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Effect of Plyometric Training Program on Motor Fitness Components and Digging Agility of Male National Volleyball Players of Pakistan

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ABSTRACT

The present study investigates the impact of an eight-week plyometric and digging agility training program on the motor fitness components of male national volleyball players in Pakistan. The primary objective was to determine the effectiveness of different training regimens in enhancing key physical attributes crucial for volleyball performance. A total of 45 national-level male volleyball players participated in the study and were randomly assigned to one of three groups: Group A (Plyometric Training), Group B (Plyometric + Digging Agility Training), and Group C (Control). The study utilized a pre-and post-test experimental design to assess agility, speed, balance, explosive strength, flexibility, and digging agility using standardized fitness assessment protocols. The results demonstrated significant improvements in motor fitness components for both experimental groups, with Group B (Plyometric + Digging Agility Training) exhibiting the most substantial gains across all variables. Specifically, Group B showed notable enhancements in agility (M = 10.77, SD = 0.50, 95% CI [10.52, 11.02]), speed (M = 3.10, SD = 0.08, 95% CI [3.06, 3.14]), and balance (M = 39.63, SD = 1.24, 95% CI [39.10, 40.16]). These findings indicate that the incorporation of sport-specific agility drills, particularly those targeting defensive movements such as digging, significantly improves volleyball-related physical performance compared to plyometric training alone. Furthermore, the study underscores the importance of integrating multi-dimensional training approaches combining plyometric and sport-specific agility drills to optimize motor fitness components. Volleyball is a sport that

demands rapid directional changes, explosive movements, and precise coordination, making agility and speed critical factors for success. The superior performance of Group B highlights the effectiveness of a combined training regimen in developing these attributes, thereby offering valuable insights for coaches and trainers designing volleyball-specific training programs. The control group (Group C) exhibited minimal changes across all fitness variables, further supporting the effectiveness of the training interventions implemented. The results of this study suggest that structured and sport-specific agility training should be an integral part of volleyball conditioning programs to enhance player performance, particularly in defensive maneuvers like digging. Future research should explore the long-term effects of such training programs and their implications for injury prevention and overall athletic development.
Keywords: Plyometric Training, Digging Agility, Motor Fitness, Volleyball Performance, Agility Training, Speed Enhancement, Explosive Strength, Balance Improvement, Flexibility Development, Sport-Specific Conditioning

Introduction

Volleyball is a globally popular sport that requires speed, strength, and coordination. Invented by William G. Morgan in 1895 as "Mintonette," it evolved into a competitive sport and was standardized by the Fédération Internationale de Volleyball (FIVB) in 1947 (Jabbarov & Innovation, 2024; Beissel et al., 2023). Its accessibility, requiring only a net and ball, has contributed to its growth across various settings, including beaches, indoor courts, and sand-based halls (Devienne, 2024).

In Pakistan, volleyball has gained popularity due to its inclusion in schools and military training programs (Saeed et al., 2023). Despite commendable performances in international competitions, Pakistani teams struggle with defensive skills, particularly digging. While the Pakistan Volleyball Federation (PVF) has established foreign coaching affiliations, inconsistent training programs hinder skill development (Lina et al., 2024). Motor fitness—comprising agility, explosive strength, balance, flexibility, and speed—is crucial for volleyball performance (Pravinbhai & Pandya, 2023). This study aims to evaluate the effects of plyometric training on motor fitness and digging agility among male national volleyball players in Pakistan.

Motor Fitness in Volleyball

Motor fitness includes flexibility, explosive strength, agility, speed, and balance, all of which are crucial for volleyball (Velkumar & Selvakumar, 2022). Flexibility supports spiking and diving while reducing injury risks (Hussein, 2023). Explosive strength, particularly through the stretch-shortening cycle (SSC), enhances jumping ability (Çakır & Ergin, 2022). Speed aids in quick directional changes, while balance is vital for stability during dynamic movements like blocking (Solovey et al., 2020).

