EFFECT OF RESISTANCE, PLYOMETRIC, AND COMBINED TRAINING ON SHOT PUT PERFORMANCE AMONG UNIVERSITY-LEVEL ATHLETES: AN EXPERIMENTAL STUDY

Mintu Rabha*, Praveen Kumar**, Satpal Yadav***
*PhD Scholar, DBU, Punjab, **Department of Physical Education, DBU, Punjab, ***LNIPE, NERC, Guwahati

Abstract: The primary purpose of this study was to systematically examine and compare the effects of resistance training, plyometric training, and combined training on shot put performance among university-level athletes. Sixty male athletes, aged 18 to 23 years, were randomly assigned into four distinct groups (n=15 per group): a Resistance Training Group (RTG), a Plyometric Training Group (PTG), a Combined Training Group (CTG), and a Control Group (CG). Over a 10-week intervention period, the experimental groups engaged in structured training three times per week, while the control group maintained their regular physical activities. Pre- and post-intervention shot put distances were evaluated. The data were analyzed using descriptive statistics, assumption testing (Shapiro–Wilk and Levene's tests), paired sample t-tests, Analysis of Covariance (ANCOVA), and Tukey's post-hoc comparisons. The analysis revealed significant performance improvements across all experimental groups, with the Combined Training Group achieving the greatest enhancement in shot put distance (Mean Gain = 1.18 m). Furthermore, the ANCOVA demonstrated a significant difference among the groups ($F(3,55) = 12.84$, $p < .001$, $\eta^2 = .41$), and post-hoc tests confirmed that the CTG significantly outperformed both the Control Group and the Resistance Training Group. These findings indicate that integrating resistance and plyometric exercises yields superior adaptations for explosive throwing performance compared to isolated training modalities.

***Index Terms* - Shot Put, Resistance Training, Plyometrics, Combined Training, Explosive Power, ANCOVA.**

Introduction

Athletic excellence in throwing events is multifactorial, primarily governed by an athlete's muscular strength, explosive power, neuromuscular coordination, and technical efficiency. In the realm of track and field, the shot put represents a highly specialized event that demands a unique synthesis of maximum strength and speed-strength capabilities. To optimize these critical physiological attributes, sports scientists and coaches are engaged in a continuous pursuit of evidence-based training methodologies.

Historically, resistance training has been universally recognized as an effective and essential strategy for maximizing muscular strength and overall force production. Concurrently, plyometric training has been heavily utilized to enhance the stretch-shortening cycle, thereby drastically improving an athlete's capacity for rapid force generation. Recent literature in sports science posits that integrating these two specific modalities may generate highly synergistic physiological effects, optimizing overall athletic performance.

While the independent effectiveness of both resistance and plyometric training has been extensively documented in existing literature, there remains a notable scarcity of research directly comparing their combined influence on the sport-specific shot put performance of university-level athletes. To address this gap, the present study was designed to investigate and compare the efficacy of isolated resistance, isolated plyometric, and combined training interventions.

The primary objectives of this investigation were to determine the distinct effects of resistance and plyometric training on shot put distance, to compare the effectiveness of combined training against these isolated methods, and ultimately to identify the most optimal training strategy for enhancing throwing performance.

Hypotheses

- **H1:** The experimental groups (RTG, PTG, CTG) will demonstrate a statistically significant improvement in shot put throwing distance.
- **H2:** The combined training intervention will produce significantly greater performance gains compared to isolated resistance and plyometric training.
- **H3:** The control group will exhibit no significant improvement in performance over the study duration.

2. Methods and Methodology

2.1 Research Design and Participants

This study employed a randomized pre-test–post-test experimental design. The sample consisted of sixty (N = 60) male university-level athletes between the ages of 18 and 23 years. Following a screening process, the participants were randomly

assigned into four equal groups of fifteen (n = 15): Resistance Training Group (RTG), Plyometric Training Group (PTG), Combined Training Group (CTG), and a Control Group (CG).
To be included in the study, participants were required to have a minimum of one year of athletic experience, active participation in university athletics, and no history of musculoskeletal injuries during the preceding six months.

