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Enhancing Lower Limb Power in Volleyball Players: Countermovement Jump vs. Calf Raise – A Controlled Experimental Study

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Abstract

Introduction: Lower limb power is a crucial factor in the jumping performance of volleyball players. Recurrent injuries can reduce lower limb power, necessitating effective training methods. Countermovement jump and calf raise exercises are commonly used to improve lower limb power; however, their comparative effectiveness has not been extensively studied experimentally.
Methods: This study employed a randomized controlled trial with a pretest-posttest two-group design. Twenty-two students aged 15–17 from a high school in Yogyakarta were randomly selected using simple random sampling. The intervention lasted four weeks, with sessions held three times per week. Lower limb power was assessed using the vertical jump test. Inclusion criteria comprised students actively playing volleyball without a history of injury in the past three months. Exclusion criteria included participants with medical conditions limiting physical activity or not completing the training sessions. Data were analyzed using paired t-tests and independent t-tests in SPSS 26.
Results: Countermovement jump was more effective than calf raises in enhancing lower limb power, with an average increase of 4.64 cm (12.3%) compared to 2.64 cm (7.2%) in the calf raise group (p = 0.002, effect size = Cohen's d = 1.02).
Conclusion: Countermovement jump is proven more effective than calf raises in improving lower limb power in volleyball players. This exercise can be considered a primary method in athletic performance enhancement programs.

Keywords: Countermovement Jump, Calf Raise, Lower Limb Power, Volleyball Players, Plyometric Training

Introduction

Lower limb power is a crucial factor in the performance of volleyball athletes, particularly in executing jumps for smashes, blocks, and jump serves. Optimal jumping ability heavily depends on the strength and explosiveness of the lower limb muscles. In volleyball, athletes must maintain peak physical condition, including strength, speed, endurance, agility, and balance.[1] However, this sport also risks injuries that may hinder athletic performance.[2]

Sports-related injuries, especially in the lower limbs—such as ankle sprains and patellar tendinopathy—can lead to neuromuscular and biomechanical impairments that negatively impact jumping ability.[3] Studies indicate that such injuries affect muscle coordination and energy efficiency during jumps, ultimately diminishing athletic performance. Data show that the prevalence of sports injuries in Indonesia reached 9.2% in 2018, an increase of 1% from 8.2% in 2013.[4] However, specific data on volleyball-related injuries among student-athletes remains limited.[5] A survey conducted at SMA Muhammadiyah 7 Yogyakarta involving 33 respondents found that 73.9% reported that their lower limb power was not optimal, highlighting the need for more effective training interventions.[6]

Physiotherapy plays a vital role in rehabilitating and enhancing lower limb power through various training methods. Countermovement jumps, and calf raises are commonly used to improve lower limb muscle power.[7,8] Countermovement jump involves a rapid squat before jumping as high as possible, aiming to enhance muscle explosiveness through the stretch-shortening cycle mechanism.[9] In contrast, calf raise targets the gastrocnemius and soleus muscles, aiming to improve ankle stabilization and muscular endurance.[10]

Several studies suggest that plyometric exercises, such as countermovement jumps, are more effective in increasing muscle explosiveness than static strength-based exercises like calf raises.[11] A study by Markovic and Mikulic (2007) found that plyometric training significantly enhances jump height and explosive power output.[12] However, direct comparative studies evaluating the effectiveness of these two exercises in the context of volleyball remain limited.

This study compares the effectiveness of countermovement jump and calf raise exercises in improving lower limb power among volleyball players. The proposed hypothesis is that countermovement jump training is more effective than calf raises training in enhancing lower limb power. By utilizing the vertical jump test as the primary measurement tool, the findings of this study are expected to contribute to the development of more effective training methods for optimizing volleyball athletes' performance, particularly in sports physiotherapy.

Methods

This study employs an experimental design using a quasi-experimental approach, specifically a parallel-group quasi-experimental design with a pre-test and post-test two-group design. This design was chosen because complete randomization was not feasible, as the subjects were students from a specialized volleyball sports class with a fixed training schedule. Therefore, this design is considered the most appropriate for evaluating the effectiveness of the intervention without disrupting the participants' routine schedules. The participant allocation ratio between the two groups is 1:1. No changes to the methodology were made after the study began; however, dropout handling was addressed by increasing the sample size by 20% to anticipate potential participant withdrawals before the survey was completed. A research flowchart is provided in the appendix to clarify the research process from recruitment to data analysis.

