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Analysis of Q-Angle as a Risk Factor for Patellofemoral Pain Syndrome in Volleyball Athletes: A Cross-Sectional Study

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Abstract
Introduction: Patellofemoral Pain Syndrome (PFPS) is a common knee injury caused by excessive loading during knee flexion, such as running or jumping, frequently experienced by volleyball athletes. One of the primary risk factors is an increased Q-angle, which leads to patellar maltracking and knee malalignment, particularly of the patella, resulting in uneven load distribution on the knee joint. This study aims to determine the relationship between Q-angle and PFPS in volleyball athletes in Karangasem.
Methods: This cross-sectional study employed purposive sampling, involving 51 male volleyball athletes aged 18–35 in Karangasem. Q-angle measurements were conducted using a goniometer in a supine position with knee extension. At the same time, PFPS diagnosis was determined using Waldron's Test, with pain criteria upon patellar compression during knee flexion in a supine position and squatting. Data were analyzed using the Chi-square test.
Results: Chi-square analysis revealed a significant relationship between Q-angle and PFPS in the right knee (p=0.003, OR=14.22, 95% CI=1.69–119.62) and left knee (p=0.004, OR=8.50, 95% CI=1.68–42.98). These findings indicate that athletes with an excessive Q-angle have a higher risk of developing PFPS.
Conclusion: A significant association exists between an increased Q-angle and PFPS in volleyball athletes in Karangasem. However, the limitations of the cross-sectional design prevent determining a causal relationship.

Keywords: Q-angle, patellofemoral pain syndrome, volleyball athletes

Introduction
The knee is a crucial region, a significant joint bearing most of the human body's weight. Excessive loading on the knee due to high-intensity activities can lead to various complaints or injuries in the knee area, including Patellofemoral Pain Syndrome (PFPS).[1] PFPS is pain around the anterior knee when the patella bears a load, particularly during flexion or bending.[2] The pain worsens during activities such as running, climbing stairs, jumping, squatting, and other strenuous activities, which can hinder daily functioning.

Individuals with high physical activity levels are at a greater risk of developing PFPS. A study conducted on individuals with high activity levels, specifically runners in Badung and Denpasar, reported a high prevalence of PFPS, with 17 knees affected out of 45 participants, equivalent to 37.8%.[3] PFPS is among the most frequently reported complaints among young adults and adolescents, especially athletes. It has been reported that nearly 25%–30% of all sports injuries and up to 40% of clinical visits for knee problems are related to PFPS.[4] An observational study involving 810 adolescent athletes found an overall PFPS prevalence of 25%, with 18% in male athletes and 26% in female athletes. Two-thirds of adolescents with PFPS were reportedly active athletes, engaging in sports five times a week.[5] The high incidence of PFPS in athletes highlights its significance as a serious issue requiring further research. Volleyball is a sport that involves frequent jumping movements, particularly during serves and smashes, which impose additional stress on the knee. This increases the risk of knee injuries and complaints, including PFPS.[6]

Various intrinsic and extrinsic factors cause PFPS. Intrinsic factors are related to individual characteristics, such as knee morphology, sex, Q-angle, hip muscle weakness, joint laxity, and patellar imbalance. Extrinsic factors, on the other hand, pertain to external influences on the human body.[4] No study has definitively identified the primary risk factor responsible for PFPS.

Several studies have indicated that an increased quadriceps angle (Q-angle) is one of the contributing factors to PFPS. The Q-angle is the angle between a line drawn from the anterior superior iliac spine (ASIS) to the mid-patella and another from the tibial tuberosity to the mid-patella.[7] A larger Q-angle increases the lateralization force on the patella, leading to more significant retro patellar pressure between the lateral femoral condyle and the lateral aspect of the patella. This increased pressure raises the risk of PFPS and, over time, may contribute to patellofemoral joint cartilage degeneration.[8] This mechanism explains how biomechanical changes in the Q-angle can contribute to PFPS risk, particularly in athletes engaged in high-load activities involving the knee, such as volleyball.