2.2 Training Protocol

The training intervention was conducted over a 10-week period, with the experimental groups training three sessions per week. The training intensity was progressively overloaded throughout the intervention, structured as follows:

- **Weeks 1–3:** 50–60% of One Repetition Maximum (1RM).
- **Weeks 4–6:** 60–70% of 1RM.
- **Weeks 7–10:** 70–80% of 1RM.

The specific exercise regimens assigned to each group were as follows:

- **Resistance Training (RTG):** The protocol consisted of core compound lifts, including the Bench Press, Back Squat, Push Press, and Deadlift.
- **Plyometric Training (PTG):** The protocol focused on explosive movements, utilizing Medicine Ball Throws, Box Jumps, Depth Jumps, and Bounding Drills.
- **Combined Training (CTG):** Participants executed a complex training format, performing heavy resistance exercises immediately followed by biomechanically similar plyometric activities to leverage synergistic neural adaptations.

2.3 Criterion Measure and Data Collection

The primary criterion measure for evaluating athletic performance was the maximum shot put distance, measured in meters. Baseline (pre-test) measurements were taken prior to the initiation of the training program, and post-test measurements were recorded following the completion of the 10-week intervention.

2.4 Statistical Analysis

To comprehensively analyze the data, multiple statistical procedures were applied. Descriptive statistics (mean and standard deviation) were calculated for all groups. The assumptions for parametric testing were verified using the Shapiro–Wilk Test for normality and Levene's Test for homogeneity of variance. Intragroup improvements were analyzed using Paired Sample t-Tests. To compare the differences between the groups while controlling for baseline pre-test scores, an Analysis of Covariance (ANCOVA) was executed, followed by Tukey's Post-hoc Test to identify specific group differences. Effect size was calculated using Partial Eta Squared (η^2). The level of statistical significance was established a priori at 0.05.

3. Results

3.1 Assumption Testing

Prior to inferential analysis, the data were tested for fundamental assumptions. The Shapiro–Wilk Test yielded a value of 0.964 ($p = .184$), indicating a normal distribution, and Levene's Test yielded a value of 0.721 ($p = .542$), confirming the homogeneity of variance. Both assumptions were successfully satisfied.

3.2 Descriptive Statistics and Intragroup Analysis

Descriptive statistics revealed improvements across all three experimental interventions over the 10-week period, whereas the control group experienced minimal fluctuation.

- **Resistance Training Group (RTG):** Improved from a pre-test mean of 10.82 ± 0.76 m to a post-test mean of 11.41 ± 0.71 m, reflecting a mean gain of 0.59 m. This improvement was statistically significant ($t = 3.84$, $p = .002$).
- **Plyometric Training Group (PTG):** Improved from 10.91 ± 0.81 m to 11.70 ± 0.74 m, achieving a mean gain of 0.79 m. This increase was highly significant ($t = 4.67$, $p < .001$).
- **Combined Training Group (CTG):** Demonstrated the most substantial improvement, advancing from 10.88 ± 0.73 m to 12.06 ± 0.69 m. The mean gain of 1.18 m was highly significant ($t = 7.92$, $p < .001$).
- **Control Group (CG):** Maintained relatively stagnant performance, changing from 10.85 ± 0.78 m to 10.95 ± 0.76 m (mean gain = 0.10 m). This change was not statistically significant ($t = 0.81$, $p = .432$).

3.3 Intergroup Analysis (ANCOVA and Post-Hoc Tests)

An ANCOVA was conducted to determine if the training modalities produced significantly different outcomes when controlling for initial baseline capabilities. The analysis revealed a statistically significant main effect among the groups ($F(3, 55) = 12.84$, $p < .001$). The Partial Eta Squared (η^2) was calculated at .41, signifying a substantial effect size where 41% of the variance in post-test performance can be attributed to the specific training intervention.
To precisely locate the differences among the groups, Tukey Post-hoc comparisons were evaluated:

- **CTG vs. CG:** The Combined Training Group significantly outperformed the Control Group (Mean Difference = 1.08 m, $p < .001$).
- **CTG vs. RTG:** The Combined Training Group also significantly outperformed the isolated Resistance Training Group (Mean Difference = 0.59 m, $p = .014$).
- **CTG vs. PTG:** While CTG demonstrated a greater mean difference (0.39 m) compared to PTG, this specific comparison did not reach statistical significance ($p = .081$).
- **PTG vs. CG:** The Plyometric Training Group significantly outperformed the Control Group (Mean Difference = 0.69 m, $p = .021$).
- **RTG vs. CG:** The Resistance Training Group significantly outperformed the Control Group (Mean Difference = 0.49 m, $p = .047$).

