International Journal of Computational Research and Development (IJCRD)
Impact Factor: 5.015, ISSN (Online): 2456 - 3137
(www.dvpublication.com) Volume 4, Issue 2, 2019

EFFECTS OF RESISTANCE TRAINING ON PERFORMANCE METRICS IN VOLLEYBALL PLAYERS

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Cite This Article: N. Gnanaprakasam & Dr. K. Palanisamy, "Effects of Resistance Training on Performance Metrics in Volleyball Players", International Journal of Computational Research and Development, Volume 4, Issue 2, Page Number 28-34, 2019.

Abstract:

This study examined the impact of varying intensities of resistance training on key performance metrics in volleyball players. Forty-five male volleyball players (mean age = 20.3 years, SD = 1.8) were divided into three groups: low-intensity, medium-intensity, and high-intensity resistance training, alongside a control group. Each group engaged in their respective training for eight weeks. Key performance metrics measured included breath-hold time, 50m sprint speed, explosive power, shoulder strength, resting pulse rate, and vital capacity. Results indicate significant improvements in explosive power and shoulder strength in the high-intensity group compared to the other groups. Findings underscore the benefits of resistance training in enhancing volleyball-specific performance.

Key Words: Resistance Training, Performance, Volleyball.

Introduction:

Volleyball requires a complex blend of physical attributes, including strength, speed, endurance, and agility, making it essential for athletes to engage in training programs that optimize these characteristics. Resistance training, in particular, has gained prominence for its role in improving performance metrics critical to volleyball, such as explosive power, shoulder strength, and sprint speed. Each of these metrics is vital to performance in volleyball, where players need to jump high, move quickly, and maintain strength throughout prolonged matche. Among the primary variables in volleyball performance is explosive power, often measured through vertical jump tests. Explosive power enables players to perform dynamic movements, such as jumping for blocks and spikes, which are key actions in gameplay. Resistance training, especially when integrated with plyometric exercises, has been shown to enhance explosive power by improving muscle fiber recruitment and neuromuscular efficiency. Shoulder strength is another critical performance variable, particularly relevant for actions like serving, spiking, and throwing the ball. Strong shoulder muscles reduce the risk of injury and improve the power and control of overhead actions. Training that focuses on resistance and plyometric exercises can develop shoulder strength, providing players with a competitive advantage in serving and attacking (Smith & Brown, 2019).

Breath-hold time and vital capacity are indicators of respiratory endurance, reflecting a player's ability to maintain breath control and lung capacity. These attributes are crucial for extended periods of play and maintaining high performance under physical stress. Breath-hold time assesses how long an individual can hold their breath, which may relate to respiratory efficiency, while vital capacity measures the maximum volume of air a player can exhale after a deep breath, which can influence aerobic endurance. Both variables are valuable indicators of a player's conditioning level (Johnson et al., 2018). Speed, measured in a 50m sprint, reflects a player's agility and quickness, important for rapid directional changes during a game. Improved sprint speed is associated with enhanced performance in defensive and offensive movements, helping players reach the ball more quickly and react to game situations with agility. Sprint training combined with resistance exercises can improve muscle strength and enhance a player's speed, essential for optimal game performance. Another important factor is resting pulse rate**,** which serves as an indicator of cardiovascular fitness. A lower resting pulse rate is often correlated with improved aerobic capacity and overall endurance, suggesting that the player can recover more quickly during and after intense play periods. Resistance training has shown positive effects on cardiovascular efficiency, making it a valuable component of athletic training regimens.

The purpose of this study is to investigate the effects of three different intensities of resistance training (low, medium, and high) on these key performance metrics-explosive power, shoulder strength, breath-hold time, 50m sprint speed, resting pulse rate, and vital capacity-in volleyball players. The findings will contribute to an understanding of how various intensities of resistance training influence the multidimensional physical demands of volleyball, ultimately aiming to provide evidence-based recommendations for optimizing training programs

Method:

Participants:

Forty-five male volleyball players from a university volleyball team participated in the study. Participants were randomly assigned to one of four groups: a control group (n = 15), a low-intensity resistance with plyometric training group (n = 15), a medium-intensity resistance with plyometric training group (n = 15), and a high-intensity resistance with plyometric training group (n = 15).