Another study reported that a 10% increase in the Q-angle can elevate pressure on the patellofemoral joint by 45%.[7] Similarly, research conducted on female basketball players at Universitas Muhammadiyah Surakarta found a strong association between Q-angle and the risk of PFPS.[9] However, conflicting findings exist, with some studies reporting no significant relationship between Q-angle and PFPS occurrence. For instance, a study involving 22 women aged 19–45 found that excessive Q-angle did not significantly increase the risk of PFPS.[7] These discrepancies may be attributed to variations in measurement methods, sample characteristics, and other factors such as sex and body mass index (BMI).[10]

Given the limited research on this topic, this study aims to investigate further the relationship between Q-angle and PFPS in male volleyball athletes. The findings may serve as a reference for athletes and physiotherapists in preventing PFPS. This study uses a cross-sectional design to analyze the association between Q-angle and PFPS risk in male volleyball athletes in Karangasem. Q-angle measurements will be performed using a goniometer, and PFPS diagnosis will be determined through Waldron’s Test. The study hypothesizes a significant relationship between increased Q-angle and the occurrence of PFPS in male volleyball athletes in Karangasem. It is assumed that the larger the Q-angle, the higher the risk of PFPS in male volleyball athletes.

Methods

This study employs an analytical observational method with a cross-sectional approach, where the independent variable is the Q-angle, and the dependent variable is PFPS. The cross-sectional method was chosen as it allows for analyzing the relationship between Q-angle and PFPS at a single point without requiring interventions or long-term observations. The study was conducted at Gelanggang Olahraga (GOR) Gunung Agung, Karangasem, the primary training center for Karangasem volleyball athletes, providing access to the target population in June 2024.

The sampling technique used in this study was purposive sampling, with 51 participants who were volleyball athletes from Karangasem. The sample size was determined based on a previous survey by Naufal et al., which found that at least 30 samples were required to detect a significant relationship between Q-angle and PFPS.[9]

Bias control was implemented by adjusting for factors such as sex, age, BMI, volleyball playing intensity, and selection through inclusion and exclusion criteria. The inclusion criteria for this study were as follows: male volleyball athletes aged 18–35 years, as this age group represents the physically active productive age with a higher risk of PFPS; a regular Body Mass Index (BMI) according to the Indonesian Ministry of Health (18.5–25 kg/m²); and voluntary participation in the study by signing the informed consent form. Meanwhile, the exclusion criteria included athletes who were no longer actively playing volleyball, had a history of lower extremity surgery, patellar dislocation and/or subluxation, a history of rheumatoid arthritis, osteoarthritis, and/or gout arthritis in the knee area, as well as ligament, meniscus, and/or bursa disorders, which were assessed through specific tests such as the Fluctuation test, Ballottement test, McMurray test, Drawer test, and Bounce Home test.

The research procedure began by providing participants with information about the study, including its objectives, benefits, and procedures, followed by obtaining informed consent. Next, a general anamnesis was conducted to collect data on name, age, sex, weight, height, playing intensity, and history of lower extremity conditions. This was followed by Q-angle measurement and PFPS assessment. The Q-angle was measured in degrees using a goniometer, performed by two independent examiners to minimize measurement bias, with the final value averaged. PFPS was diagnosed using Waldron’s test, with pain in the knee during the test serving as the diagnostic criterion. The goniometer has an intraclass correlation coefficient (ICC) of 0.79–0.90, indicating high reliability and stability as a measurement tool for Q-angle.[7]

Following data collection, statistical analysis was conducted using IBM SPSS 27.0, including univariate and bivariate analyses. Univariate analysis aimed to determine each variable's characteristics and frequency distribution, including age, sex, BMI, playing intensity, Q-angle measurements on the right and left knees, and the presence or absence of PFPS in both knees. Bivariate analysis was used to examine the relationship between Q-angle and PFPS occurrence using the Chi-square test, as both Q-angle (normal, abnormal) and PFPS (yes, no) are categorical variables, making this test suitable for analyzing their association. Additionally, the odds ratio (OR) was calculated to determine the strength of the relationship between the two variables. This study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Universitas Udayana, with ethical approval number 0612/UN14.2.2.VII.14/LT/2024.

