest measurement was found in the MIS measurement, while the shortest patellar height was measured using the BP method. The normal value of the IS method is 0.78–1.26, the MIS method is > 1.98, the CD method is 0.79–1.23, and the BP method is 0.70–1.10 for patellar height in Indonesia. This study also shows no significant difference in the value of patellar height between male and female sex using the IS measurement method.

**Conclusion:** There is a difference in the standard value of patellar height, which is commonly used by other countries with the standard value of patellar height in Indonesia, but it is not significant.

## 1. Background

The patella is the most prominent sesamoid bone in the human body and plays an essential role in various physiological movements of the knee joint. The position of the patella plays an important role in transmitting the direction of the leverage that occurs in the knee joint. The patella's location and position, such as patellar height, patellar shift, and patellar tilt, causes the patella to have a biomechanical function to increase and concentrate the force of the quadriceps muscle. The resultant force is then transmitted through the patellar tendon to the tibial tuberosity [1,2].

The patella can be malaligned, causing a change in the direction of the force transmitted at the patellofemoral junction, which can be caused by patellar height. Patellar height is the distance between the patellar bone's upper and lower ends and the patellar tendon's length. Another study also found that patellar height is the most influential factor in patellar malalignment. The most common malalignments are the patella alta and the patella infera (steel). The patella alta is a position of the patella that is superior to the trochlea position. This condition is

caused by subluxation or dislocation, chondromalacia patella, Sinding-Larsen-Johansson syndrome, and Osgood-Schlatter disease. Patella infera (steel) is a position of the patella that is inferior to the trochlea and can be caused by congenital factors as well as trauma during exercise [3–6].

Measurement of patellar height is an important factor to know because it can be a predisposing factor for various abnormalities in the knee joint. These abnormalities can include progressive patellofemoral osteoarthritis, patellofemoral pain, pain on the knee joint's anterior side, and dislocation or subluxation of the patella. Research conducted in China from 2014 to 2019 showed a strong correlation between the condition of the patella alta and the incidence of recurrent patellar dislocations. Abnormal patellar height conditions cause malalignment conditions that increase the incidence of mistracking when physiological movements occur in the knee joint [7,8].

Therefore, the measurement of patellar height can be used to determine joint abnormalities and be a predisposing factor for joint abnormalities in patients, so it is necessary to take measurements. Patellar height can be measured using several sizes, such as the Insal-

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Salvati ratio, the modified Insall-Salvati ratio, the Caton-Deschamps index, and the Blackburne-Peel index. Each measurement method has a normal value based on the difference between the location and the measured area. The Insall-Salvati ratio has a normal value of 0.8–1.2, while the modified Insall-Salvati ratio has a normal value of 1.2–2.1. The Blackburne-Peel index has a normal value of 0.54–1.06. The Caton-Deschamps index has a normal value of 0.6–1.3 [1,9,10].

Several studies have been conducted in several countries to obtain primary data on average values according to that country's race and ethnicity. Research in Korea used the Insall-Salvati ratio and reported a normal value of the patellar height of 0.64–1.20. Another study was conducted in India using the Insall-Salvati ratio and reported normal values for patellar height of 0.7–1.5. Similar studies have also been conducted in Vietnam and the United Arab Emirates. The research results in Vietnam using the Insall-Salvati ratio showed a normal value of 0.72–1.32. A similar study in the United Arab Emirates reported the normal value of the Insall-Salvati ratio ranging from 0.86 to 1.54. From the results of these studies, it can be concluded that the normal value of patellar height has differences in each population which may be influenced by ethnic differences [11–14].

Several studies discuss patellar height measurement, but most of these studies were conducted abroad. We recognize that each country has unique anatomical characteristics related to racial and cultural differences. In Indonesia, research on patellar height measurement has been carried out. This study describes the characteristics of patellar height measurement with MRI modality [15].

