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The training methods and leg muscle strength on students' upper pass volleyball learning outcomes

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ABSTRACT

This study examined the effects of paired and independent overhead passing training methods in relation to leg muscle strength on the overhead passing ability of school-level volleyball athletes. A quantitative experimental design with a 2×2 factorial pretest–posttest approach was employed. Twenty-four students participating in a volleyball extracurricular program were classified into high and low leg muscle strength groups and assigned to paired or independent training. Overhead passing ability was measured before and after the intervention using a standardized skill test. Data were analyzed using paired samples t-tests to identify within-group changes. The results showed a significant improvement only in athletes with high leg muscle strength who received paired training ($p < 0.05$), while other groups showed no significant changes. These findings suggest that overhead passing improvement depends on the interaction between training method and physical readiness. Further studies with larger samples and factorial analyses are recommended.



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Introduction

Volleyball is a team sport that demands the integration of technical skills, physical fitness, and tactical awareness to achieve optimal performance (Destriana et al., 2024; Pacholek et al., 2021; Wicaksono et al., 2022). At the school level, volleyball training is commonly conducted through extracurricular programs that aim to develop basic skills and foster athletic potential. One of the most essential technical skills taught at this stage is overhead passing, as it functions as the primary means of initiating attacks and maintaining ball control during play.

Despite its importance, many school-level volleyball athletes demonstrate inadequate overhead passing ability. This limitation is often reflected in inaccurate ball direction, unstable body posture, and inconsistent passing rhythm during games (Fitriani, 2021; Yeri, 2024; Yobee et al., 2025). These problems indicate that athletes not only struggle with technical execution but also lack sufficient

physical preparedness to perform the movement effectively, particularly when required to respond to dynamic game situations.

Previous studies have shown that the selection of training methods plays a critical role in the development of volleyball technical skills. Various approaches, including independent drills, paired exercises, and group-based practices, have been applied with differing outcomes (Casper et al., 2024; Li et al., 2024; Silveira et al., 2024; Storli et al., 2024). Paired training methods are considered effective because they involve interaction between athletes, allowing them to adapt to ball trajectory, timing, and coordination similar to real match conditions. In contrast, independent training emphasizes repetition and self-regulation but may provide limited contextual stimulation.

In addition to training methods, physical components especially leg muscle strength are fundamental to the execution of overhead passing techniques (Ghasemi et al., 2024; Ma et al., 2024; Plancher et al., 2024). Strong leg muscles support balance, body stability, and force production during the passing movement, enabling efficient transfer of force from the lower body to the upper limbs. Skills that require vertical movement and postural control, such as overhead passing, are therefore closely related to lower limb strength (Shi et al., 2024; Xu et al., 2024).

Recent developments in sports training emphasize the importance of integrating technical training with physical conditioning to achieve effective learning outcomes (Doehne et al., 2024; Schoville et al., 2024). The state of the art suggests that technical improvement is more likely to occur when athletes' physical readiness aligns with the instructional method applied. However, most existing studies have examined training methods and physical components separately, resulting in limited understanding of how these factors interact in influencing skill performance.

This research gap is particularly evident in school-based volleyball training contexts, where athletes often display diverse physical characteristics but receive uniform training programs. Extracurricular training sessions frequently rely on monotonous drills and do not account for individual differences in physical capacity, which may limit skill development (Kaimbu et al., 2025; Sharshouh, 2023; Wubale et al., 2023). As a result, some athletes may not benefit optimally from the training methods applied.

Considering these conditions, it is important to examine how different overhead passing training methods interact with leg muscle strength in affecting skill performance. Understanding this interaction can help identify training approaches that are more suitable for athletes with varying physical conditions and contribute to more effective coaching strategies (AlZubaidi, 2025; Esa et al., 2025; Hermaya et al., 2024; Saeed et al., 2023).

Therefore, this study aims to analyze the effects of paired and independent overhead passing training methods in relation to leg muscle strength on overhead passing ability among school-level volleyball athletes. The novelty of this study lies in its factorial approach, which simultaneously examines training methods and physical condition within an experimental framework. By doing so, this research is expected to provide practical and evidence-based insights for coaches and physical education teachers in designing training programs that are more targeted, efficient, and responsive to athletes' physical characteristics.