Results

From a total accessible population of 56 volleyball athletes in Karangasem, 51 met the inclusion criteria, while five athletes were excluded due to a history of knee injuries. Thus, the final study sample comprised 51 subjects with no missing data. The research flowchart is shown in Figure 1.

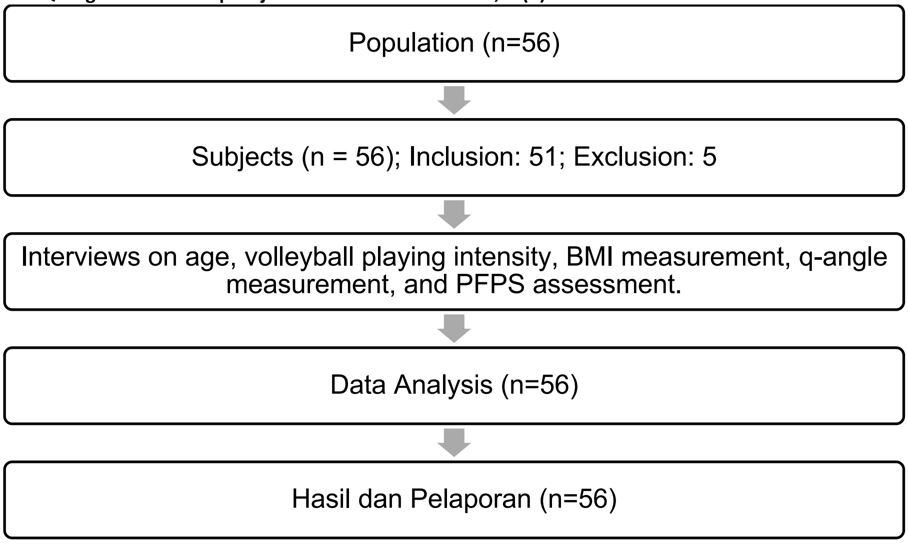

Figure 1. Flowchart

The characteristics of the study subjects, including age, BMI, playing intensity, Q-angle measurements, and the presence of PFPS, are presented in Tables 1–3.

Table 1. Subject Characteristics by Age, BMI, and Playing Intensity

Variable	Frequency (n)	Percentage (%)
Age (years)		
18–23	42	82.4
24–29	7	13.7
30–35	2	3.9
BMI		
Normal	51	100
Playing Intensity (sets/week)		
Low (<6)	1	2
Moderate (6–11)	24	47.1
High (12–30)	26	51
Total	51	100

Most subjects (82.4%) were in the 18–23 age range, and all had a normal BMI (100%). Regarding playing intensity, most subjects (51.0%) had a high intensity of volleyball play (12–30 sets per week), suggesting a higher risk of knee injuries due to repetitive knee loading.

Table 2. Subject Characteristics by Q-angle Measurements on Right and Left Knees

Knee Side	Q-angle	Frequency (n)	Percentage (%)
Right	Normal	17	33.3
	Abnormal	34	66.7
Left	Normal	19	37.3
	Abnormal	32	62.7
Both Sides	Normal	10	19.6
	Abnormal (both knees)	25	49.0
	Abnormal (one knee)	16	31.4

Most subjects had an abnormal Q-angle on the right knee (66.7%) and left knee (62.7%). Additionally, 49% of subjects had abnormal Q-angles in both knees, while 31.4% had an abnormal Q-angle in one knee only.

Table 3. Subject Characteristics by Presence of PFPS

Knee Side	PFPS	Frequency (n)	Percentage (%)
Right	Yes	16	31.4
	No	35	68.6
Left	Yes	18	35.3
	No	33	64.7
Both Sides	Yes	7	13.7
	No	24	47.1
	PFPS (one knee)	20	39.2

Among the subjects, 31.4% experienced PFPS in the right knee, while 35.3% had PFPS in the left knee. Additionally, 13.7% had PFPS in both knees, and 39.2% had PFPS in only one knee.