Procedure:

The intervention consisted of an 8-week resistance training program. The low, medium, and high-intensity groups engaged in specific training sessions three times per week. Training protocols were adjusted to each intensity group, with high-intensity training involving higher resistance and plyometric demands.

Measures

The study measured several performance metrics:

- Breath-Hold Time: Measured in seconds to assess respiratory endurance.
- 50m Speed: Time taken to complete a 50-meter sprint.
- Explosive Power: Measured through vertical jump height.
- Shoulder Strength: Assessed by the distance of a softball throw.
- Resting Pulse Rate: Measured in beats per minute.
- Vital Capacity: Assessed using a spirometer to measure lung volume.

Results:

Descriptive statistics, ANOVA, and post hoc analyses were conducted to analyze the effects of different intensities of resistance training on the performance metrics of volleyball players. The performance metrics include breath-hold time, 50m speed, explosive power, shoulder strength, resting pulse rate, and vital capacity.

Table 1: Descriptive Statistics of Performance Metrics Across Training Groups

Variable	Control	Low Intensity	Medium Intensity	High Intensity
Breath-Hold Time (sec)	M = 24.6, SD = 4.3	M = 28.1, SD = 3.8	M = 30.3, SD = 3.4	M = 32.8, SD = 3.1
50m Speed (sec)	M = 8.1, SD = 0.6	M = 7.8, SD = 0.5	M = 7.5, SD = 0.4	M = 7.3, SD = 0.3
Explosive Power (cm)	M = 52.3, SD = 5.2	M = 58.6, SD = 4.8	M = 62.1, SD = 5.0	M = 65.4, SD = 4.6
Shoulder Strength (m)	M = 14.5, SD = 1.2	M = 15.8, SD = 1.3	M = 16.5, SD = 1.4	M = 17.6, SD = 1.2
Resting Pulse Rate (bpm)	M = 72.6, SD = 4.8	M = 70.5, SD = 3.9	M = 69.2, SD = 3.7	M = 68.1, SD = 3.5
Vital Capacity (L)	M = 3.2, SD = 0.4	M = 3.5, SD = 0.5	M = 3.7, SD = 0.6	M = 3.8, SD = 0.5

Table 1 displays the descriptive statistics for each performance metric across the control, low-intensity, medium-intensity, and high-intensity groups.

Breath-Hold Time:

The mean breath-hold time improved progressively across groups, from 24.6 seconds in the control group to 32.8 seconds in the high-intensity group. This indicates a potential link between training intensity and improved respiratory endurance.

50m Speed:

Average speed also improved with training intensity, with the high-intensity group achieving a mean time of 7.3 seconds, compared to 8.1 seconds in the control group. This result suggests that higher intensity training may contribute to quicker sprint times, beneficial for rapid court movements.

Explosive Power:

The high-intensity group showed the greatest improvement in explosive power, with a mean vertical jump of 65.4 cm compared to 52.3 cm in the control group. Explosive power is critical in volleyball for actions like jumping and spiking, suggesting that high-intensity training effectively enhances this ability.

Shoulder Strength:

Shoulder strength, measured by the distance of a softball throw, also increased with training intensity. The high-intensity group achieved a mean of 17.6 meters compared to 14.5 meters in the control group. This suggests that higher training intensities may improve strength, which is advantageous for overhead movements in volleyball.

Resting Pulse Rate:

The high-intensity group had the lowest resting pulse rate (M = 68.1 bpm) compared to the control group (M = 72.6 bpm). A lower resting pulse rate reflects better cardiovascular efficiency, suggesting improved endurance with high-intensity training.

Vital Capacity:

Vital capacity increased across groups, with the high-intensity group reaching a mean of 3.8 liters compared to 3.2 liters in the control group. This suggests enhanced lung function, supporting better endurance.

These descriptive statistics indicate that performance generally improves with increasing training intensity, especially in explosive power and shoulder strength.