The study was conducted in February at a public high school in Yogyakarta that offers a specialized volleyball sports class. The total study population consisted of 60 students enrolled in this class, comprising 10th and 11th-grade students. Participants were selected through purposive sampling to ensure they met specific criteria relevant to the study's objectives. The inclusion criteria were: students from the 10th and 11th grades who were enrolled in the specialized volleyball sports class, had typical vital signs, were either male or female, were not experiencing illness or injury, and were willing to participate in the study. The exclusion criteria included students not enrolled in the specialized volleyball sports class, those unwilling to participate, or those who were uncooperative during the intervention.

The sampling technique used was purposive sampling. Randomization was not performed due to limitations in grouping subjects with different training routines. However, initial characteristic matching was conducted based on height, weight, and physical activity levels before the intervention to ensure equivalence in baseline characteristics between the countermovement jump and calf raise groups.

The intervention consisted of countermovement jump and calf raise exercises performed three times per week for four weeks on the school sports field under the supervision of a certified sports coach and the researcher. The countermovement jump exercise was performed for 10 repetitions across four sets, starting with feet shoulder-width apart, hands on hips, and an upright posture. Participants performed a maximal jump from a half-squat position, ensuring entire knee and hip extension during the airborne phase and landing. The calf raise exercise was performed for 10 repetitions across three sets, with participants standing upright on a block or step, raising their heels as high as possible, holding the position for three seconds, and then returning to the starting position.

Progressive overload was applied by increasing the repetitions by two per week and extending the hold duration in the calf raise exercise by one second per week. All exercises were conducted under the supervision of a certified coach to ensure proper execution and prevent injury risks.

The primary outcome of this study was lower limb power, measured using the vertical jump test. The measurement procedure required participants to stand at the starting line and jump while reaching for the measurement board to record their highest touch point. Each participant performed three trials, and the highest recorded jump was used for analysis. The reliability of the measurement tool has been confirmed in previous studies, demonstrating high validity in assessing lower limb power. To control external factors that might influence measurement outcomes, participants were instructed to avoid intense exercise 24 hours before testing and to perform a standardized warm-up before the test.

Sample size calculations were performed using OpenEpi, referencing a study by Perez-Castilla et al. (2023). The parameters used were a Confidence Interval of 85%, a Power of 90%, a 1:1 ratio, a Mean of 196.2 and 26.9, and a Standard Deviation of 168.7 and 21.8. The calculation determined a requirement of 11 samples per group (totaling 33 samples). The justification for selecting the study by Perez-Castilla et al. (2023) was based on the similarity in lower limb power measurement methods, making the chosen parameters relevant to this research context. To account for potential dropouts, the sample size was increased by 20%, resulting in 13 participants per group. If any participants withdrew before completing the study, the analysis would proceed using per-protocol analysis to maintain the validity of the result.

This study employed a non-randomized allocation, where participants were assigned based on availability and willingness to participate in a specific training program. To ensure comparability between groups, baseline characteristic matching was performed based on age, gender, and height before the intervention.

Blinding was not implemented in this study due to the nature of the intervention, which required active participation from subjects and direct supervision from coaches. However, to minimize expectation bias, the assessors conducting the vertical jump test were blinded to the participants' intervention groups, and the researchers supervising the intervention differed from those assessing the test outcomes.

Data analysis was conducted using SPSS Statistics 26, following these steps: normality testing using the Shapiro-Wilk test to determine whether data followed a normal distribution, homogeneity testing using Levene's test to ensure comparable variance between groups, and hypothesis testing using the paired sample t-test to compare within-group changes before and after the intervention, as well as the independent sample t-test to compare effectiveness between the two intervention groups. A significance level of $p < 0.05$ was used. If outliers were identified, missing data were handled using a per-protocol analysis approach.