MRI is a good diagnostic technology for assessing soft tissue, such as the knee. However, MRI also has drawbacks, including being expensive, not all hospitals have MRI facilities, and it takes a long time in terms of the duration of the MRI. Therefore, this study uses x-ray, where x-ray is a radiological examination that is faster, cheaper, and easier. Therefore, this study aims to determine the value of the patellar height measurement using x-ray radiology modalities in the Indonesian population using several existing index parameters.

**2. Materials and methods**

This research is descriptive with 131 subjects aged 20–40 without knee fracture, pain, trauma or surgery history and not pregnant for female subject. Subject with congenital anatomic abnormalities in patella were excluded. Data were collected from December 2021 to February 2022 in RSUD Dr. Saiful Anwar, Malang, East Java, Indonesia. The results of patellar X-ray were measured using the Insall-Salvati, Modified Insall-Salvati, Caton-Deschamps, and Blackburne-Peel methods. Data tabulation is done with Microsoft Excel 365 for Windows program, while data analysis using SPSS 25.0 (NY, Armonk USA).

**3. Results**

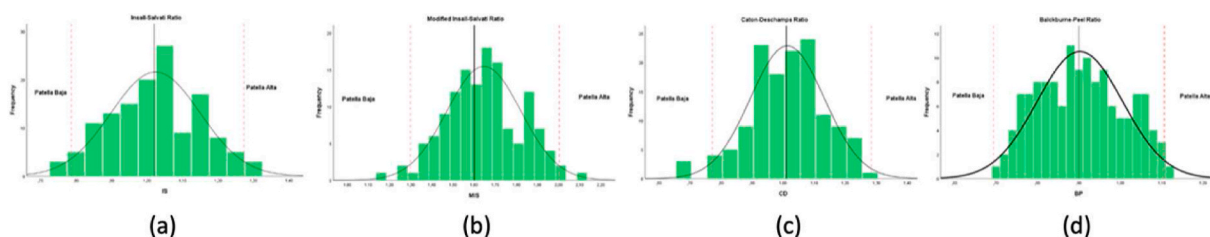
Descriptive analysis is intended to determine the general description of the research variables. This descriptive analysis is expected to provide an overview of the state of patient data. The patellar height value is displayed in the form of descriptive data, and the data is tested for normal distribution and then displays the average value (mean) and

standard deviation. To find out the description for each variable can be seen in Fig. 1. From the primary data, it was found that the enormous number of samples, most of the subjects, were male, with a percentage of 64%. The average age of the subjects in this study was 31.82 ± 4.13 years old. The average age for males was 32.86 ± 2.47 years old, while for females was 29.98 ± 5.62 years old.

The difference in the size of the patellar height by gender and the combination is shown in Table 1. The table shows differences in the minimum and maximum values for the male and female sex using all types of patellar height measurement methods. Patellar height CD in males has a higher value than in females. Fig. 1 shows that the straight line shows the mean (1.02), and the dotted line shows the standard deviation (+2SD, 1.26; -2SD, 0.78). These results indicate that the distribution of data on the IS measurement is normal. Fig. 1 also shows that the straight line represents the mean (1.64), and the dashed line shows the standard deviation (+2SD, 1.98; -2SD, 1.30). These results indicate that the data distribution on the MIS measurement is normal. The results show that the straight line represents the mean (1.01) and the dashed line indicates the standard deviation (+2SD, 1.23; -2SD, 0.79). These results indicate that the distribution of data on the CD measurement is normal. Fig. 1 shows that the straight line indicates the mean (0.90), and

