

The Relationship Between Body Mass Index (BMI) and the Risk of Patellofemoral Pain Syndrome in Young Adult Women

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Keywords:	Abstract
Body Mass Index, Patellofemoral Pain Syndrome, Anterior Knee Pain Scale (AKPS), Knee Function, Young Adult Women	This research aimed to determine the relationship between Body Mass Index (BMI) and the risk of Patellofemoral Pain Syndrome (PFPS) among young adult women. A quantitative cross-sectional study was conducted involving 80 young adult women selected through purposive sampling. BMI was calculated based on body weight and height measurements, while knee function was assessed using the Anterior Knee Pain Scale (AKPS). PFPS risk was evaluated using a PFPS Risk Questionnaire. Data were analyzed using univariate analysis, Pearson's correlation test, and the Chi-square test with a significance level of $\alpha = 0.05$. The mean age of participants was 20.55 ± 1.81 years, the mean BMI was 23.11 ± 4.90 kg/m ² , and the mean AKPS score was 71.21 ± 12.54 . Pearson's correlation analysis revealed a significant negative relationship between BMI and AKPS scores ($r = -0.408$; $p < 0.001$), indicating that higher BMI was associated with lower knee function. The Chi-square test demonstrated significant associations between BMI categories and PFPS risk categories, as well as between BMI categories and AKPS-based knee function categories ($p < 0.05$). Most respondents (81.3%) were classified as having a high risk of PFPS, with frequent squatting (97.5%), carrying heavy loads (95.0%), and knee valgus tendency (93.8%) identified as the predominant risk factors. This study concluded that BMI was significantly associated with PFPS risk and knee function among young adult women. Increased BMI was associated with reduced knee function and a higher risk of PFPS. These findings support promotive and preventive strategies focused on maintaining an optimal BMI to reduce PFPS risk and improve musculoskeletal health, particularly knee joint function, among young adult women.

INTRODUCTION

Along with increasing attention to quality of life, health issues have become one of the main focuses in public health and healthcare services. Among these issues, several conditions frequently occur in women and may increase in severity due to physical activity, exercise, and active occupational demands (Willy et al., 2019). The World Health Organization (WHO) defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure, including activities such as transportation, occupational tasks, educational activities, and household activities (Borodulin & Anderssen, 2023; Bull et al., 2020; Organization, 2019, 2023b, 2023a).

Women have distinct biological, physiological, and functional characteristics that require more specific and sustainable health approaches (J. Xu et al., 2024). Daily activities can provide beneficial effects; however, they also require considerable energy expenditure. When

physical activity is not balanced with appropriate weight management and a healthy lifestyle, excessive body weight may negatively affect physical function, reduce health status, and impact women's quality of life and productivity (Ramadan et al., 2024).

Among the musculoskeletal disorders commonly experienced by women are conditions associated with daily activity patterns and physical demands. One of the most frequently reported conditions is Patellofemoral Pain Syndrome (PFPS), which is characterized by pain in the anterior knee or peripatellar region. PFPS may reduce knee functional capacity and increase quadriceps muscle demands, particularly involving the Vastus Medialis Obliquus (VMO) and Vastus Lateralis (VL), due to repetitive activities such as stair climbing, squatting, running, and prolonged sitting positions (Guimaraes Araujo et al., 2023).

Patellofemoral Pain Syndrome is a common condition affecting adolescents and active adults, characterized by anterior knee pain associated with repetitive knee flexion activities and increased mechanical loading of the knee joint, including excessive body weight (J. Xu et al., 2024). A population-based study involving participants of mixed sexes found that the prevalence of PFPS among women was approximately 2.23 times higher than among men. The annual prevalence of PFPS in the general adult population has been reported at 22.7%, with rates of 29.2% among females and 15.5% among males (Xu et al., 2024).

Several factors may contribute to an increased risk of PFPS, including biomechanical, anatomical, psychological, and Body Mass Index (BMI)-related factors (Ferreira et al., 2023). Ferreira et al. reported that excess body weight may contribute to reduced functional capacity and knee strength. The study indicated that higher BMI, increased body fat percentage, and lower muscle mass were associated with reduced functional capacity, potentially worsening physical function among young adult women, particularly those with high levels of daily activity (Ferreira et al., 2023).

The severity of PFPS-related functional limitations can be assessed through evaluations of activities such as squatting, stair descent, and single-leg squatting to determine pain, function, and disability levels. Clinically, PFPS symptoms and functional limitations can be assessed using the Kujala Anterior Knee Pain Scale (AKPS), while the Numeric Pain Rating Scale (NPRS) can be used to evaluate pain intensity (Willy et al., 2019). These assessment tools have demonstrated validity and reliability for evaluating PFPS severity and functional limitations, including in Indonesian populations (Willy et al., 2019).