Results

This study uses a pre-test and post-test two-group design to determine the difference in the effects of countermovement jump and calf raise exercises on lower limb power in volleyball players. This research design was chosen as it allows for the evaluation of changes before and after the intervention in two groups. A quasi-experimental parallel-group design was selected to address ethical and practical constraints in complete randomization while enabling intervention evaluation in the participants' natural environment.

Sampling was conducted using a purposive sampling technique, and participants were then divided into two intervention groups. The subject selection process is illustrated in Figure 1.

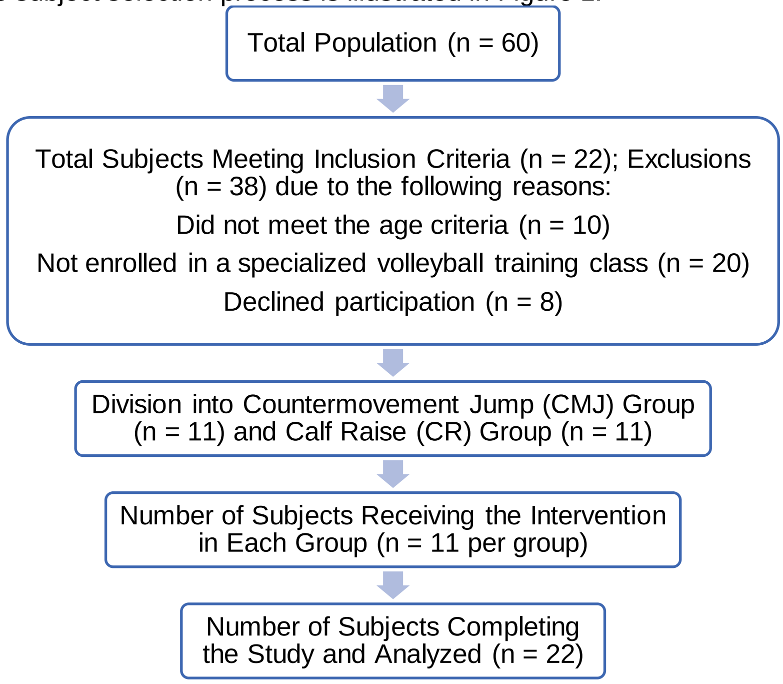

Figure 1. Flow Chart

Table 1 presents the frequency distribution of participants based on their Body Mass Index (BMI) categories in both Group I (CMJ) and Group II (CR).

Table 1. Frequency Distribution of Study Sample Based on Body Mass Index (BMI)

BMI Category	Group I (CMJ)		Group II (CR)	
	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
Underweight	2	18.2	2	18.2
Normal	4	36.4	5	45.2
Overweight	1	9.1	2	18.2
Obesity I	4	36.4	1	9.1
Obesity II	0	0	1	9.1
Total	11	100	11	100

Notes:

- **Group I:** Countermovement Jump
- **Group II:** Calf Raise
- **BMI Categories:** <18.5 (Underweight), 18.5 - 22.9 (Normal), 23 - 24.9 (Overweight), 25 - 29.9 (Obesity I), ≥30 (Obesity II)

Based on Table 1, most participants in Group II (Calf Raise) were in the normal BMI category, comprising 5 participants (45.2%). Meanwhile, in Group I (Countermovement Jump), the most common BMI category was Obesity I, with 4 participants (36.4%). The distribution of underweight and overweight individuals was relatively balanced between the two groups. Table 2 illustrates the frequency distribution of participants' ages across both groups.

Table 2. Frequency Distribution of Study Sample Based on Age

Age (years)	Group I (CMJ)		Group II (CR)	
	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
15	2	18.2	2	18.2
16	3	27.3	3	27.3
17	6	54.5	6	54.5
Total	11	100	11	100

Based on Table 2, the most common age among participants was 17 years, with 6 participants (54.5%) in both Group I and Group II. The remaining participants were 15 or 16, with the lowest frequency at 15 years (18.2% in each group). Table 3 provides the gender distribution of participants in each group.