Table 4. Relationship Between Q-angle and PFPS in the Right Knee

Q-angle (Right Knee)	PFPS (Right Knee)	Total	p-value	OR (95% CI)
Abnormal	Yes (16, 47.1%)	No (18, 52.9%)	34 (100%)	
Normal	Yes (1, 5.9%)	No (16, 94.1%)	17 (100%)	0.003
Total	17 (33.3%)	34 (66.7%)	51 (100%)	

The Chi-square test yielded a p-value of 0.003 ($p<0.05$), indicating a significant relationship between Q-angle and PFPS in the right knee. The odds ratio (OR) was 14.22, meaning that athletes with an abnormal Q-angle in the right knee were 14.22 times more likely to develop PFPS than those with a normal Q-angle (95% CI: 1.69–119.62).

Table 5. Relationship Between Q-angle and PFPS in the Left Knee

Q-angle (Left Knee)	PFPS (Left Knee)	Total	p-value	OR (95% CI)
Abnormal	Yes (16, 50.0%)	No (16, 50.0%)	32 (100%)	
Normal	Yes (2, 10.5%)	No (17, 89.5%)	19 (100%)	0.004
Total	18 (35.3%)	33 (64.7%)	51 (100%)	

For the left knee, the Chi-square test yielded a p-value of 0.004 ($p<0.05$), confirming a significant relationship between Q-angle and PFPS. The odds ratio (OR) was 8.5, meaning that athletes with an abnormal Q-angle in the left knee were 8.5 times more likely to develop PFPS than those with a normal Q-angle (95% CI: 1.68–42.98).

Discussion

Subject Characteristics

This study was conducted at GOR Gunung Agung, Karangasem Regency, targeting male volleyball athletes who were either from Karangasem or held an official Karangasem athlete identification card. The total number of research subjects was 51 athletes, aged between 18 and 35 years, with the dominant age group being 18–23 years (42 subjects, 82.4%). This finding is consistent with a study on male volleyball athletes participating in the Olympic Games and World Championships from 2000 to 2012, which reported that the age range of male volleyball players was 18–36 years.[11] Age can be a contributing factor to an increased risk of injury. PFPS is the most common diagnosis among young and physically active individuals, affecting 25% of athletes, with more than 70% aged between 16 and 25 years.[12] During this period, athletes tend to have high levels of physical activity, leading to a greater risk of injury due to intense training and competitive matches.

Based on the study results, all 51 athletes (100%) had a standard body mass index (BMI). In line with this, a study involving 1,465 male volleyball athletes who participated in the Olympic Games and World Championships from 2000 to 2012 found that their average BMI ranged from 22.5 to 23.4 kg/m².[11] Excess body weight or an overweight BMI in athletes can lead to adverse effects, including a higher risk of injury. Therefore, the normal BMI observed in this study's subjects helps ensure that excessive body weight does not influence the relationship between the Q-angle and PFPS.[13]

Additional data from this study revealed that most subjects had a high level of volleyball playing intensity, with 26 athletes (51.0%) falling into this category. Volleyball is an intermittent, high-intensity sport involving explosive movements.[14] This finding aligns with Iskandar and Wirno (2021), who stated that sessions should be conducted for 3–5 sets, 3–5 times per week to achieve optimal training results.[15] High volleyball playing intensity affects jumping and running activities, increasing the number of knee flexion movements. This, in turn, places more significant stress on the patellofemoral joint, heightening the risk of injury or exacerbating PFPS.[3]