Plyometric Training in Volleyball

Plyometric training enhances power and neuromuscular control by utilizing eccentric and concentric muscle actions. The SSC plays a crucial role in energy storage and release, improving jump height, lateral speed, and agility (Bompa & Buzzichelli, 2021). Studies show that plyometric training enhances lower-body strength, reaction time, and movement efficiency, benefiting volleyball players significantly (Ramírez-delaCruz et al., 2022). A meta-analysis found that plyometric training combined with agility exercises led to greater improvements in vertical jump and lateral speed than plyometric training alone (Moran et al., 2024). Exercises like box jumps, depth jumps, and lateral bounds improve leg power and defensive responses (Radcliffe, 2025). Additionally, plyometric training enhances reaction time and digging agility, helping players counter fast spikes (Esposito et al., 2024). However, research has primarily focused on attacking skills rather than defensive techniques like digging (Silva et al., 2019).

Digging Agility and Defensive Performance

Digging, a crucial defensive skill, requires rapid footwork, quick reflexes, and agility to neutralize opponent attacks and facilitate counterplay (Harat et al., 2025). Skilled diggers can shift momentum by disrupting offensive plays (Uzor et al., 2024). Agility drills such as cone drills, lateral shuffles, and footwork exercises enhance positioning and mobility for effective digging (Chuang et al., 2022). Combining plyometric and agility training strengthens defensive reflexes, enabling faster reactions to low balls (Leghemo et al., 2024). Most studies, however, emphasize technical aspects of digging rather than conditioning methods (Aulia et al., 2022).

Plyometric vs. Combined Training for Defensive Skills

Research suggests that combining agility training with plyometric exercises is more effective than plyometric training alone. Chuang et al. (2022) found that combined training significantly improved vertical jumps and lateral movement. Moran et al. (2019) reported a 20% agility

improvement in athletes undergoing both training methods compared to those in plyometric-only programs. While plyometric training builds power, agility training enhances reaction time and directional changes, which are vital for digging (Hammami et al., 2019). However, no study has examined the effectiveness of combined training in Pakistani volleyball players.

Research Aim

Motor fitness significantly impacts volleyball performance, especially defensive movements. Agility, explosive strength, and balance are crucial for reacting to attacks. Although plyometric training is widely acknowledged for power development, its impact on digging remains underexplored. Comparative studies suggest that a combination of plyometric and agility training is the most effective approach for defensive performance. However, no research has specifically examined plyometric-based interventions for defensive skills in Pakistani volleyball. Addressing this gap can improve Pakistan's competitiveness in international volleyball.

This study aims to assess the effects of plyometric training on motor fitness components in male national volleyball players of Pakistan. The hypotheses are:

1. There is a significant effect of plyometric training on motor fitness components post-intervention among male national-level volleyball players in Pakistan
2. There is a significant effect of digging agility training on digging agility skills post-intervention among male national-level volleyball players in Pakistan

Research Design

This study utilized an experimental pre-post research design to assess the impact of an eight-week plyometric and digging agility training program on motor fitness components and digging agility among male national volleyball players in Pakistan. The design incorporated two experimental groups and one control group to measure the effectiveness of each intervention. Group A underwent plyometric training, Group B received a combination of plyometric and digging agility training, while Group C continued with regular volleyball training as the control (Franklin & Journal, 2021). Pre- and post-intervention assessments were conducted using standardized tests, such as the T-Test for agility and the Vertical Jump Test for explosive strength, ensuring reliable measurements of performance changes (Hammami et al., 2017). The pre–post-test design allowed for a clear evaluation of cause-and-effect relationships between training interventions and performance outcomes.

Inclusion and Exclusion Criteria

Participants were selected based on specific criteria to ensure consistency and relevance to the study.

Inclusion Criteria:

- **Male National Volleyball Players:** Participants must have competed at the national level in provincial, district, or institutional tournaments at least once (Silva et al., 2019).
- **Age and Physical Fitness:** Players aged between 20 and 30 years, as per competition standards, were included to ensure a high level of physical fitness (Silva et al., 2019).
- **Consent to Participate:** Participants signed informed consent forms, agreeing to follow the study's training and testing procedures.

Exclusion Criteria:

- **Injury or Health Conditions:** Players with medical conditions, injuries, or chronic diseases that could interfere with high-intensity training were excluded.
- **Non-Compliance:** Participants unwilling or unable to adhere to the training program and testing schedules were not included in the study.