Table 3. Frequency Distribution of Study Sample Based on Gender

Gender	Group I (CMJ)		Group II (CR)	
	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
Male	7	63.6	9	81.8
Female	4	36.4	2	18.2
Total	11	100	11	100

Based on Table 3, male participants dominated both groups, with nine male participants (81.8%) in Group II (Calf Raise) and 7 (63.6%) in Group I (Countermovement Jump). Female participants were fewer, with Group II having only two female participants (18.2%), while Group I had 4 (36.4%).To determine the effectiveness of the CMJ and CR exercises, a paired sample t-test was conducted to compare the pre-test and post-test results within each group. The findings are displayed in Table 4.

Table 4. Paired Sample T-Test Results

Sample	N	Mean ± SD	p-value
Group I	11	-4.636 ± 1.502	0.000
Group II	11	-2.636 ± 1.120	0.000

Based on Table 4, both exercise interventions led to a statistically significant improvement in lower limb power, as indicated by the p-values of 0.000 ($p < 0.05$) in both groups. The Countermovement Jump group exhibited a more remarkable mean improvement (-4.636 ± 1.502) than the Calf Raise group (-2.636 ± 1.120), suggesting that CMJ exercises substantially enhanced lower limb power. An independent sample t-test was conducted to compare the effectiveness of CMJ and CR exercises, as shown in Table 5.

Table 5. Independent Sample T-Test Results

Description	Mean	p-value
Post-test lower limb power (Groups I & II)	4.64 (CMJ) vs. 2.64 (CR)	0.002

Table 5 shows a statistically significant difference in the post-test lower limb power between the two groups ($p = 0.002$, $p < 0.05$). The Countermovement Jump group (mean improvement: 4.64) demonstrated a more significant power increase than the Calf Raise group (mean improvement: 2.64). These results indicate that CMJ exercises enhance lower limb power in volleyball players more effectively than CR exercises.

The study results indicate that both countermovement jump and calf raise exercises significantly improve lower limb power in volleyball players. However, the countermovement jump exercise is more effective than the calf raise, as demonstrated by the independent sample t-test results.

Training was conducted under the strict supervision of certified sports trainers to ensure intervention quality. Training progression was systematically designed with increasing intensity and repetitions weekly, following validated training protocols. External factors affecting measurement outcomes were controlled by instructing participants to refrain from heavy exercise before measurement. Additionally, the reliability of the measurement tool was verified, as the vertical jump test has been validated in previous studies as an accurate method for assessing lower limb power.

Efforts to minimize bias included using blinded assessors for outcome evaluation. The statistical significance threshold was set at $p < 0.05$, and strategies for handling outliers included data elimination or transformation when necessary.

Overall, this study demonstrates that countermovement jump exercises are more effective than calf raise exercises in enhancing lower limb power in volleyball players.

Discussion

Several factors can influence muscle power, including body mass index (BMI). According to research, an ideal body weight significantly impacts the speed, strength, and power required for propulsion and achieving maximal muscle power.[13] This study's results indicate that the prescribed training contributed to increased leg power, aligning with the initial research hypothesis. Strong muscles are essential in all sports that rely on physical strength. Maintaining minimal body fat is critical in sports requiring high mobility from a fixed point, such as running and jumping. Muscle size can increase, automatically leading to weight gain and enhanced strength when subjected to regular resistance training.

Muscle power also changes with age, with peak muscle mass development occurring during adolescence. Increased muscle power and strength in adolescents can be achieved by developing essential motor skills. The ability of muscles to gain strength and power develops rapidly until around the age of 20.[8.] According to Handariati and Gandika's 2021 study, respondents aged 12-16 had standard leg power, while those aged 17-19 exhibited above-average explosive leg power.[14] At ages 17-18, muscle mass increases due to training-induced hypertrophy. Besides being influenced by physical growth, muscular activity also determines muscle strength.[13] However, this study did not specifically analyze the effects of training across different age groups, which future research could explore to compare the effects of training across a broader age range.

Additionally, leg muscle strength is influenced by sex. Males typically have greater lower limb strength than females due to hormonal differences during puberty. Males have higher levels of growth hormone, testosterone, and IGF-1, contributing to increased muscle fiber size. In contrast, females produce more estrogen, which promotes higher body fat accumulation and may slow muscle mass growth.[15] The interaction between growth hormones, sex steroids such as estrogen and androgens, and IGF-1 production leads to changes in body composition, including water, muscle, fat, and bone proportions.[16] However, this study did not compare the effects of CMJ and calf-raise training based on sex, which could be an avenue for future research.