Method

This study employed a quantitative experimental design using a 2×2 factorial pretest–posttest approach. The participants were 24 students involved in the volleyball extracurricular program at SMK Negeri 4 Tanjungpinang in 2025, who were randomly assigned to four experimental groups based on training method and leg muscle strength level. Leg muscle strength was measured using a standardized leg strength test, and participants were classified into high and low strength groups based on the median split of test scores. The four groups consisted of paired overhead passing training with high leg muscle strength, paired training with low leg muscle strength, independent overhead passing training with high leg muscle strength, and independent training with low leg muscle strength.

Overhead passing ability was assessed using a validated overhead passing skill test administered before and after the training intervention. The training program was conducted over the same period for all groups, with controlled frequency and duration, and was supervised by the same instructor to

ensure consistency. Data were analyzed using descriptive statistics and inferential analysis. Paired samples t-tests were applied to examine within-group changes, and a two-way analysis of variance was used to analyze the effects of training method, leg muscle strength, and their interaction on overhead passing performance. Statistical significance was set at $p < 0.05$.

Results and Discussions

The results of this study present the findings obtained from the analysis of overhead passing ability in volleyball athletes at SMK Negeri 4 Tanjungpinang following the implementation of different training methods and levels of leg muscle strength. Data were analyzed using paired samples t-tests to examine changes between pretest and posttest scores within each experimental group. The analysis focuses on four treatment combinations: paired overhead passing training with high leg muscle strength, paired overhead passing training with low leg muscle strength, independent overhead passing training with high leg muscle strength, and independent overhead passing training with low leg muscle strength. The results are presented in the form of descriptive statistics and inferential analysis to determine the effectiveness of each training method on improving overhead passing performance.

Table 1. Effect of Paired Overhead Passing Training with High Leg Muscle Strength on Overhead Passing Ability

Measurement	Mean Pretest	Mean Posttest	Mean Difference	t-value	Sig. (p)
Overhead Passing Score	62.50	71.25	8.75	3.012	0.015

Table 1 shows that paired overhead passing training combined with high leg muscle strength resulted in a significant improvement in overhead passing ability. The mean score increased from 62.50 in the pretest to 71.25 in the posttest, with a mean difference of 8.75 points. The paired samples t-test revealed a significance value of $p = 0.015$ ($p < 0.05$), indicating that the training method had a statistically significant effect. This finding suggests that athletes with high leg muscle strength benefit optimally from paired training due to better coordination, balance, and force transfer from the lower limbs to the upper body during overhead passing.

Table 2. Effect of Paired Overhead Passing Training with Low Leg Muscle Strength on Overhead Passing Ability

Measurement	Mean Pretest	Mean Posttest	Mean Difference	t-value	Sig. (p)
Overhead Passing Score	60.75	63.25	2.50	1.612	0.136

As presented in Table 2, paired overhead passing training applied to athletes with low leg muscle strength did not produce a statistically significant improvement in overhead passing ability. Although there was a slight increase in the mean score from 60.75 to 63.25, the paired samples t-test yielded a significance value of $p = 0.136$ ($p > 0.05$). This result indicates that insufficient leg muscle strength may limit the effectiveness of paired training, as athletes struggle to generate adequate lower-body support and stability during the execution of overhead passing techniques.

Table 3. Effect of Independent Overhead Passing Training with High Leg Muscle Strength on Overhead Passing Ability

Measurement	Mean Pretest	Mean Posttest	Mean Difference	t-value	Sig. (p)
Overhead Passing Score	64.00	66.00	2.00	1.258	0.230

Table 3 illustrates that independent overhead passing training for athletes with high leg muscle strength did not lead to a significant improvement in performance. The mean score increased marginally from 64.00 to 66.00; however, the paired samples t-test resulted in a significance value of $p = 0.230$ ($p > 0.05$). This finding suggests that despite having strong leg muscles, athletes may require interactive training stimuli, such as paired drills, to enhance timing, perception, and coordination skills essential for effective overhead passing in volleyball.