Procedure

The study was conducted at the Choudhary Akram Volleyball Academy (CAVA) in Shakargarh, Punjab, Pakistan. Convenience sampling was used to select 45 male national volleyball players, who were then divided into three equal groups of 15 (Egami & Lee, 2024). The intervention focused on the effects of an eight-week plyometric and digging agility training program on motor fitness and defensive skills.

- **Group A** performed plyometric training, emphasizing explosive movements such as box jumps and bounding drills.
- **Group B** combined plyometric exercises with digging agility training to enhance defensive responsiveness.
- **Group C** acted as the control group, continuing regular volleyball training without specialized interventions.

Training sessions were held three times per week over eight weeks, following ACSM (2020) guidelines. Performance improvements were evaluated through standardized pre- and post-testing, assessing agility (T-Test), speed (30-meter sprint), balance (Stork Stand Test), explosive

strength (Vertical Jump Test), flexibility (Sit and Reach Test), and digging agility (Volleyball-Specific T-Test). Visual aids were used during assessments to maintain consistency.

Data Analysis

Data were analyzed using SPSS version 29, employing descriptive statistics, t-tests, ANOVA, and post hoc Tukey tests to determine statistical differences between groups. Normality tests, including the Shapiro-Wilk and Kolmogorov-Smirnov tests, were conducted to ensure data reliability. The primary objective was to identify performance improvements and evaluate the effectiveness of plyometric and agility-based training interventions.

Ethical Considerations

The study received approval from the Institutional Review Board (IRB) of the University of Sindh, Jamshoro. Ethical safeguards included obtaining informed consent, maintaining confidentiality and anonymity, and ensuring participants' right to withdraw from the study at any time. These measures protected participant welfare and ensured data integrity.

Results

Table 1. Descriptive Statistics of Age

Descriptive Statistics of Age			
Groups	**Minimum**	**Maximum**	**Mean ± S.D**
Plyometric Training Group A	**20.00**	**29.00**	**24.0667 ± 2.71153**
PTG + Digging Agility Training Group B	**20.00**	**29.00**	**24.2667 ± 2.81493**
Control Group C	**20.00**	**29.00**	**25.0000 ± 2.67261**

The table presents the descriptive statistics of age for the three study groups:

1. Plyometric Training Group (Group A)
2. Plyometric + Digging Agility Training Group (Group B)
3. Control Group (Group C)

The descriptive statistics include minimum age, maximum age, mean age, and standard deviation (S.D.) for each group.

- **Minimum and Maximum Age:**
    1. Across all three groups, the minimum age is 20 years, and the maximum age is 29 years, indicating that all participants fall within the pre-defined study criteria (20–30 years).
- **Mean Age:**
    1. The mean age of Group A (Plyometric Training Group) **is** 24.07 years (±2.71 S.D.).
    2. The mean age of Group B (Plyometric + Digging Agility Training Group) is 24.27 years (±2.81 S.D.).
    3. The mean age of Group C (Control Group) is slightly higher at 25.00 years (±2.67 S.D.).
    4. These values indicate that the participants' average age is similar across groups, with only a slight variation.
- **Standard Deviation (S.D.):**
    1. The standard deviation shows how much individual ages deviate from the mean age within each group.
    2. Group A (2.71) and Group B (2.81) have slightly greater variability in age compared to Group C (2.67)**.**
    3. This suggests that Group B has a slightly wider age distribution, while Group C is more consistent in age distribution.

The age distribution across all three groups is relatively similar, with minimal variation in means and standard deviations. Since all groups have participants in the same age range, the study ensures age-related factors do not influence the outcomes**,** maintaining the validity of the training intervention results.