This study has several limitations, including a relatively small sample size (22 volleyball athletes), which may limit the generalizability of these findings to a broader population. Additionally, the relatively short study duration did not allow for the evaluation of the effects of long-term training. Future studies with extended training periods could explore whether the observed effects are sustained over time or only temporary. The specific intervention methods (CMJ and calf raise) may not fully represent training approaches used in other sports. External factors, such as athletes' prior training experience, were also not fully controlled in this study, potentially affecting training responses. Another limitation includes selection bias, as subjects were chosen based on specific criteria and potential information bias in measuring muscle power.

The paired sample t-test results for pre- and post-intervention leg power using the countermovement jump test showed a p-value of 0.000, indicating that p<0.05, leading to the acceptance of Ha and rejection of Ho. This result confirms that CMJ training significantly enhances leg power. However, while statistically significant, further research is needed to determine whether this power increase translates into improved athletic performance, such as higher jump height or increased smash speed in volleyball matches. The countermovement jump involves multiple lower limb muscles, including the quadriceps, hamstrings, gastrocnemius, soleus, gluteus maximus, and core muscles. Regular training enhances muscle contraction efficiency, leading to overall power improvements.

He et al. (2022) explained that utilizing the stretch-shortening cycle (SSC) mechanism increases strength, speed, and muscle activation during the eccentric phase of the countermovement jump while improving jump height during the concentric phase.[17] Implementing the SSC mechanism can enhance lower limb muscle strength and jump height, forming the basis for volleyball training programs.[18] In practice, coaches should consider the optimal frequency and intensity of CMJ training to maximize its benefits.

However, this study did not address each training method’s potential risks or side effects. For instance, plyometric training such as CMJ can increase the risk of injury if performed with improper technique, especially for athletes with a history of knee or ankle injuries. Similarly, while calf raises training strengthens the calf muscles, it may lead to muscle strain or soreness if performed excessively without adequate warm-up.[19–21] Therefore, coaches and athletes must consider safety aspects and proper techniques when implementing these exercises to reduce injury risks.

Several claims regarding the effects of CMJ and calf raise training require support from relevant references or empirical data. For example, the statement that "CMJ training, when performed repeatedly, increases muscle mass, contraction strength, and tendon strength" should be reinforced by relevant biomechanical studies or presented as a hypothesis for further testing.[22,23]

The independent t-test results comparing the countermovement jump and calf raise training groups (each consisting of 11 participants) showed a significant difference with a p-value of 0.002 (p<0.05). The mean leg power was higher in the countermovement jump training group than in the calf raise group, indicating that CMJ training enhances leg power in volleyball players.[24,25] This finding provides a foundation for developing training programs to improve volleyball athletes’ performance by optimizing exercise variations tailored to specific sports requirements.[26,27]

The results of this study contribute to the understanding of effective training methods for improving lower limb power in volleyball athletes. Given the small sample size, these findings should be interpreted cautiously when generalizing to broader populations, such as athletes from different sports or varying training backgrounds. However, the findings align with existing literature on plyometric training benefits, reinforcing its practical application in strength and conditioning programs.

From a practical perspective, the study supports using CMJ as a primary exercise for developing explosive power in volleyball athletes. Strength and conditioning coaches may consider integrating CMJ into regular training regimens while tailoring intensity and volume to individual athletes' needs. Moreover, sports organizations and training institutions could benefit from further research examining long-term adaptations to plyometric training, providing a more comprehensive understanding of its effectiveness in different athletic populations.

Additionally, these findings underscore the importance of individual factors, such as sex and age, in training adaptations. Future studies could explore personalized training programs that consider these variables to optimize performance gains. Beyond sports, insights from this research may also be relevant in rehabilitation settings, where plyometric training can improve lower limb function in individuals recovering from injuries or undergoing physical therapy.

Conclusion

Countermovement jump (CMJ) and calf raise exercises have significantly enhanced lower limb power in volleyball players (p = 0.000). However, CMJ was more effective than calf raise, with an average increase of 4.64 in the CMJ group compared to 2.64 in the calf raise group (p = 0.002). This difference in effectiveness suggests that jump-based training provides a more optimal stimulus for improving lower limb power than isolated calf muscle exercises.