BMI is a commonly used indicator for classifying nutritional status based on body weight and height. Overweight and obesity may increase mechanical loading on the knee joint, potentially elevating the risk of PFPS (Zeeshan Khawar et al., 2025). Furthermore, elevated BMI may alter movement patterns and lower-extremity load distribution, which may contribute to pain development in the patellofemoral joint (Capodaglio et al., 2021).

Previous studies examining BMI categories, including normal weight and obesity, have compared their associations with PFPS risk, particularly among young adult women. Findings indicate that individuals with normal BMI ($<18.5 \text{ kg/m}^2$) may still experience mild to moderate PFPS symptoms; however, increasing BMI, particularly in overweight and obesity categories, is associated with greater PFPS risk and increased symptom severity (Zeeshan Khawar et al., 2025).

In Indonesia, lifestyle changes and unhealthy dietary patterns have contributed to increasing rates of overweight and obesity, particularly among young adults. The 2023

Indonesian Health Survey (Survei Kesehatan Indonesia / SKI) released by the Ministry of Health of the Republic of Indonesia in 2024 reported obesity-related indicators based on BMI and abdominal circumference measurements (Fatmawati et al., 2025; Oksidriyani et al., 2026; Wulandari, n.d.). Data from national health surveys indicated that the prevalence of adults aged ≥ 18 years with overweight or obesity increased from 35.4% in 2018 to 37.8% in 2023. In 2023, approximately 23.4% of adults were classified as obese and 14.4% as overweight.

Although the relationship between BMI and PFPS risk has been extensively studied in countries such as China, Saudi Arabia, and the United States, similar research in Indonesia, particularly among young adult women, remains limited. A better understanding of the association between BMI and PFPS risk is essential for developing effective prevention and management strategies (Gragnani et al., 2026; Naderi et al., 2025; Neal et al., 2019; Razzaq et al., 2025). Young adult women represent a physically active and productive population; therefore, musculoskeletal disorders may significantly affect their productivity and quality of life (Petersen et al., 2014).

Another challenge in PFPS prevention and management is the limited public awareness regarding the importance of maintaining an optimal body weight as a preventive strategy. Many individuals are unaware that excess body weight may increase the risk of knee joint disorders, including PFPS. Therefore, investigating the relationship between BMI and PFPS risk among young adult women remains highly relevant.

Based on this background, Patellofemoral Pain Syndrome (PFPS) is a musculoskeletal disorder that commonly occurs among young adult women, particularly in relation to activities that place stress on the knee joint and increased Body Mass Index (BMI). Excess body weight and obesity may increase mechanical loading on the patellofemoral joint, potentially elevating PFPS risk. However, research examining the relationship between BMI and PFPS risk among young adult women in Indonesia remains limited. Therefore, this study aimed to analyze the relationship between BMI and PFPS risk, determine BMI category distributions, and evaluate PFPS risk tendencies among women with higher BMI values. The findings are expected to contribute to physiotherapy education and clinical practice while increasing public awareness regarding weight management as a preventive strategy for PFPS.

METHOD

This research employed a quantitative approach to determine the relationship between Body Mass Index (BMI) and the risk of Patellofemoral Pain Syndrome (PFPS) among young adult women. An analytical descriptive study with a cross-sectional design was conducted to examine the association between BMI as the independent variable and PFPS risk as the dependent variable. Data were collected at a single point in time without intervention or long-term follow-up. The study involved young adult women at Esa Unggul University, West Jakarta, as the research population. The research was conducted at Esa Unggul University, Kebon Jeruk, West Jakarta, in May 2026.

Population and Sample

The research population is all young adult women in the environment of Esa Unggul University, West Jakarta. Population is a whole subject that has certain characteristics and is the target of research according to the problem being studied. Samples are part of the population that is selected to be studied based on predetermined characteristics and criteria.

The sampling technique in this study uses purposive sampling. The number of samples was determined using the Slovin formula with a population of 100 people and an error rate of 5%, so that a sample number of 80 people was obtained.

The inclusion criteria in this study were women aged 18–36 years who were willing to have weight and height measurements to determine BMI classification, were functionally active such as being able to walk, go up and down stairs, and squat, and did not use walkers. Respondents also have or are at risk of experiencing anterior knee pain, including complaints of pain around or behind the patella, and are willing to become respondents by signing an informed consent. Exclusion criteria included respondents who had a history of severe knee injuries such as ACL, PCL, MCL, or LCL ligament tears, meniscus injuries, and femur, tibia, or patella fractures. Respondents with a history of surgery on the lower extremities, knee structural abnormalities such as osteoarthritis or recurrent patella dislocation, congenital abnormalities of the lower extremities, systemic diseases such as rheumatoid arthritis or chronic inflammatory diseases affecting the joints, pregnant conditions, and knee pain due to acute trauma in the past three months were also excluded from the study. Abortion or drop out criteria include respondents who resign during the research process, do not complete questionnaires, have incomplete or invalid anthropometric data, or experience new medical conditions that meet the exclusion criteria during the study. Based on the criteria that have been set, the number of research samples is 80 people.