Figure 1. Distribution of Departments across Groups

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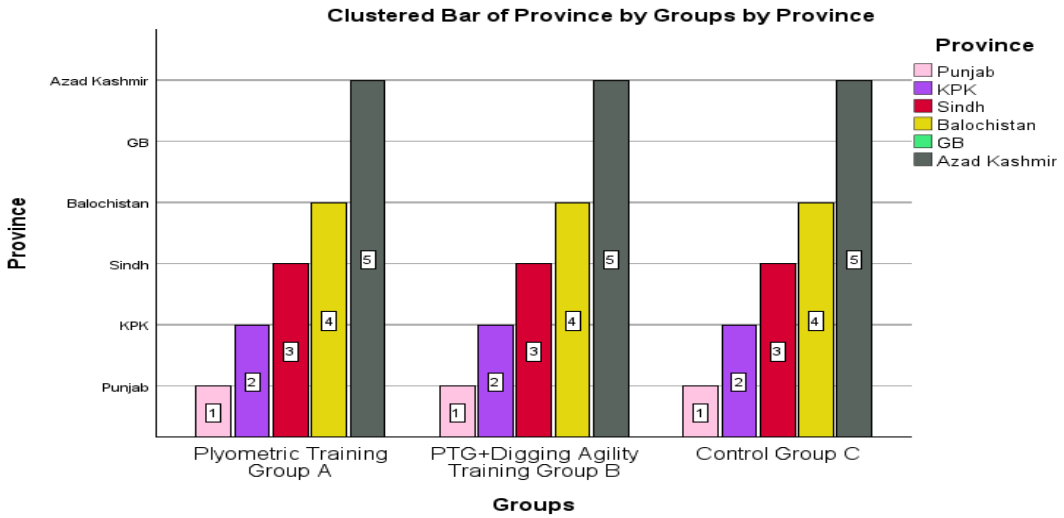


The bar chart illustrates the distribution of volleyball players from different departments (organizations) across the three study groups:

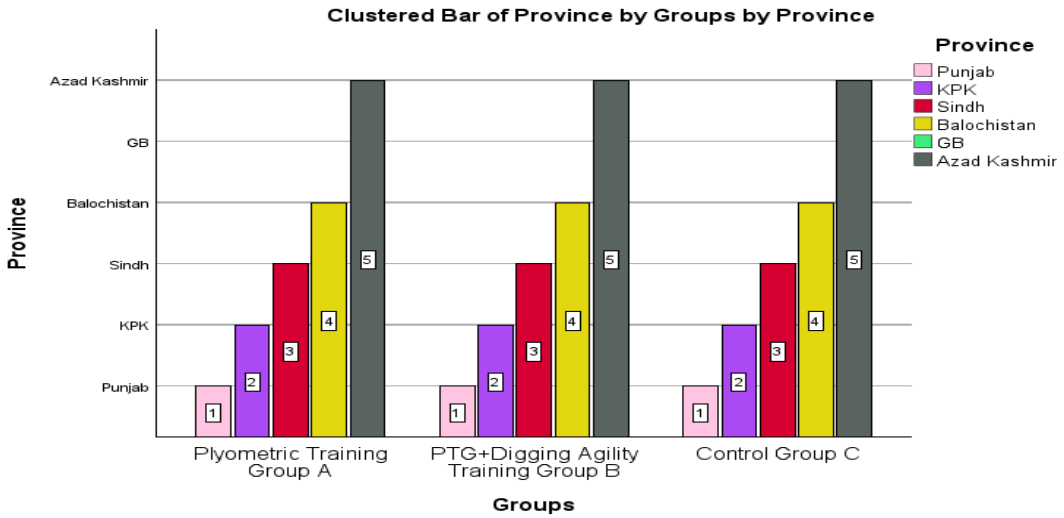
1. Plyometric Training Group (Group A)
2. Plyometric + Digging Agility Training Group (Group B)
3. Control Group (Group C)

Each department is represented by a different color, with numbers indicating the **count** of participants from each department.

- CAVA and Army have strong representation across all groups.
- Group B (Plyometric + Digging Agility Training) has a higher number of players from CAVA and Navy, suggesting a preference for combined training in these organizations.
- Group C (Control Group) has the most diverse representation**,** including players from Sindh Police, UMT, and other institutions**.**
- Sindh Police has the highest number of participants in the control group**,** indicating that many of their players continued regular volleyball training without specialized interventions.

The distribution of players is not uniform across groups, with some departments contributing more players to specific training programs. This variation may impact training outcomes based on institutional support and training priorities.