This study has several limitations, including a limited sample size, a relatively short intervention duration, and external factors that were not fully controlled, such as other physical activities and rest patterns. Additionally, prior training experience and individual motivation may have influenced the study results.

These findings can serve as a reference for coaches in designing more effective training programs to enhance lower limb power in volleyball athletes. Future research should include a control group, extend the intervention duration, and explore the effectiveness of these exercises for different player positions or in other sports requiring high lower limb power.

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Additional Information

1. **Research Registration**
   This study is not registered in official clinical trial registries such as ClinicalTrials.gov, ISRCTN, or WHO ICTRP, as it does not fall under the category of a clinical trial. However, we remain committed to maintaining transparency in research methodology and reporting.
2. **Access to Research Protocol**

The full research protocol is not available online. If needed, please get in touch with the corresponding author for further information.

3. **Funding Sources and Role of Funders**
This research was conducted independently without financial support from any institution or external sponsor. The researchers themselves covered all research expenses. No conflicts of interest could influence the study design, data collection, analysis, or publication of the research findings.

References

1. Su W, Feng J. Effects of deep jumping on explosive strength in the lower limbs of athletes. Rev Bras Med Esporte. 2023;29.
2. Drew MK, Raysmith BP, Charlton PC. Injuries impair the chance of successful performance by sportspeople: a systematic review. Br J Sports Med. 2017 Aug;51(16):1209-14.
3. Qin Z, Qin Y, Wang J. Neuromuscular training effects on athletes' jumping and lower limb injury: a systematic review. J Mot Behav. 2024 Sep 2;56(5):600-13.
4. Baus J, Harry JR, Yang J. Jump and landing biomechanical variables and methods: a literature review. Crit Rev Biomed Eng. 2020;48(4):211-22.
5. Syafi' Uddin Z, Setijono H, Wiriawan O. Evaluasi pembelajaran dan latihan siswa SMANOR Sidoarjo pada prestasi nasional: studi pada atlet putra bola voli pantai SMANOR Sidoarjo. JIME [Internet]. 2020 Oct;6. Available from: http://ejournal.mandalanursa.org/index.php/JIME/index
6. Nurfadhila R, Tomoliyus T, Alim A, Ndayisenga J, Sukamti ER. Exploring study of Yogyakarta physical fitness athletes in Indonesia. Int J Hum Mov Sports Sci. 2022 Feb;10(1):38-44.
7. Sánchez-Sixto A, Harrison AJ, Floría P. Larger countermovement increases the jump height of countermovement jump. Sports. 2018 Dec 1;6(4):E160.
8. Amal MN, Fariz A, Halimah N, Pradita A. Perbedaan pengaruh wobble board dan calf raise exercise terhadap peningkatan stabilitas ankle pada pemain Bintang Futsal Academy Karawang. 2024 Dec 22;10.
9. Warneke K, Keiner M, Lohmann LH, Hillebrecht M, Wirth K, Schiemann S. The influence of maximum strength performance in seated calf raises on countermovement jump and squat jump in elite junior basketball players. Sport Mont. 2022 Jun 1;20(2):63-8.
10. Anjasmara B, Novia Widanti H, Yudha Mulyadi S. Kombinasi calf raise exercise dan core stability exercise dapat meningkatkan keseimbangan tubuh pada mahasiswa jurusan fisioterapi Poltekkes Kemenkes Makassar. 2021 Jun;3.
11. Gunarto W, Winaya IMN, Griadhi IPA, Adiputra LMISH. The difference of squat exercise using calf raises in plyometric jump intervention to the box on explosive power lower extremity of baskets extracurricular in Denpasar high school. Majalah Ilm Fisioterapi Indones. 2019 May 15;7(2):9.