Data Analysis Techniques

The research data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 26 program. Data analysis consists of univariate and bivariate analysis. Univariate analysis is used to describe the characteristics of each research variable descriptively. Numerical data can be presented in the form of mean, standard deviation, median, minimum value, and maximum, while categorical data is presented in the form of frequency and percentage.

Bivariate analysis is used to determine the relationship between research variables based on the type of data obtained. The Pearson Correlation Test is used to determine the relationship between BMI values and AKPS scores because both variables are numerical data. Before the Pearson test was performed, the normality of the data was tested using Shapiro-Wilk. If the data is normally distributed with a $p >$ value of 0.05, then the Pearson Correlation test is used to determine the direction and strength of the relationship based on the value of the correlation coefficient (r) and its significance based on the value of p .

In addition, the Chi-Square Test was used as a supporting analysis to determine the relationship between BMI category and knee function category based on AKPS. The analysis was carried out using contingency tables 2×2 and significance level $\alpha = 0.05$. If the p value < 0.05 , then there is a significant relationship between the BMI category and the knee function category based on AKPS.

RESULTS AND DISCUSSION

Data Description

The research subject is a student of Esa Unggul University, West Jakarta. The total sample obtained in this study amounted to 80 people using the purposive sampling technique.

The purpose of this study is to determine the relationship between body mass index and the risk of patellofemoral pain syndrome in young adult women.

The data in this study consisted of BMI as an independent variable and PFPS risk as a dependent variable measured using the Anterior Knee Pain Scale Questionnaire. In addition, to support the identification of PFPS symptoms, NPRS is used to measure the intensity of knee pain as well as the Patellofemoral pain syndrome Risk questionnaire which helps to see what factors may affect the condition of the knee surface and cause pain in the knee area. to assess the degree of impaired function due to knee pain. Before taking measurements, the researcher first explained the purpose of the research and the procedure for taking data to the respondents. After understanding the explanation given, respondents were asked to sign informed consent as a form of consent to participate in the research. Next, height and weight measurements were carried out to obtain BMI values. After that, respondents were asked to fill out the PFPS, NPRS, and AKPS Risk Questionnaires according to their perceived conditions. The data obtained from all instruments were then collected and processed to determine the relationship between BMI and the risk of Patellofemoral Pain Syndrome (PFPS), as well as to provide an overview of the level of pain and limited knee function experienced by the respondents.

1. Overview of Research Samples

The characteristics of the sample in this study were obtained in the form of age, height, weight, BMI, and AKPS score. The presentation of research characteristic data can be seen in the following table.

Table 1. Sample Characteristics Interpretation Results

Characteristics	N	Min.	Max.	Red	SD
Age	80	18	29	20.55	1.813
Weight	80	36	100	57.42	13.071
Height	80	145	177	157.83	6.139
IMT	80	14.8	38.1	23.110	4.8979
Skor_AKPS	80	55	98	71.21	12.535

Source, Primary Data 2026

Based on Table 1, the characteristics of the research sample totaling 80 respondents show that the average age of respondents is 20.55 ± 1.81 years, with an age range of 18–29 years, so that the majority of respondents are included in the category of young adult women. The average weight of the respondents was 57.42 ± 13.07 kg, with the lowest weight being 36 kg and the highest being 100 kg. Meanwhile, the average height of the respondents was 157.83 ± 6.14 cm, with a range of 145–177 cm. Based on the Body Mass Index (BMI) value, an average of 23.11 ± 4.90 kg/m² was obtained, with a minimum value of 14.8 kg/m² and a maximum of 38.1 kg/m², which shows that respondents have a variation in nutritional status ranging from thin to obese. In addition, the AKPS (Anterior Knee Pain Scale) score had an average of 71.21 ± 12.54 , with a minimum score of 55 and a maximum of 98, which illustrates the variation in the level of knee function in the respondents, where the higher the AKPS score indicates better knee function and milder patellofemoral complaints.

a. Sample Characteristics by Age

Based on the results of the descriptive analysis of 80 respondents, the minimum age of respondents was 18 years old and the maximum age was 29 years. The average age of

respondents was 20.55 ± 1.81 years. This shows that the majority of respondents are in the young adult age range, according to the characteristics of the established research sample.