Figure 2. Provincial distribution across Groups



The bar chart represents the distribution of volleyball players by province across three study groups: Plyometric Training Group (A), Plyometric + Digging Agility Training Group (B), and Control Group (C).

- GB (Gilgit-Baltistan) and Balochistan have the highest representation across all groups.
- Sindh and KPK also contribute significantly, while Punjab has the lowest number of participants in all groups.
- Azad Kashmir is not represented in any group.

This variation in provincial representation suggests regional differences in volleyball participation and training opportunities.

Table 2. Within Group Comparisons of Groups

Pair	Mean Difference	Std. Error	T	p-value	95% CI (Lower - Upper)	Conclusion
Agility (Pre) vs. Agility (Post)	**1.099**	**0.102**	**10.798**	**< 0.001**	**[0.894, 1.304]**	**Significant difference**
Balance Stork Balance Stand (Pre vs. Post)	**-1.480**	**0.189**	**-7.825**	**< 0.001**	**[-1.861, -1.098]**	**Significant difference**
Speed 30m Sprint Test (Pre vs. Post)	**0.803**	**0.072**	**11.113**	**< 0.001**	**[0.657, 0.948]**	**Significant difference**

Explosive Strength Vertical High Jump (Pre vs. Post)	**-0.723**	**0.068**	**-10.693**	**< 0.001**	**[-0.859, -0.586]**	**Significant difference**
Flexibility Sit & Reach (Pre vs. Post)	**-0.666**	**0.090**	**-7.409**	**< 0.001**	**[-0.848, -0.485]**	**Significant difference**
Digging Agility (Pre vs Post)	**-1.99**	**0.69**	**-2.85**	**<0.001**	**[-3.41-2.85]**	**Significant difference**

The table presents the results of paired sample t-tests comparing pre- and post-intervention performance in different motor fitness components among volleyball players. The mean difference**,** standard error**,** t-value**,** p-value, and 95% confidence interval (CI) are reported for each test.

- **Agility (T-Test)**
    1. Mean Difference: 1.099, indicating improved agility after training.
    2. p-value < 0.001**,** confirming a significant improvement.
- **Balance (Stork Stand Test)**
    1. Mean Difference: -1.480, showing a decline in balance.
    2. p-value < 0.001, indicating a significant change.
- **Speed (30m Sprint Test)**
    1. Mean Difference: 0.803**,** suggesting faster sprint times.
    2. p-value < 0.001, showing a significant increase in speed.
- **Explosive Strength (Vertical Jump Test)**
    1. Mean Difference: -0.723**,** indicating improved jump height.
    2. p-value < 0.001**,** confirming a significant difference.
- **Flexibility (Sit & Reach Test)**
    1. Mean Difference: -0.666, showing increased flexibility.
    2. p-value < 0.001, confirming a significant change.
- **Digging Agility**
    1. Mean Difference: -1.99, indicating better digging agility post-training.
    2. p-value < 0.001**,** confirming statistical significance.

All motor fitness components and digging agility showed significant improvements post-training **(**$p < 0.001$**),** validating the effectiveness of the plyometric and agility training program.