**Table 1**  
Size difference based on gender.

Size	Combined (n = 136)	Male (n = 87)	Female (n = 49)	p-value
<b>Insall-Salvati</b>				
Tibial Tuberosity – Inferior Pole (TI)	4,40 ± 0,58	4,62 ± 0,51	4,03 ± 0,52	≤0,001*
Superior Articular Surface – Inferior Pole (SI)	4,32 ± 0,42	4,55 ± 0,29	3,90 ± 0,28	≤0,001*
Insall Salvati (TI/SI)	1,02 ± 0,12	1,01 ± 0,12	1,03 ± 0,13	0,500*
<b>Modified Insall-Salvati</b>				
Tibial Tuberosity – Inferior Articular Surface (TA)	5,08 ± 0,59	5,20 ± 0,49	4,73 ± 0,61	≤0,001*
Superior Articular Surface – Inferior Articular Surface (SS)	3,10 ± 0,34	3,26 ± 0,27	2,82 ± 0,26	≤0,001*
Modified Insall-Salvati (TA/SS)	1,64 ± 0,17	1,62 ± 0,17	1,67 ± 0,16	0,095*
<b>Caton-Deschamps</b>				
Superior Articular Surface – Inferior Articular Surface (SI)	4,32 ± 0,42	4,55 ± 0,29	3,90 ± 0,28	≤0,001*
Superoanterior Tibial Plateau – Inferior Articular Surface (ST)	3,13 ± 0,43	3,30 ± 0,37	2,82 ± 0,37	≤0,001*
Caton-Deschamps (ST/SI)	1,01 ± 0,11	1,01 ± 0,12	1,00 ± 0,11	0,547*
<b>Blackburne-Peel</b>				
Superior Articular Surface – Inferior Articular Surface (SI)	4,32 ± 0,42	4,55 ± 0,29	3,90 ± 0,28	≤0,001*
Tangensial Tibial Plateau – Inferior Articular Surface (TT)	2,79 ± 0,40	2,92 ± 0,37	2,55 ± 0,32	≤0,001*
Blackburne-Peel (TT/SI)	0,90 ± 0,10	0,89 ± 0,10	0,90 ± 0,09	0,661*



**Fig. 1.** Histogram and normality curve of (a) Insall-salvati, (b) Modified insall salvati, (c) Caton-deschamps, and (d) Blackburne-peel.

the dashed line indicates the standard deviation (+2SD, 1.10; -2SD, 0.70). These results indicate that the distribution of data on BP measurement is normal.

Table 1 shows that the average size of women is lower than men for the size of tibial tuberosity - inferior pole (TI) and superior articular surface - inferior pole (SI). In contrast, for the insert Salvati (TS/SI) size, women have a higher average than men. Based on the independent *t*-test statistical test, there was a significant difference in the size of the tibial tuberosity - inferior pole (TI) and superior surface - inferior pole (SI) ( $p < 0.05$ ). The independent *t*-test showed no significant difference in the Insall-Salvati ratio based on gender ( $p > 0.05$ ).

Women have a lower average compared to men for the size of the tibial tuberosity - inferior articular surface (TA) and superior articular surface - inferior articular surface (SS). In contrast, for the modified insall Salvati (TA/SS) size, women have an average higher average than men. Based on the independent *t*-test statistical test, there was a significant difference in the size of the tibial tuberosity - inferior articular surface (TA) and superior articular surface - inferior articular surface (SS) ( $p < 0.05$ ). The independent *t*-test showed no significant difference in the Modified Insall-Salvati ratio based on gender ( $p > 0.05$ ).

Men have a higher average than women. Based on the independent *t*-test statistical test, there was a significant difference in the size of the superior articular surface - inferior articular surface (SI) and superoanterior tibial plateau - inferior articular surface (ST) ( $p < 0.05$ ). Based on the independent *t*-test, there was no significant difference in the Caton-Deschamps ratio by sex ( $p > 0.05$ ).

Men also have a higher average than women. Based on the independent *t*-test statistical test, there was a significant difference in the size of the superior articular surface - inferior articular surface (SI) and tangential tibial plateau - inferior articular surface (TT) ( $p < 0.05$ ). The independent *t*-test showed no significant difference in the Blackburne-Peel ratio based on gender ( $p > 0.05$ ).