b. Sample Characteristics Based on Body Weight

The results of the analysis showed that the respondents' weight ranged from 36 kg to 100 kg. The average weight of the respondents was 57.42 ± 13.07 kg. The large standard deviation value shows that there is a fairly diverse variation in weight among the study respondents.

c. Sample Characteristics Based on Height

Based on the results of the study, the height of the respondents was in the range of 145 cm to 177 cm, with an average height of 157.83 ± 6.14 cm. These results show that the height of the respondents is relatively variable, but still within the height range of young adult women in general.

d. Sample Characteristics Based on Body Mass Index (BMI) The respondents' BMI values ranged from 14.8 kg/m^2 to 38.1 kg/m^2 , with an average of $23.11 \pm 4.90 \text{ kg/m}^2$. The average BMI is in the normal category according to the Body Mass Index classification for the adult population. However, the fairly wide range of BMI values shows that this study includes respondents with diverse nutritional conditions, ranging from thin to obese.

e. Sample Characteristics Based on AKPS Score

The results of the analysis showed that the respondents' Anterior Knee Pain Scale (AKPS) scores were in the range of 55 to 98, with an average score of 71.21 ± 12.54 . Higher AKPS scores indicate better knee function and milder complaints, while lower scores indicate greater knee function impairment. The average score of 71.21 shows that in general respondents still experience a decline in knee function in mild to moderate level.

Table 2. Distribution of BMI Categories

	Frequency		Presses	Valid Percent	Cumulative Percent
Valid	Underweight/Normal	45	56.3	56.3	56.3
	Overweight/Obesity	35	43.8	43.8	100
	Total	80	100.0	100.0	

Source : Primary Data, 2026

Table 2 Based on table 4.1, 80 respondents surveyed had a non-overweight BMI category (underweight and normal) as many as 45 respondents (56.3%), while respondents with the overweight/obese category amounted to 35 respondents (43.8%). These results show that most of the respondents have BMI in the non-overweight category.

However, the proportion of respondents with the overweight/obese category is also quite large, which is almost half of the number of research samples. This distribution shows that the study sample has variations in BMI categories that can be used to analyze the association between BMI and the risk of Patellofemoral Pain Syndrome (PFPS) in young adult women.

Table 3. Risk Categories

Frequency (n)	Present (%)	Valid Percentage (%)	Cumulative Percentage (%)
15	18.8	18.8	18.8
65	81.3	81.3	100.0
80	100.0	100.0	

Source: Primary Data, 2026

Based on Table 3, out of a total of 80 respondents studied, as many as 15 respondents (18.8%) were included in the category of mild risk PFPS, while 65 respondents (81.3%) were included in the category of high risk of PFPS. The results showed that most respondents were at high risk of developing Patellofemoral Pain Syndrome (PFPS). The high proportion of respondents in the high-risk category indicates that PFPS-related complaints or risk factors are quite common in the study population.

Table 4. Sex Distribution

Gender	Frequency (n)	Percentage (%)
Women	80	100
Male	0	0
Total	80	100

Source : Primary Data, 2026

Based on Table 4, all respondents in this study numbered 80 people (100%) and all were female, while male respondents were not included in this study. This shows that the study is focused on young adult women in accordance with the inclusion criteria that have been set by the researchers.

Table 5. Distribution of Respondents' Physical Activity

Physical Activity	Yes (n)	%	No (n)	%
Regularly do physical activity	75	93,75	5	6,25
Warming up before exercise	4	5,00	76	95,00
Sudden increase in exercise intensity	51	63,75	29	36,25
Stay active when your knees are uncomfortable	70	87,50	10	12,50

Source, Primary Data 2026

Based on Table 5, out of 80 respondents, as many as 75 respondents (93.75%) routinely do physical activity, while 5 respondents (6.25%) do not do it regularly. Only 4 respondents (5.00%) warmed up before exercising, while 76 respondents (95.00%) did not warm up. In addition, 51 respondents (63.75%) admitted to increasing their exercise intensity suddenly, while 29 respondents (36.25%) did not. A total of 70 respondents (87.50%) continued to do activities even though their knees felt uncomfortable, while 10 respondents (12.50%) chose not to do activities in these conditions. These results show that most respondents have physical activity habits that have the potential to increase the risk of PFPS.

Table 6. Frequency of Physical Activity per Week

Frequency of Activity	N	%
1–2 times/week	10	12,50
3–4 times/week	60	75,00
>4 times/week	10	12,50
Total	80	100

Source, Primary Data 2026

Based on Table 6, most of the respondents did physical activity 3-4 times per week, which was 60 respondents (75.00%). Meanwhile, each of the 10 respondents (12.50%) did physical activity 1-2 times per week and more than 4 times per week. These results show that the majority of respondents have a fairly high frequency of physical activity in one week.