Table 3. Summary of Between Group Comparisons

Test	Group Means (Post-Test)	Subset	ANOVA (F, p)	Outperforming Group
Agility (Pre)	**Group C = 12.3520, Group A = 12.4447, Group B = 12.4700**	**1**	**F(2, 42) = 0.222, p = 0.802**	**None (no significant difference)**
Agility (Post)	**Group B = 10.7700, Group A = 11.2200, Group C = 11.9800**	**1 < 2 < 3**	**F(2, 42) = 21.565, p < 0.001**	**Group B (PTG + Digging Agility)**
Balance Stork Balance Stand (Pre)	**Group B = 37.0200, Group A = 37.3880, Group C = 37.4500**	**1**	**F(2, 42) = 0.404, p = 0.670**	**None (no significant difference)**
Balance Stork Balance Stand (Post)	**Group C =37.6333, Group A = 39.0333, Group B = 39.6300**	**1 < 2**	**F(2, 42) = 13.157, p < 0.001**	**Group B (PTG + Digging Agility)**
Speed 30m Sprint Test (Pre)	**Group C = 4.3000, Group B = 4.3433, Group A = 4.4887**	**1**	**F(2, 42) = 1.294, p = 0.285**	**None (no significant difference)**
Speed 30m Sprint Test (Post)	**Group B = 3.0967, Group A = 3.6167, Group C = 4.0100**	**1 < 2 < 3**	**F(2, 42) = 31.063, p < 0.001**	**Group B (PTG + Digging Agility)**
Explosive Strength Vertical High Jump (Pre)	**Group C = 1.9220, Group B = 2.1740, Group A = 2.2000**	**1**	**F(2, 42) = 2.822, p = 0.071**	**None (no significant difference)**
Explosive Strength Vertical High Jump (Post)	**Group C = 2.1707, Group B = 3.1333, Group A = 3.1600**	**1 < 2**	**F(2, 42) = 53.559, p < 0.001**	**Group A ≈ Group B (both significantly better)**
Flexibility Sit & Reach (Pre)	**Group C = 7.5267, Group B = 7.6067, Group A = 7.7473**	**1**	**F(2, 42) = 0.229, p = 0.797**	**None (no significant difference)**
Flexibility Sit & Reach (Post)	**Group C = 7.6933, Group A = 8.3600, Group B = 8.8267**	**1 < 2**	**F(2, 42) = 8.511, p < 0.001**	**Group B (PTG + Digging Agility)**

This table presents ANOVA results comparing the post-test performance across three groups:

- Group A (Plyometric Training)
- Group B (Plyometric + Digging Agility Training)
- Group C (Control Group - Regular Training Only)

Each row shows group means, statistical significance **(**F, p-values**),** and which group performed best **(**Outperforming Group**).**

- **Agility (T-Test)**
    1. Pre-Test: No significant difference among groups (**p = 0.802**).

2. Post-Test: Group B performed best (**p < 0.001**), confirming that plyometric + digging agility training improved agility the most**.**

- **Balance (Stork Stand Test)**
    1. Pre-Test: No significant difference (p = 0.670).
    2. Post-Test: Group B had the highest balance improvement (p < 0.001).
- **Speed (30m Sprint Test)**
    1. Pre-Test: No significant difference (p = 0.285).
    2. Post-Test: Group B showed the fastest sprint times (p < 0.001), proving its training was most effective for speed.
- **Explosive Strength (Vertical Jump Test)**
    1. Pre-Test: No significant difference (p = 0.071).
    2. Post-Test: Both Groups A and B significantly outperformed Group C (p < 0.001).
- **Flexibility (Sit & Reach Test)**
    1. Pre-Test: No significant difference (p = 0.797).
    2. Post-Test: Group B showed the most improvement (p < 0.001).
- Group B (Plyometric + Digging Agility Training) consistently outperformed other groups in agility, balance, speed, and flexibility.
- Explosive strength improved significantly in both Groups A and B.
- The control group (Group C) showed the least improvement, proving the effectiveness of specialized training interventions.
- This study examined the effects of an eight-week plyometric and digging agility training program on agility, explosive strength, balance, speed, and flexibility in male national volleyball players. The results demonstrated that Group B (plyometric training combined with digging agility drills) achieved the most significant improvements across all motor fitness attributes. The findings support the assertion that incorporating sport-specific digging drills enhances lateral movement and reaction time, aligning with previous research (Silva et al., 2019).
- The T-Test analysis confirmed that agility improved significantly in Group B. Explosive strength, as measured by the Vertical Jump Test, increased in both experimental groups, particularly in Group A, supporting the idea that plyometric training enhances power

(Chu, 1998). These results are consistent with the principles of the stretch-shortening cycle (SSC), which underpin plyometric exercises to enhance jump performance (Haibach-Beach et al., 2024).