#### 4. Discussion

Patellar height is the distance formed by the patella and the length of the patellar tendon. Patellar height is an important thing to know because it can be a predisposing factor for various abnormalities in the knee joint. In Indonesia, there is no data on the value of patellar height in normal people.

In this study, the majority of subjects consisted of 87 men with a percentage of 64.0% with an average age of 31.82 years. Meanwhile, for 49 women, 36.0% with an average age of 29.98 years. Another study in Korea used more female subjects (75.26%) than boys (24.74%), with an average age of 69.3 years for women and 69.2 years for men. Compared with previous research, the subjects used in our study used more male subjects, with an average age of both sexes being younger than in the Korean study. In another study in Vietnam, the subjects used were similar to ours, with several male subjects (54.28%) more than female subjects (45.72%). However, the age of the subjects in this study in Vietnam differs from ours. The mean age of men in the previous study was 34.82 years which was not significantly different from the mean age of the men in our study. However, the mean age of female subjects in the previous study was older (46.58 years) when compared to the mean age of the women in our study (29.98 years) [11,13].

The longest size is found in the MIS measurement in the measurement of patellar height. Chareancholvanich and Narkbunnam (2015) found similar results, who also found the longest patellar height measurement using the MIS method. The MIS measurement was carried out by measuring the distance between the upper and lower points of the patellar articular cartilage with the distance between the point of the tibial tuberosity and the most inferior point of the articular surface of the patella at 30° knee flexion [16].

This study measured the shortest patellar height using the BP method. Another study comparing patellar height with various measurement methods found similar results [17]. This measurement was

carried out by calculating the distance between the upper and lower points of the patellar articular cartilage with a horizontal line projecting anteriorly to the surface of the tibial plateau, perpendicular to the height of the most inferior point of the patellar articular surface at 30° knee flexion [16].

Based on standard values, the IS method's measurements have a normal range of 0.8–1.2. This study found that the normal size of the patella using the IS method was 0.78–1.26. The standard reference value for measurement using the MIS method is  $< 2.0$ , while in this study, the normal value using the MIS method is  $< 1.98$ . The measurement of the CD method has a normal value if it is in the range between 0.6 and 1.3. The normal value using CD method was 0.79–1.23, and BP method has a normal size of 0.70–1.10 in this study. The result is different from the standard value, which has a normal value of the patella is 0.8–1.0 [18]. This difference in patellar height is caused by the ethnic differences studied. Research showed differences in bone geometry and bone density between white, black, and Asian ethnicities [19]. Other research proves that different ethnicities have a different distance between the lower point of the patella and the point of the tibial tuberosity so that they have different heights of the patella [20].

This study found that the normal patellar height using the IS method was 0.78–1.26. This result is also different from the measurements using the IS method in Korea, namely 0.64–1.20 [11]. The results of studies in other countries also found different results from this study, namely 0.7–1.5 in India [12], 0.72–1.32 in Vietnam [13] and 0.86–1.54 in the United Arab Emirates [14]. The study's results confirm that ethnicity is a factor that influences differences in the size of the patellar height. This is probably caused by the anthropometric differences in each ethnic group. However, we have not found any research articles that examine the relationship between anthropometry and patellar height in normal people.

This study showed that there was no significant difference in the value of patellar height between male and female sex using the IS ( $p = 0.500$ ), MIS ( $p = 0.095$ ), CD ( $p = 0.547$ ), and BP ( $p = 0.661$ ) measurement methods). This finding is similar to the results of a study by Rhatomy et al. (2021), who found no significant difference in patellar height between men and women using the Insall-Salvati and Caton-Deschamps methods. However, Hong et al. (2020) found a significant difference in patellar height between men and women using the Insall-Salvati method [11,15].