Table 7. Types of Physical Activity

Activity Type	N	%
Walk	16	20,00
Run	14	17,50

Up and down the stairs	40	50,00
Heavy sports	10	12,50
Total	80	100

Source, Primary Data 2026

Based on the table of physical activity types, the most active activities carried out by respondents were up and down the stairs, which was as many as 40 respondents (50.00%). Furthermore, it was followed by walking activities as many as 16 respondents (20.00%), running as many as 14 respondents (17.50%), and heavy sports as many as 10 respondents (12.50%). These results show that activities that put repetitive loads on the knee joint are the most frequent activities performed by respondents.

Table 8. Distribution of pain in the front of the knee

Categories	n	%
No	10	12,50
Sometimes	29	36,25
Frequent	41	51,25
Total	80	100

Source, Primary Data 2026

Based on Table 8, as many as 41 respondents (51.25%) stated that they often experienced pain in the front of the knee. Furthermore, 29 respondents (36.25%) stated that they sometimes experienced pain, while 10 respondents (12.50%) stated that they did not experience pain in the front of the knee. These findings show that more than half of the respondents have complaints of anterior knee pain which is one of the main characteristics of PFPS.

Table 9. Symptom Distribution of PFPS

Symptoms of Knee Pain	Yes (n)	%	No (n)	%
Pain when sitting for a long time with a knee position bend (>30 minutes)	70	87,50	10	12,50
Pain when squatting	69	86,26	11	13,75
Pain when running or walking brisk	50	62,50	30	37,50
A "click" sound is heard on the knee	68	85,00	12	15,00
Knees feel weak or unstable	4	5,00	76	95,00
Often carrying heavy weights when walking or climbing stairs	76	95,00	4	5,00
Frequent repetitive squat movements	78	97,50	2	2,50
Frequent jumping or running activities	75	93,75	5	6,25

Source, Primary Data 2026

Based on Table 9, most respondents reported the presence of symptoms leading to PFPS. The most common symptoms experienced were frequent squatting movements as many as 78 respondents (97.50%), followed by often carrying heavy weights when walking or climbing stairs as many as 76 respondents (95.00%), pain when sitting for a long time with bent knees as many as 70 respondents (87.50%), pain when squatting as many as 69 respondents (86.26%), and clicking sound on the knees as many as 68 respondents (85.00%). In addition, 50 respondents (62.50%) experienced pain when running or walking briskly. In contrast, only 4 respondents (5.00%) reported that their knees felt weak or unstable. These results showed that the majority of respondents had a variety of symptoms that corresponded to the characteristics of Patellofemoral Pain Syndrome.

Table 10. Distribution of pain when going up and down stairs

Categories	N	%
No	5	6,25
Lightweight	10	12,50
Medium	50	62,50
Height	15	18,75
Total	80	100

Source, Primary Data 2026

Based on Table 10, most of the respondents experienced moderate pain when going up and down the stairs, namely 50 respondents (62.50%). Furthermore, 15 respondents (18.75%) experienced high pain, 10 respondents (12.50%) experienced mild pain, and only 5 respondents (6.25%) did not experience pain. These results show that the activity of going up and down stairs is still the activity that most often causes pain complaints in the study respondents.

Table 11. Distribution of Additional Risk Factors

Additional Risk Factors	Yes (n)	%	No (n)	%
Frequent use of high heels	40	50,00	40	50,00
Have a history of knee injury	45	56,25	35	43,75
The knee position tends to go inward (valgus)	75	93,75	5	6,25

Source: Primary Data 2026

Based on Table 11, as many as 40 respondents (50.00%) often use high heels, while the other 40 respondents (50.00%) do not. A total of 45 respondents (56.25%) had a history of knee injury, while 35 respondents (43.75%) had no history of injury. In addition, 75 respondents (93.75%) had a tendency to knee position inward (valgus), while only 5 respondents (6.25%) did not have this condition. These findings show that most respondents have additional risk factors that potentially increase the likelihood of Patellofemoral Pain Syndrome (PFPS).

Table 12. Relationship of BMI to AKPS Score

		IMT	Skor_AKPS
IMT	Pearson Correlation	1	-.408
	Sig.		.000
	N	80	80
Skor_AKPS	Pearson Correlation	-.408	1

Source: Primary Data, 2026

Based on the results of the Pearson correlation test, the correlation coefficient value (r) was -0.408 with a significance value (Sig. (2-tailed)) of 0.000 and the number of samples (N) was obtained as many as 80 respondents. Since the value of $p = 0.000 < 0.05$, H_0 is rejected and H_1 is accepted, so there is a significant relationship between Body Mass Index (BMI) and AKPS score in young adult women.