- Balance, assessed via the Stork Stand Balance Test, improved across all groups, with Group B exhibiting the highest gains. This suggests that agility drills enhance proprioceptive control and dynamic stability, essential for volleyball movements (Hammami et al., 2019). Additionally, the 30-meter Sprint Test showed the most significant improvements in Group B, indicating that integrating plyometric and agility training enhances sprint biomechanics and neural movement control (Moran et al., 2024). These findings align with prior research indicating that agility-focused programs improve both unidirectional and bidirectional velocity (Silva et al., 2019).
- The Sit-and-Reach Test results demonstrated significant flexibility improvements in both experimental groups, with Group B showing the greatest gains. The dynamic, sport-specific movements likely contributed to enhanced hamstring and lower back flexibility, crucial for defensive actions in volleyball (Chuang et al., 2022). In contrast, the control group (Group C) exhibited only minor improvements in all fitness components, reinforcing the importance of structured training interventions (Dobbs et al., 2019).
- This study also provides novel insights into the role of digging agility in volleyball training. Unlike previous studies focusing solely on agility and power, this research incorporates defensive actions to enhance reactive agility, a key aspect of digging (Oppici et al., 2022). The significant improvement in digging agility in Group B demonstrates that incorporating sport-specific drills into regular training can enhance performance in competitive settings (Trajković et al., 2020). These findings align with the ecological dynamics perspective, which emphasizes that training should mimic real-game scenarios to facilitate skill transfer (Jiang et al., 2022).
- **Discussion**
- Furthermore, this research contributes to the understanding of training efficacy in resource-limited environments like Pakistan, where access to advanced sports science facilities is minimal. The results suggest that even with limited resources, well-structured training programs can lead to substantial athletic performance improvements. The study's

methodological approach, including standardized tests and statistical analyses, allows for comparison with international research (Fretheim et al., 2006).

- However, certain limitations should be acknowledged. The study did not include a follow-up assessment to determine the long-term retention of motor fitness improvements. Future research should investigate the sustainability of these effects over time (Rokita, 2024). Additionally, factors such as nutrition, sleep, and other physical activities were not controlled, which could have influenced the outcomes (Ewert & Sibthorp, 2009). Implementing an active control group in future studies may help differentiate the specific effects of specialized training from general physical activity improvements (Sedgwick & Greenwood, 2015).

Implications & Future Directions

- The study's findings have important implications for volleyball training, particularly in developing countries with limited sports science resources. The significant improvements in agility, explosive strength, balance, speed, and flexibility highlight the need for structured, sport-specific training interventions. Volleyball coaches and trainers should integrate plyometric and digging agility drills to enhance athletes' overall performance (Silva et al., 2019).
- Moreover, the study underscores the importance of defensive-focused training, demonstrating that enhancing digging agility is crucial for performance. The results align with research advocating for neuromuscular training in sports to enhance competition readiness. These findings are particularly relevant for training programs at the national and club levels, where a gap exists between general fitness training and sport-specific skill development.
- From a practical perspective, integrating plyometric exercises and multidirectional agility training into volleyball practice is recommended. This is especially beneficial for teams preparing for higher-level competition, as improved motor fitness directly contributes to better defensive capabilities and overall gameplay. Additionally, the study highlights that structured interventions, even in low-tech training environments, can positively impact athletic performance.

- Future research should explore the long-term effects of training interventions to determine whether ongoing practice is necessary to maintain fitness gains. Cognitive-motor training—such as reaction-based agility drills with visual and auditory cues—may enhance game-specific reactivity. Expanding the study to include female athletes and mixed-gender groups would provide insight into gender-specific adaptations. Further research on training duration, intensity, and environmental factors (e.g., training on sand vs. hard surfaces) could optimize training programs for different volleyball players.

Conclusion

This study evaluated the effects of plyometric and digging agility training on the motor fitness components and digging agility of male national volleyball players in Pakistan. The findings revealed significant improvements in both experimental groups, with Group B outperforming Group A and the control group in agility, speed, balance, explosive strength, flexibility, and digging agility. These results highlight the additional benefits of combining digging agility training with plyometric exercises. The strong performance of Group B emphasizes the value of sport-specific training programs that address the unique demands of volleyball. The findings support the effectiveness of integrating plyometric and agility-focused drills to enhance defensive skills and overall athletic performance. Ultimately, these results underscore the importance of evidence-based training strategies in volleyball. Coaches, trainers, and sports administrators should incorporate comprehensive training programs into athlete development plans. Additionally, institutions and governing bodies should allocate resources to sustain these training methods, fostering competitive excellence in the sport.

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