The Q-angle measurements indicated that more research subjects had an abnormal Q-angle in the right knee (34 subjects, 66.7%) compared to the left knee (32 subjects, 62.7%). It was observed that abnormal Q-angle occurrences were higher in the right knee than in the left, which may be influenced by the dominant leg used for support. This finding aligns with a study by Anom (2022) on recreational runners, which showed that 33 out of 45 participants (73.3%) had an abnormal Q-angle in the right knee. Paranjape and Singhania (2019) also stated that an uneven load distribution on the knee joint could result in excessive stress on one knee, increasing susceptibility to injury.[16]

An increased Q-angle is generally associated with a higher risk of knee injuries, including PFPS.[4] In this study, 16 out of 51 subjects (31.4%) experienced PFPS in the right knee, 18 out of 51 subjects (35.3%) in the left knee, and seven subjects (13.7%) in both knees. Reports indicate that nearly 25%–30% of all sports injuries and up to 40% of patients with knee-related issues are linked to PFPS, particularly in running, volleyball, and basketball.[17]

Relationship Between Q-Angle and Patellofemoral Pain Syndrome in Volleyball Athletes

Based on the chi-square test results (Tables 4 & 5), the study found p=0.003 for the right knee and p=0.004 for the left knee. Both p-values indicate statistical significance ($p<0.05$), demonstrating a significant relationship between Q-angle magnitude and patellofemoral pain syndrome (PFPS) in the right and left knees of volleyball athletes in the Karangasem Regency. This finding suggests that a larger Q-angle is associated with an increased risk of PFPS in volleyball athletes, supporting the initial hypothesis that an increased Q-angle correlates with a higher risk of PFPS.

Biomechanically, an excessive Q-angle generates greater lateralization forces on the patella, leading to patellar instability during knee flexion and extension, commonly called maltracking. Maltracking increases friction and abnormal pressure on the patellofemoral joint, causing pain and cartilage damage that leads to PFPS.[18] Patients with PFPS typically exhibit an increased Q-angle, indicating more significant knee valgus, which results in knee malalignment.[19] This malalignment alters the contact location and pressure distribution within the patellofemoral joint, making it physiologically unable to manage excessive stress. The increased pressure between the lateral trochlea and the patella ultimately causes pain, recognized as PFPS. This pressure intensifies in weight-bearing positions during knee flexion, such as squatting, jumping, and running—fundamental activities in volleyball, mainly when performed at high intensity.[20]

The findings of this study align with research conducted by Phatama et al. in 2022, which examined the relationship between anterior knee pain (AKP) or PFPS and Q-angle measurements in Asian female populations.[12] Their study found a significant association between Q-angle magnitude and the occurrence of PFPS in Asian women. Women generally have a more extensive and variable Q-angle than men due to a wider pelvis (gynecoid type), shorter femur, or more laterally positioned tibial tuberosity. Therefore, the study concluded that female subjects may not be ideal for determining a specific relationship between Q-angle and PFPS. Additionally, women tend to have weaker quadriceps, hip external rotators, hip extensors, and hip abductors than men.[21]

The current study is further supported by research by Anom et al. in 2022,[3] which examined the relationship between Q-angle magnitude and PFPS in recreational runners. Their findings demonstrated a significant relationship, with p=0.031 for the right knee and p=0.032 for the left knee. Excessive training can also contribute to injuries in sports involving running, jumping, or high knee-loading movements.[4] Epidemiological studies indicate that patellofemoral pain is most prevalent among active young individuals.[22] Rapid acceleration in athletics or military training is often a key cause of PFPS.[17]

Additional data from research conducted by Naufal et al. in 2020 also demonstrated a strong relationship between Q-angle and PFPS risk in basketball players.[9] Their study highlighted the crucial role of hip abductor weakness in PFPS, as these muscles help control knee Q-angle during dynamic movements, particularly repetitive flexion. Muscle imbalances, such as reduced quadriceps strength—especially in the vastus medialis obliquus (VMO)—contribute to patellar maltracking, which leads to PFPS.[17] Quadriceps muscle tightness can increase pressure between the femur and the patella, while hamstring and gastrocnemius tightness can dynamically enlarge the Q-angle.[23]