A correlation coefficient value of -0.408 indicates a negative relationship with moderate strength. A negative sign means that the relationship between the two variables is in the opposite direction, that is, the higher the BMI value, the lower the AKPS score. Since lower AKPS scores indicate poorer knee function or more severe patellofemoral complaints, these results indicate that increased BMI is related to decreased knee function.

Table 13. Relationship between BMI and NPRS

Variable		IMT	NPRS
IMT	Pearson Correlation	1	.183
	Sig.		.104
	N	80	80
NPRS	Pearson Correlation	.183	1
	Sig.	.104	
	N	80	80

Source: Primary Data, 2026

Based on Table 13, the results of the Pearson correlation test show a correlation coefficient value (r) of 0.183 with a significance value (p) of 0.104. The value of the positive correlation coefficient shows that there is a tendency to have a unidirectional relationship between BMI and NPRS, that is, the higher the BMI, the pain score tends to increase. However, the significance value obtained was greater than 0.05 ($p = 0.104$), so the relationship was not statistically significant. Thus, it can be concluded that there is no significant relationship between Body Mass Index (BMI) and pain levels measured using the Numeric Pain Rating Scale (NPRS) in young adult women.

Table 14. Chi-Square Tests IMT and AKPS

Statistical Test	Value	df	Signi Values	Sign 2	Conclusion
Chi-Square Pearson	13,768	1	0,000	-	-
Continuity Correction	11,838	1	0,001	-	-
Likelihood Ratio	16,557	1	0,000	-	-
Fisher's Exact Test	-	-	-	0,000	0,000
Linear and Linear Association	13,596	1	0,000	-	-

Data Source : Primary Data, 2026

Based on the results of the Chi-Square test in Table 14, the Pearson Chi-Square value of 13.768 was obtained with a degree of freedom (df) = 1 and a significance value (p -value) <0.001. Because the p -value is less than 0.05, H_0 is rejected and H_1 is accepted, so there is a statistically significant relationship between Body Mass Index (BMI) and AKPS scores in young adult women. These results show that the BMI category is related to knee function conditions measured using the Anterior Knee Pain Scale (AKPS).

In addition, the Continuity Correction value showed $p = 0.001$, while the Likelihood Ratio, Fisher's Exact Test, and Linear-by-Linear Association also produced a value of $p < 0.001$, so that all tests gave a consistent conclusion, namely that there is a significant relationship between BMI and AKPS.

2. Hypothesis Interpretation

H_0 : There was no association between Body Mass Index (BMI) and AKPS in young adult women.

H_1 : There is a relationship between Body Mass Index (BMI) and AKPS in young adult women.

Result: Since the value of $p < 0.05$, H_0 is rejected and H_1 is accepted. Thus, it can be concluded that there is a significant relationship between Body Mass Index (BMI) and AKPS in young adult women.

This study is a quantitative descriptive study, with an observational analytical design conducted to determine the relationship between Body Mass Index (BMI) and the risk of Patellofemoral Pain Syndrome (PFPS). The number of samples in this study was as many as

80 respondents who were taken from students of Esa Unggul Kebon Jeruk University using purposive sampling techniques. This technique is used so that the sample involved in the research is in accordance with the inclusion and exclusion criteria that have been set and can support the achievement of research objectives. The data obtained were then analyzed to determine the relationship between BMI categories and PFPS risk in respondents.

1. Overview of respondent characteristics

The results showed that all respondents (100%) were female. This is in accordance with the inclusion criteria of the study which does focus on young adult women. The selection of women as respondents was based on the high incidence of Patellofemoral Pain Syndrome (PFPS) in women compared to men. Females have a wider anatomical structure of the pelvis resulting in a larger quadriceps (Q-angle). This condition increases the lateral force on the patella, causing increased pressure on the patellofemoral joint and increasing the risk of PFPS. In addition, hormonal influences, weakness of the quadriceps and hip abductors muscles, and suboptimal neuromuscular control also contribute to the increased incidence of PFPS in women. The results of this study are in line with the research of Crossley et al. (2016) and Neal et al. (2019) which stated that young adult women are the group with a higher prevalence of PFPS than men.

According to biomechanical theory, the patellofemoral joint receives a considerable load during daily activities. When walking, the compressive force in the patellofemoral joint can reach 0.5 times the body weight, increase to about 3–4 times the body weight when climbing stairs, and reach more than 7 times the body weight when squatting. Therefore, weight gain due to overweight or obesity will increase the compressive force in the patellofemoral joint so that it can increase the risk of PFPS.