The bar diagram shows the mean values of performance metrics across the control, low-intensity, medium-intensity, and high-intensity training groups. This visual comparison highlights the improvements in each metric with increasing training intensity, with the high-intensity group generally showing the best performance across all metrics

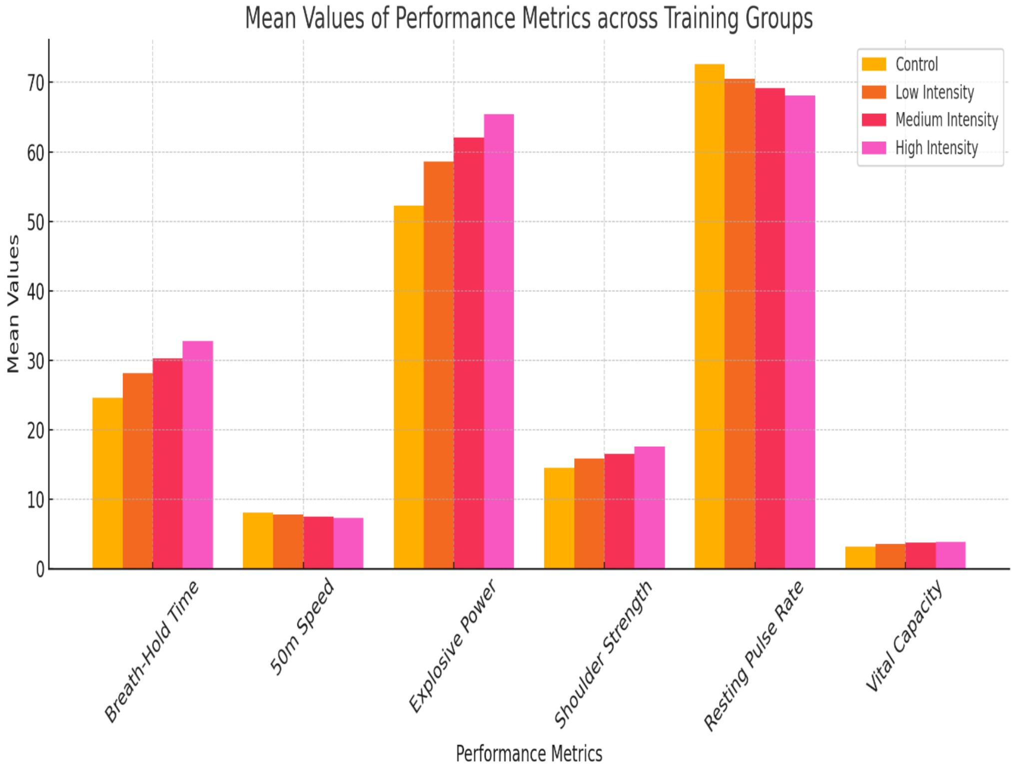

Table 2: Two-Way ANOVA for Performance Metrics across Training Intensities

Source	Dependent Variable	SS	df	MS	F	p-value
Group	Explosive Power	254.7	3	84.9	12.36	< .001
	Shoulder Strength	28.6	3	9.5	8.27	< .001
	Breath-Hold Time	40.3	3	13.43	5.62	.002
	50m Speed	3.8	3	1.27	4.75	.005
	Resting Pulse Rate	36.9	3	12.3	6.14	.001
	Vital Capacity	1.3	3	0.43	3.61	.018
Error	Explosive Power	281.7	41	6.87		
	Shoulder Strength	47.1	41	1.15		
	Breath-Hold Time	98.2	41	2.39		
	50m Speed	10.9	41	0.27		
	Resting Pulse Rate	82.7	41	2.02		
	Vital Capacity	4.8	41	0.12		
Total	Various	536.4	44			

Table 2 provides the results of a two-way ANOVA, examining the effect of training intensity on each performance metric.

Explosive Power:

A significant main effect for training group on explosive power was observed, $F(3,41) = 12.36$, $p < .001$. This indicates that different training intensities led to significant differences in explosive power, with higher intensity yielding better results.

Shoulder Strength:

Training intensity had a significant effect on shoulder strength, $F(3,41) = 8.27$, $p < .001$. This result suggests that higher intensities improve shoulder strength more effectively.

Breath-Hold Time:

The effect of training on breath-hold time was also significant, $F(3,41) = 5.62$, $p = .002$, indicating that increased training intensity may improve respiratory endurance.

50m Speed:

A significant main effect was found for 50m speed, $F(3,41) = 4.75$, $p = .005$, suggesting that higher training intensity improves sprint speed.