Research conducted by Althani et al. (2016) regarding the Insall Salvati ratio in the population in Middle Eastern countries showed that the average Insall Salvati ratio was  $1.20 \pm 0.17$ , with the Insall-Salvati value being higher in men ( $1.22 \pm 0.12$ ) than in women ( $1.18 \pm 0.17$ ). The study also recommended determining the abnormal patella's position size of 0.86 for the steel patella and 1.54 for the alta patella [14]. Meanwhile, other research showed that the average Insall-Salvati ratio in the male population in Vietnam was  $1.01 \pm 0.15$ , and the average Insall-Salvati ratio in the female population was  $1.03 \pm 0.15$ . These results indicate no significant difference in the Insall-Salvati ratio was observed based on gender differences. The study recommended an Insall-Salvati ratio of  $> 1.32$  for the patella alta and  $< 0.72$  for the patella steel [13].

A cohort study conducted in India also showed a difference in the ratio of Insall Salvati in India compared to the population in western countries. The study showed that the average ratio of Insall Salvati was  $1.14 \pm 0.18$ , with the ratio considered normal if it was in the range of  $\pm 40\%$ . This study also showed that the Insall Salvati ratio was significantly higher in women than men ( $1.17 : 1.12$ ). The cut-off point of the patella alta was significantly greater in the Indian population compared to the standard value ( $> 1.5 : > 1.2$ ). In this cohort study, we recommend the diagnosis of patella alta with Insall Salvati ratio  $> 1.5$  and patella steel with a ratio  $< 0.7$  [21].

In this study, the measurement of normal patellar height using the Insall Salvati method showed that the most common size found was 1.03 which was found in 8 subjects (5.88%), while in the Modified Insall-

Salvati method, it was found that the most common size was 1.65, which was found in 6 subjects (4.41%). This study also found that the measurement of normal patellar height using the Caton-Deschamps method showed that the most common sizes found were 0.94, 1.03, and 1.09, of which the three sizes were found in 7 subjects (5,14%). Meanwhile, the Blackburne and Peel method showed that the most common measure found was 0.92, which was found in 10 subjects (7.35%). From this study, it was found that using the Insall Salvati method, and there were three subjects (2.20%) with steel patella (<0.78) and four subjects (2.94%) with patella alta (>1.26). Using the Modified Insall Salvati method, this study found three subjects (2.20%) with patella alta (>1.98). Another result using the Caton Deschamps method found three subjects (2.20%) with patella alta (>1.23) and five subjects (3.67%) with steel patella (<0.79). Meanwhile, the results of measurements using the Blackburn Peel method found one subject (0.73%) with patella alta (>1.10). The analysis above shows differences in the standard value of patellar height with the value of Indonesian patellar height. Thus, the research hypothesis is accepted. The results of this study can be used as an initial study to find the normal value of patellar height in a wider population. Indonesia has its own patellar height reference value.

## 5. Conclusion

The normal value for the IS method is 0.78–1.26, the MIS method is > 1.98, the CD method is 0.79–1.23, and the BP method is 0.70–1.10 for patellar height in Indonesia. There is a difference in the value of patellar height in Indonesia compared to the standard value other countries, but it is not significant. A limitation of this study is the small sample involved. So the suggestion for the next research is to increase the sample size in more hospitals from various cities in Indonesia. So that it can better represent the Indonesian population.

## Ethical approval

This study doesn't need Ethical Review.

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## Author contributions

Edi Mustamsir: conceptualization, writing original draft preparation, supervision.

Isa Yunansyah: writing the paper and editing, data interpretation, data collecting.

Krisna Yuarno Phatama: writing the paper and editing, data interpretation, supervision.

## Registration of research studies

1. Name of the registry:
2. Unique Identifying number or registration ID:
3. Hyperlink to your specific registration (must be publicly accessible and will be checked):

## Guarantor

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## Provenance and peer review

Not commissioned, externally peer-reviewed.

## Consent

This study doesn't need inform consent.

## Declaration of competing interest

We declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2022.104411>.

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