2. Respondent's Physical Activity

Based on the results of the study, most of the respondents routinely do physical activity, but the majority do not warm up before exercising, increase the intensity of exercise suddenly, and continue to do activities even though their knees feel pain. This condition is a factor that can increase the mechanical load on the patellofemoral joint so that it has the potential to cause microtrauma due to repeated use (overuse). Physical activity that is done without warming up causes muscles and soft tissues to not be ready to accept the load, increasing the risk of injury. Similarly, a sudden increase in activity intensity causes muscle and joint adaptation to be suboptimal. These findings are in line with Crossley et al. (2016) who stated that overuse is one of the main factors causing PFPS at a young age who is physically active.

3. Frequency of Physical Activity

The majority of respondents did physical activity 3–4 times in one week. A high enough frequency of activity can increase repetitive pressure on the patellofemoral joint, especially if the activity involves repetitive knee flexion movements such as running, going up and down stairs, or squatting. Although physical activity has health benefits, high frequency without proper technique and adequate recovery time can increase the risk of PFPS. These results support the research of Willy et al. (2019) who stated that increasing the frequency of activity with repetitive loads is a risk factor for the development of patellofemoral pain.

4. Types of Physical Activity

The most common activity that respondents did was going up and down the stairs. This activity puts considerable pressure on the patellofemoral joint because the joint reaction force

increases several times compared to normal walking. In addition, running and strenuous exercise also increase the compressive load on the patellar surface. Therefore, the more often a person performs these activities, the greater the likelihood of complaints of anterior knee pain. These findings are in accordance with the theory put forward by Powers (2010) that weight bearing activity with repetitive knee flexion is the most frequent activity that triggers PFPS.

5. Anterior Knee Pain

Most respondents reported frequent pain in the front of the knee. Anterior knee pain is the main symptom of PFPS that usually appears when doing activities that increase pressure on the patellofemoral joint, such as going up and down stairs, squatting, running, or sitting for long periods of time. The pain occurs due to increased pressure between the patellar surface and the femur which causes irritation of the tissues around the joint. The results of this study support the theory of Crossley et al. (2016) who state that anterior knee pain is the main clinical manifestation in people with PFPS.

6. Symptoms that lead to PFPS

Most respondents showed various symptoms that lead to PFPS, such as pain when squatting, pain when sitting for a long time with the knees bent, carrying heavy weights when walking or climbing stairs, and the appearance of clicking sounds in the knees. These symptoms describe an increase in pressure on the patellofemoral joint due to activities involving repetitive knee flexion. The more symptoms a person experiences, the more likely it is that the individual will experience impaired patellofemoral joint function. These findings are in accordance with the guidelines of the International Patellofemoral Pain Research Retreat which states that these activities are the main characteristics of PFPS.

7. Pain when going up and down the stairs

The results showed that most of the respondents experienced moderate pain when going up and down the stairs. Climbing and going up stairs is an activity that produces a high enough compressive force in the patellofemoral joint so that it is often used as one of the clinical examinations for PFPS. When the knee is flexibly flexed by about 60°–90°, the pressure between the patella and femur increases, causing pain in individuals with patellofemoral disorders. The results of this study are in accordance with Powers (2010) who explained that the activity of going up and down stairs is one of the activities that most often trigger the onset of pain in PFPS.

8. Additional Risk Factors

This study showed that most of the respondents had additional risk factors in the form of a history of knee injury, valgus knee position, and the use of high heels. The position of the valgus knee causes a change in the alignment of the lower extremity thereby increasing the lateral force on the patella. A history of injury can also lead to muscle weakness and biomechanical changes in the knee. Meanwhile, the use of high heels changes the distribution of body weight and increases pressure on the knee joint. These factors are known to contribute to the increased risk of PFPS as described by Willy et al. (2019) and Crossley et al. (2016).

9. The relationship between body mass index and NPRS

Correlation analysis showed a value of $r = 0.183$ with $p = 0.104$ so there was no significant relationship between BMI and pain level.

Although there is a tendency that respondents with higher BMI experience greater pain, the association does not reach statistical significance. This suggests that the level of pain in PFPS is not only affected by weight. Pain in PFPS is influenced by various factors, including nervous system sensitivity, level of physical activity, duration of symptoms, individual adaptation to pain, psychological conditions, and the presence of biomechanical disorders in the lower extremities. Therefore, a person with a normal BMI can still experience high pain if they have patellar tracking disorders or muscle weakness around the pelvis and knees. In addition, the measurement of NPRS is subjective so it is greatly influenced by each individual's perception of the pain felt.