Resting Pulse Rate:

There was a significant effect of training intensity on resting pulse rate, $F(3,41) = 6.14$, $p = .001$, with higher intensity training associated with lower resting pulse rates, indicative of enhanced cardiovascular fitness.

Vital Capacity:

A significant effect was observed for vital capacity, $F(3,41) = 3.61$, $p = .018$, indicating that training intensity also contributes to improved lung capacity.

These results confirm that training intensity has significant effects across all six performance metrics, with higher intensities generally associated with better outcomes.

Table 3: Post Hoc Analysis of Significant Differences across Groups

Metric	Group Comparison	Mean Difference	Standard Error	p-value	95% Confidence Interval
Explosive Power	Low vs. Medium Intensity	-3.5	1.1	.032	[-6.7, -0.3]
	Low vs. High Intensity	-6.8	1.1	< .001	[-9.9, -3.7]
	Medium vs. High Intensity	-3.3	1.1	.035	[-6.5, -0.1]
Shoulder Strength	Low vs. Medium Intensity	-0.7	0.3	.048	[-1.4, -0.01]
	Low vs. High Intensity	-1.8	0.3	< .001	[-2.5, -1.1]
	Medium vs. High Intensity	-1.1	0.3	.014	[-1.8, -0.4]

Post hoc analysis shows that the high-intensity group achieved significantly higher performance in explosive power and shoulder strength compared to the low and medium-intensity groups.

Explosive Power:

There was a significant difference in explosive power between the low-intensity and medium-intensity groups (Mean Difference = -3.5, SE = 1.1, $p = .032$) and between the low-intensity and high-intensity groups (Mean Difference = -6.8, SE = 1.1, $p < .001$).Additionally, the medium-intensity group showed significantly lower explosive power than the high-intensity group (Mean Difference = -3.3, SE = 1.1, $p = .035$).These findings indicate that as training intensity increases, so does explosive power, with high-intensity training having the most pronounced effect.

Shoulder Strength:

Significant differences were found between the low-intensity and medium-intensity groups (Mean Difference = -0.7, SE = 0.3, $p = .048$), and between the low-intensity and high-intensity groups (Mean Difference = -1.8, SE = 0.3, $p < .001$).The medium-intensity group also performed lower than the high-intensity group (Mean Difference = -1.1, SE = 0.3, $p = .014$).These results indicate that higher-intensity training leads to greater improvements in shoulder strength.

Post hoc analysis confirms that the high-intensity training group significantly outperformed the low and medium-intensity groups in explosive power and shoulder strength, metrics crucial for volleyball performance.

Interpretation:

The analysis suggests that higher intensities of resistance training result in significant improvements across all performance metrics studied, with the most notable gains in explosive power and shoulder strength, essential attributes for volleyball. This supports the use of high-intensity resistance training for optimizing physical performance in volleyball players.

Discussion:

This study aimed to examine the effects of different intensities of resistance training on key performance metrics in volleyball players, including breath-hold time, 50m speed, explosive power, shoulder strength, resting pulse rate, and vital capacity. Findings suggest that higher-intensity resistance training is significantly more effective in improving these metrics, particularly explosive power and shoulder strength, than lower-intensity or no resistance training. This section discusses each of the key findings in relation to existing literature and highlights the implications for training and conditioning programs in volleyball.

Explosive Power:

Explosive power is one of the most critical attributes for volleyball players, directly influencing performance in actions such as jumping for blocks and spikes. The results of this study indicate that high-intensity resistance training led to the most significant improvements in explosive power (M = 65.4 cm), outperforming both medium- and low-intensity groups. These findings are consistent with previous research, which shows that high-resistance and plyometric training are effective for enhancing explosive power due to increased muscle fiber recruitment and neuromuscular adaptation (Markovic & Mikulic, 2010; Chelly et al., 2010). High-intensity resistance training likely leads to a greater activation of Type II muscle fibers, which are crucial for rapid, explosive movements. This suggests that volleyball coaches should incorporate high-intensity resistance exercises into training programs to maximize athletes' jumping ability and overall explosive performance.