This study has significant clinical implications for volleyball athletes, particularly in preventing and managing knee injuries like PFPS. Understanding the relationship between Q-angle and PFPS allows physiotherapists and coaches to identify athletes with abnormal Q-angles and implement appropriate preventive interventions. Training programs focused on strengthening the muscles surrounding the knee, particularly the quadriceps and hip abductors, can help prevent patellar maltracking, a primary cause of PFPS. Moreover, these findings support developing more effective rehabilitation programs for athletes already experiencing PFPS, emphasizing VMO strengthening and reducing dynamic Q-angle through proper biomechanical exercises. Techniques such as safe landing mechanics after jumps and maintaining neutral knee alignment can help minimize excessive knee pressure. Ensuring muscle balance and correct posture during play can reduce knee injury risks and enhance athletic performance.[24]

This study has several limitations that must be considered. It employed a purposive sampling technique, which may affect the generalizability of the findings since the sample was selected based on specific criteria, potentially limiting its representation of a broader population. This study did not analyze other factors contributing to PFPS, such as muscle flexibility, strength, and individual biomechanical habits. The relatively short study duration also restricted long-term monitoring of PFPS progression in subjects. Future research should include advanced diagnostic tools such as MRI to assess PFPS further.

Conclusion

Based on the research findings, it can be concluded that there is a significant relationship between the q-angle and patellofemoral pain syndrome (PFPS) in volleyball athletes in Karangasem. A larger q-angle is associated with a higher risk of PFPS. These findings support the need for early prevention and intervention strategies, focusing on strengthening the quadriceps and hip abductor muscles to reduce the risk of PFPS in volleyball athletes. Additionally, future researchers are encouraged to analyze other biomechanical factors, such as muscle flexibility and quadriceps-hamstring balance, conduct longitudinal studies to observe PFPS progression over an extended period, and evaluate specific interventions for PFPS. This study did not receive funding from government agencies, private entities, or nonprofit organizations.

Author Contribution

Ni Ketut Evitri Widhiantari: Conceptualization, methodology, data collection, data analysis, and manuscript drafting.
M. Widnyana: Supervision, guidance on research design, and critical review of the manuscript.
I Made Jawi: Supervision, validation, and manuscript editing.
Agung Wiwiek Indrayani: Supervision, methodological consultation, and final manuscript review.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Udayana (Approval No. 0611/UN14.2.2.VII.14/LT/2024). All participants provided informed consent prior to data collection.