12. Markovic G. Does plyometric training improve vertical jump height? A meta-analytical review. Br J Sports Med. 2007 Jun;41(6):349-55.
13. Bagus P, Agatha D, Made I, Parwata Y, Yasa A. Hubungan indeks massa tubuh overweight dengan daya ledak otot tungkai dalam olahraga lompat jauh gaya jongkok pada siswa laki-laki di SMA Negeri 8 Denpasar. 2022 May.
14. Nurhalimah I, Sari T, Ningrum R, A'isyah Nurhayati U. Hubungan kemampuan fungsional dan agility pada pemain sepak bola di sekolah sepak bola Hizbul Wathan Universitas Muhammadiyah Yogyakarta [Internet]. Pros Semin Nas Penelit Pengabdian Kepada Masyarakat LPPM Univ 'Aisyiyah Yogyakarta. 2024. Available from: www.surveilndonesia.co
15. Sihombing MRBS, Siregar NP, Ismail WM, Bestari R. Hubungan antara indeks massa tubuh dengan kekuatan otot tangan dan tungkai bawah pada atlet Zauzy Taekwondo Club Binjai. J Kedokteran dan Kesehatan-Fak Kedokteran Univ Islam Sumatera Utara [Internet]. 2024 Jul [cited 2025 Mar 3];23(2):138-44. Available from: https://jurnal.fk.uisu.ac.id/index.php/ibnusina
16. Bchini S, Hammami N, Selmi T, Zalleg D, Bouassida A. Influence of muscle volume on jumping performance in healthy male and female youth and young adults. BMC Sports Sci Med Rehabil. 2023 Dec 1;15(1).
17. He L, Li YG, Wu C, Yao S, Su Y, Ma GD, et al. The influence of repeated drop jump training on countermovement jump performance. Appl Bionics Biomech. 2022;2022:1-9.
18. Pratiwi FZ, Setijono H, Fuad Y. Effect of plyometric front cone hops training and counter movement jump training to power and strength of leg muscles. J Sportif J Penelit Pembelajaran. 2018 May 27;4(1):105.
19. Simanullang A, Suhartini S. Pengaruh latihan hurdle drills dan calf raises terhadap hasil lompat jauh pada Spartan Atletik Club, Universitas Jambi. 2023;3(2):131-42. Available from: https://doi.org/10.22437/jp.v3i2.29723
20. Nurhayati UA, Hasnawati BN. Circuit training is more effective than interval training on increasing VO2 max in football players. Annu Physiother Sci Meet Proc [Internet]. 2023 Sep 25 [cited 2025 Jan 30];1(1):49-58. Available from: https://proceedings.ifi.or.id/index.php/titafi/article/download/21/22
21. Azhari, Nurhayati UA. Perbedaan pemberian burpees training dan moderate-intensity continuous training terhadap fleksibilitas pada mahasiswa dengan kondisi overweight dan obesitas. Pros Semin Nas Penelit Pengabdian Kepada Masyarakat LPPM Univ 'Aisyiyah Yogyakarta. 2024 Sep 28;2(3):26-43.
22. Cruz RMS da, Nurhayati UA. Study literature review efektivitas latihan lompat gawang terhadap peningkatan vertical jump pada atlet voli. [Yogyakarta]: Program Studi Fisioterapi S1 Fakultas Ilmu Kesehatan Universitas 'Aisyiyah Yogyakarta; 2020.
23. Fadillah AR, Yani F, Nadhir Ollin Norlinta S. Perbedaan single leg stand dan star excursion balance test terhadap keseimbangan statis atlet sepak bola Pesat Tempel pasca cedera sprain ankle. Physio J. 2023 Sep 30;3(2):81-8.

24. Audini VA, Wibowo E. Perbedaan intervensi towel toe curl dan calf raise terhadap myofascial release pada peningkatan fungsional ankle kasus plantar fasciitis. J Fisioterapi. 2018;18.
25. Khairullah RR, Norlinta SNO. The effect of aerobic exercise on functional capacity increase in coronary heart disease patients: a narrative review. Fisio MU Physiother Evid. 2023 Jan 17;4(1).
26. Nurhayati UA, Hasnawati BN. Functional capacity training for improvement of VO2 max in football players: differences in the effects of circuit training and interval training models. J Pendidikan Jasmani Olahraga. 2024 Apr 1;9(1):37-45.
27. Norlinta SNO, Wulandhari R. Optimalisasi kapasitas fisik pada siswa sekolah selama pembelajaran online. J Abdidas. 2021 Aug 25;2(4):975-81.