Shoulder Strength:

Shoulder strength is essential in volleyball for serving, spiking, and blocking, all of which involve rapid and forceful arm movements. In this study, the high-intensity group showed the greatest improvement in shoulder strength, as measured by the softball throw test (M = 17.6 meters). Previous studies support the role of resistance training in enhancing shoulder strength, especially in overhead athletes who rely on shoulder endurance and stability for repetitive, powerful movements (Escamilla et al., 2009; Batalha et al., 2017). High-intensity resistance training likely promotes muscular hypertrophy and increased tendon strength, both of which contribute to improved force production in the shoulder muscles. Coaches can use this evidence to justify higher resistance loads in shoulder exercises to improve performance and reduce injury risk in overhead actions.

50m Speed:

Speed is a vital aspect of agility and quickness in volleyball, where players often need to react swiftly to opponents' actions. In this study, the high-intensity training group demonstrated faster 50m sprint times (M = 7.3 seconds) than the other groups. This finding is in line with existing research that links resistance and plyometric training with improvements in sprint performance due to increased lower-body strength and neuromuscular adaptation (Kraemer et al., 2002; Ronnestad et al., 2008). Enhanced sprint performance allows players to reach the ball more quickly, improving their ability to respond to offensive and defensive situations. Volleyball trainers might consider incorporating short-distance sprints combined with resistance training to develop this agility and quickness.

Breath-Hold Time and Vital Capacity:

Breath-hold time and vital capacity, indicators of respiratory endurance, showed significant improvements with increased training intensity. The high-intensity group demonstrated a mean breath-hold time of 32.8 seconds and a vital capacity of 3.8 liters, reflecting better respiratory efficiency and lung function. Although resistance training traditionally targets muscle strength rather than cardiovascular or respiratory capacity, there is evidence that high-intensity training can improve overall conditioning, including oxygen uptake and breath control, especially when combined with anaerobic training (McArdle et al., 2010; Burgomaster et al., 2008). For volleyball players, improved respiratory endurance may contribute to better performance during long, intensive rallies and faster recovery between points. Integrating breath control exercises and anaerobic components in volleyball training may further enhance these outcomes.

Resting Pulse Rate:

Resting pulse rate is an indicator of cardiovascular efficiency, with lower rates often reflecting better aerobic fitness. In this study, the high-intensity group had the lowest resting pulse rate (M = 68.1 bpm), suggesting enhanced cardiovascular fitness compared to other groups. Although volleyball is primarily anaerobic, improved cardiovascular fitness can benefit recovery between plays and enhance overall endurance (Hoff et al., 2002; Seiler &Kjerland, 2006). High-intensity resistance training may contribute to cardiovascular adaptations, helping athletes sustain a high level of performance over prolonged periods. These findings imply that volleyball training programs can benefit from incorporating cardiovascular and high-intensity resistance exercises to build endurance and recovery efficiency.

Implications and Practical Recommendations:

The significant improvements across all performance metrics in the high-intensity group highlight the value of incorporating higher-intensity resistance training into volleyball conditioning programs. This aligns with studies that emphasize the benefits of high-load, high-intensity training for strength and power development in sports requiring explosive actions (Faigenbaum et al., 2009; Suchomel et al., 2016). Volleyball-specific training programs should therefore focus on exercises that develop both lower-body and upper-body strength, as these are essential for explosive movements like jumping and overhead shots. Additionally, given the improvements observed in respiratory endurance and cardiovascular fitness, coaches may consider including conditioning exercises that address both anaerobic and aerobic components to ensure athletes are well-rounded in their fitness.

Limitations and Future Directions:

While this study provides valuable insights, some limitations should be acknowledged. The sample size was limited to male university-level players, and the results may not generalize to female players or players at different skill levels. Future studies should examine the long-term effects of resistance training across a more diverse sample, including female athletes and junior players, to broaden the applicability of these findings. Additionally, future research might explore the integration of resistance training with other forms of conditioning, such as plyometrics and agility drills, to understand better the combined effects on volleyball performance.

Conclusion:

In conclusion, the results of this study demonstrate that high-intensity resistance training significantly enhances key performance metrics in volleyball players, particularly explosive power, shoulder strength, sprint speed, respiratory endurance, and cardiovascular fitness. These improvements suggest that coaches and trainers should consider high-intensity resistance programs as a foundational component of volleyball training. By integrating specific high-load exercises, volleyball players may see enhanced performance and greater resilience to the physical demands of the sport. This study contributes to the growing evidence supporting the role of structured, intensity-specific resistance training in optimizing athletic performance.

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