References

1. Sanchis-Alfonso V, Ramírez-Fuentes C, Roselló-Sastre E, Dye SF, Teitge RA. Pathophysiology of anterior knee pain. In: Patellofemoral Pain, Instability, and Arthritis: Clinical Presentation, Imaging, and Treatment. 2020. p. 93–116.
2. Silva DO, Briani RV, Ferrari D, Pazzinatto MF, Aragão FA, Azevedo FM. Q angle and subtalar pronation are not good predictors of pain and function in subjects with patellofemoral pain syndrome. Fisioter Pesqui. 2015;22:169–75.
3. Anom IGP, Thanaya SAP, Wahyuni N, Andayani NLN. Hubungan Besar Q-Angle Dengan Kejadian Patellofemoral Pain Syndrome Pada Komunitas Pelari Rekreasional Di Kabupaten Badung Dan Kota Denpasar. Maj Ilmiah Fisioter Indones. 2022;10(1):58.
4. Halabchi F, Abolhasani M, Mirshahi M, Alizadeh Z. Patellofemoral pain in athletes: clinical perspectives. Open Access J Sports Med. 2017;8:189–203.
5. Rathleff MS. Patellofemoral pain during adolescence: much more prevalent than appreciated. Br J Sports Med. 2016;50(14):831–2.
6. Mardela R, Syukri A. Hubungan Daya Ledak Otot Tungkai Dan Koordinasi Mata-Tangan Dengan Kemampuan Jump Service Atlet Bolavoli Putra Tim Universitas Negeri Padang. J Performa Olahraga. 2016;1(1):28–47.
7. Almeida GPL, França FJR, Magalhães MO, Burke TN, Marques AP. Q-angle in patellofemoral pain: relationship with dynamic knee valgus, hip abductor torque, pain and function. Rev Bras Ortop. 2016;51:181–6.
8. Freedman BR, Brindle TJ, Sheehan FT. Re-evaluating the functional implications of the Q-angle and its relationship to in-vivo patellofemoral kinematics. Clin Biomech. 2014;29(10):1139–45.
9. Naufal AF, Khasanah DA, Noviyana U. Derajat Quadriceps Angle Mempengaruhi Patellofemoral Pain Syndrome. J Fisioter Rehabil. 2020;4(1):72–8.
10. Skouras AZ, Kanellopoulos AK, Stasi S, Triantafyllou A, Koulouvaris P, Papagiannis G, et al. Clinical significance of the static and dynamic Q-angle. Cureus. 2022;14(5):e24752.
11. Palao JM, Manzanares P, Valadés D. Anthropometric, physical, and age differences by the player position and the performance level in volleyball. J Hum Kinet. 2014;44:223–9.
12. Phatama KY, Isma SPP, Devi LK, Siahaan LD, Pribadi A, Pradana AS, et al. Relationship of anterior knee pain with quadriceps angle and anthropometric measurements in an Asian female population. Malays Orthop J. 2022;16(2):95–101.
13. Arjuna F. Pengaruh latihan sirkuit dengan interval istirahat tetap dan menurun terhadap komposisi tubuh pemain bola voli putri. Medikora J Ilm Kesehat Olahraga. 2020;19(1):8–16.
14. Wu X. High-intensity interval training impacts on the endurance of volleyball players. Rev Bras Med Esporte. 2023;29:e2023_0047.
15. Iskandar H, Wirno M. Pengaruh latihan dumbbell terhadap kemampuan servis atas dalam permainan bola voli pada siswa SMP Negeri 2 Tomini. Tadulako J Sport Sci Phys Educ. 2021;9(2):63–9.
16. Paranjape S, Singhania N. Effect of body positions on quadriceps angle measurement. SciMed J. 2019;1(1):20–4.
17. Wiguna GLNAA, Setiawan CR. Patellofemoral pain syndrome: literature review. Int J Sci Res Publ. 2022;12(5):21.
18. Papadopoulos K, Stasinopoulos D, Ganchev D. A systematic review of reviews on patellofemoral pain syndrome. Exploring the risk factors, diagnostic tests, outcome measurements, and exercise treatment. Open Sports Med J. 2015;9(1):7–17.
19. Yazdi H, Nazarian A, Wu JS, Amiri A, Hafezi P, Babikian M, et al. Different references for valgus cut angle in total knee arthroplasty. Arch Bone Jt Surg. 2018;6(4):289.
20. Gaitonde DY, Ericksen A, Robbins RC. Patellofemoral pain syndrome. Am Fam Physician. 2019;99(2):88–94.
21. Lin YH, Chang FS, Chen KH, Huang KC, Su KC. A mismatch between femur and tibia coronal alignment in the knee joint: classification of five lower limb types according to femoral and tibial mechanical alignment. BMC Musculoskelet Disord. 2018;19:1–9.
22. Rothermich MA, Glaviano NR, Li J, Hart JM. Patellofemoral pain: epidemiology, pathophysiology, and treatment options. Clin Sports Med. 2015;34(2):313–27.
23. Petersen W, Rembitzki I, Liebau C. Patellofemoral pain in athletes. Open Access J Sports Med. 2017;8:143–54.
24. Jellad A, Kalai A, Guedria M, Jguirim M, Elmhamdi S, Salah S, et al. Combined hip abductor and external rotator strengthening and hip internal rotator stretching improves pain and function in patients with patellofemoral pain syndrome: a randomized controlled trial with crossover design. Orthop J Sports Med. 2021;9(4):2325967121989729.