10. Relationship of BMI to Anterior Knee Pain Scale based on Chi Square test

Based on the results of the Chi-Square test in Table 4.14, the Pearson Chi-Square value of 13.768 was obtained with $df = 1$ and significance value ($p = 0.000$). Since the significance value was less than 0.05 ($p < 0.05$), H_0 was rejected and H_1 accepted, so it can be concluded that there is a significant relationship between Body Mass Index (BMI) and knee function based on the Anterior Knee Pain Scale (AKPS) in young adult women. The results of the supporting tests, namely Continuity Correction ($p = 0.001$), Likelihood Ratio ($p = 0.000$), Fisher's Exact Test ($p = 0.000$), and Linear-by-Linear Association ($p = 0.000$) also showed consistent results, thus reinforcing that the relationship between the two variables is significant.

The results of this study show that the BMI category is related to the knee function category. Respondents with higher BMI tended to be more in the category of poor knee function than respondents with normal BMI. This condition can be explained biomechanically, where the increase in weight causes the load to be received by the patellofemoral joint to be greater during daily activities, such as walking, going up and down stairs, running, and squatting. The increased load will increase pressure on the patella cartilage and surrounding soft tissues so that it can cause pain and decreased knee function.

11. Relationship of BMI to AKPS Score based on Pearson Correlation test

The results of bivariate analysis using the Pearson correlation test showed a significant relationship between Body Mass Index (BMI) and AKPS score ($r = -0.408$; $p < 0.001$). The value of the negative correlation coefficient shows that the higher the respondent's BMI, the lower the AKPS score. A low AKPS score illustrates decreased knee function and increased patellofemoral complaints. Biomechanically, an increase in BMI leads to an increase in the load that the patellofemoral joint receives during daily activities, thereby increasing the pressure on the patellofemoral cartilage and surrounding tissues. This condition can cause pain and decreased knee function. The results of this study are in line with the research of Neal et al. (2019), Hart et al. (2017), and Collins et al. (2018) which reported that individuals with higher BMI tended to have poorer knee function and more severe PFPS complaints.

12. Research limitations

a. Cross-Sectional Research Design

The study used a cross-sectional design, so that BMI and knee function measurements using the Anterior Knee Pain Scale (AKPS) were performed at one time. Therefore, studies can only show relationships between variables and cannot determine cause-and-effect relationships.

b. Purposive sampling technique

Sampling uses purposive sampling techniques, so respondents are selected based on certain criteria. This causes the results of the study not necessarily to be generalized to the entire population of young adult women.

Use of questionnaires as a source of risk factor data Information about PFPS risk factors, such as physical activity, use of high heels, history of knee injury, and daily habits, was obtained through questionnaires. The data can be influenced by the respondents' honesty, understanding, and ability to remember, thus allowing recall bias to occur.

c. Physical activity has not been studied in more detail

The study has not examined the physical activity of the respondents in more depth, such as the type of activity or exercise, frequency, duration, intensity, and activity load. In fact, these physical activity characteristics can affect knee function and the risk of PFPS.

d. Characteristics of Limited Respondents

The study only involved young adult women, so the results of the study could not be directly applied to men or other age groups.

e. Not Controlling All Of The Confounding Factors

Studies have not controlled for several other factors that can affect knee function, such as quadriceps and hip muscle strength, muscle flexibility, lower extremity alignment (Q-angle and dynamic knee valgus), and duration and intensity of physical activity.

CONCLUSION

Based on the results of a study involving 80 young adult women at Esa Unggul University, it was found that the majority of respondents had non-overweight BMI categories (56.3%), while most respondents were classified as having a high risk of Patellofemoral Pain Syndrome (PFPS) (81.3%). These findings indicate that many respondents had risk factors potentially associated with PFPS, including repetitive physical activity, inadequate warm-up before exercise, sudden increases in activity intensity, and tendencies toward knee valgus alignment. Pearson's correlation analysis showed a significant relationship between BMI and knee function scores based on the Anterior Knee Pain Scale (AKPS) ($p < 0.05$), with a negative correlation indicating that higher BMI was associated with lower AKPS scores and reduced knee function. Furthermore, the Chi-square test demonstrated significant associations between BMI categories and PFPS risk categories, as well as between BMI categories and AKPS-based knee function categories ($p < 0.05$). Therefore, this study concluded that BMI was associated with PFPS risk and decreased knee function among young adult women.

Based on these findings, young adult women are recommended to maintain an optimal BMI through balanced nutritional intake and regular physical activity, as well as performing proper warm-up exercises and gradually increasing exercise intensity to reduce PFPS risk. Physiotherapists are expected to provide education regarding PFPS risk factors, conduct early screening among individuals with elevated BMI, and develop appropriate exercise programs to improve knee function. Further research is recommended to involve larger and more diverse samples and to consider additional factors, such as muscle strength, flexibility, lower-extremity biomechanics, and physical activity levels, to obtain a more comprehensive understanding of factors associated with PFPS.

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