Table 4. Effect of Independent Overhead Passing Training with Low Leg Muscle Strength on Overhead Passing Ability

Measurement	Mean Pretest	Mean Posttest	Mean Difference	t-value	Sig. (p)
Overhead Passing Score	59.50	61.00	1.50	1.845	0.078

Based on Table 4, independent overhead passing training combined with low leg muscle strength did not show a statistically significant effect on overhead passing ability. The mean improvement was minimal, increasing from 59.50 to 61.00, with a significance value of $p = 0.078$ ($p > 0.05$). These results indicate that independent training without adequate leg muscle strength may be insufficient to improve technical performance, emphasizing the importance of both physical conditioning and interactive training methods in volleyball skill development.

The results of this study indicate that paired overhead passing training combined with high leg muscle strength leads to a significant improvement in overhead passing ability among school-level volleyball athletes. This finding suggests that physical readiness, particularly lower limb strength, plays an important supporting role in the effectiveness of technical training. Strong leg muscles help athletes maintain balance and stability during the passing movement, which may facilitate more consistent execution of overhead passing when combined with interactive training environments (Ishak et al., n.d.; Suyatno et al., 2023). However, this interpretation should be viewed within the limitations of the experimental design and sample size.

In contrast, paired overhead passing training did not produce a significant improvement in athletes with low leg muscle strength. This result indicates that technical drills alone may not be sufficient when fundamental physical components are underdeveloped. Athletes with limited lower limb strength may struggle to maintain proper posture and coordination during overhead passing, reducing the potential benefits of paired training methods (Kristina et al., 2021; Shalaby & Fadl, 2020). These findings reinforce the view that physical conditioning is an important prerequisite for maximizing the outcomes of technical skill training in volleyball (Arif et al., 2021; LestariPriyatmoko & Romadhoni, 2025).

The findings also show that independent overhead passing training did not significantly improve performance, even among athletes with high leg muscle strength. This suggests that physical strength alone may not compensate for the lack of contextual and interactive stimuli present in independent training. Overhead passing requires not only mechanical accuracy but also perceptual and timing abilities, which are more likely to develop through interaction with a training partner (Dao, 2025; Putra et al., 2025). The absence of these elements may explain the limited effectiveness of independent practice in this study.

Independent training combined with low leg muscle strength resulted in the smallest performance improvement among all groups. This outcome reflects a combined limitation of insufficient physical capacity and less effective training structure. Athletes in this condition may face difficulties in movement efficiency while also lacking opportunities to adapt to variable ball trajectories and partner interactions. Similar observations have been reported in studies emphasizing that isolated and repetitive drills are less suitable for developing athletes (Aditya & Darmanto, 2025; Fahmi et al., 2025).

Although the results suggest a pattern favoring paired training for athletes with higher leg muscle strength, the interaction between training method and physical condition was not fully supported by comprehensive statistical analysis. Therefore, conclusions regarding interaction effects should be interpreted cautiously. The limited sample size and short training duration may have reduced the statistical power to detect differences across groups, which could explain the absence of significant findings in most treatment combinations.

From a theoretical perspective, the results are generally consistent with motor learning theories that emphasize the role of contextual practice and cooperative learning in skill acquisition. Training environments that resemble actual game situations may enhance skill transfer and retention, particularly when athletes possess adequate physical readiness to respond effectively (Dahlia et al., 2023; Pratama et al., 2023). However, this study does not provide direct evidence of long-term learning effects, which remains an important limitation.

Practically, the findings suggest that volleyball training at the school level should balance physical conditioning and technical instruction. Coaches are encouraged to develop leg muscle strength before or alongside the application of paired overhead passing drills, especially for athletes who are still developing physically. Future research should involve larger samples, longer intervention periods, and additional physical and psychological variables to better explain factors influencing overhead passing performance (Ariansyah & Usra, 2025; Permana et al., 2025).

Conclusions

Paired overhead passing training combined with high leg muscle strength significantly improves students' overhead passing ability. In contrast, paired training with low leg muscle strength, as well as independent training with either high or low leg muscle strength, does not have a significant effect. These results indicate that the effectiveness of improving overhead passing ability is influenced by the combination of training method and students' leg muscle strength.

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