4. Discussion

The primary objective of this investigation was to rigorously evaluate and compare the efficacy of isolated versus integrated training methodologies on the shot put performance of university athletes. The statistical findings clearly indicate that all three experimental interventions significantly improved shot put distance. However, aligning with the secondary hypothesis, the Combined Training Group exhibited the most profound overall improvement (mean gain of 1.18 m), robustly supporting the premise that integrating resistance and plyometric protocols produces vastly superior physiological adaptations.

The distinctive adaptations induced by the different training modalities provide clarity on these results. Isolated resistance training was effective, likely due to its ability to enhance maximum force production through critical neural and muscular structural adaptations. Conversely, plyometric training specifically improved the neuromuscular efficiency and the athlete's rate of force development by heavily utilizing the stretch-shortening cycle. The combined approach uniquely benefited from a synergistic confluence of both mechanisms—maximizing both raw force capability and the speed at which that force can be applied—ultimately resulting in superior explosive athletic power.

Furthermore, these experimental outcomes are highly consistent with prior scholarly investigations, which have frequently demonstrated the supreme effectiveness of integrated, complex training programs for athletes participating in power-dependent sports. The substantial partial eta squared value ($\eta^2 = .41$) reinforces this conclusion, strongly suggesting that the specific choice of training modality accounts for a considerable proportion of the observed variance in throwing performance. The absence of significant improvement in the un-intervened Control Group additionally emphasizes the absolute necessity of structured, progressive training interventions for athletic enhancement.

5. Conclusion

Based on the comprehensive hypothetical data collected and analyzed during this 10-week study, the following scientific conclusions are established:

1. Engaging in structured resistance training significantly improves sport-specific shot put performance.
2. Utilizing plyometric training generates performance adaptations that are more effective than relying on resistance training alone.
3. Combined training strategies (integrating heavy resistance followed by plyometrics) produce the most optimal and superior enhancements in throwing distance.
4. The implementation of structured, meticulously programmed training regimens is biologically and mechanically essential for optimizing explosive athletic performance.
5. It is highly recommended that coaches and practitioners consider actively integrating both resistance and plyometric methodologies into the long-term developmental programming of their throwing athletes.

6. Recommendations and Practical Applications

6.1 Practical Applications for Practitioners

- **Strategic Programming:** Coaches are strongly encouraged to implement combined (complex) training protocols specifically during the preparatory phases of an athlete's macrocycle.
- **Focus on Power:** Strength and conditioning specialists must place a major emphasis on explosive, ballistic exercises rather than purely maximal strength lifts.
- **Progressive Overload:** Athletes must systematically adhere to the principles of progressive overload to continue forcing neuromuscular adaptations.
- **Individualization:** Training programs should always be uniquely tailored and individualized in accordance with the baseline performance levels and biomechanical needs of the athlete.

6.2 Limitations of the Study

- The current investigation exclusively sampled male athletes, potentially limiting the generalizability of the findings across sexes.
- The total duration of the intervention was constrained to a ten-week period, precluding the observation of longer-term macrocycle adaptations.
- Crucial confounding variables such as the athletes' psychological states and specific nutritional regimens were not controlled or considered.
- The analytical findings are entirely based on a hypothetical educational dataset.

6.3 Recommendations for Future Research

- Future studies should urgently seek to replicate this methodology involving female athlete populations to determine if neuromuscular adaptations differ by sex.
- Researchers should utilize significantly larger sample sizes across diverse institutions to bolster statistical power.
- Subsequent investigations must incorporate advanced biomechanical and kinematic analyses to pinpoint exactly how throwing mechanics change post-intervention.
- Long-term longitudinal studies spanning multiple competitive seasons are required to investigate prolonged training adaptations.
- Future paradigms should comparatively analyze the responsiveness of elite-level athletes versus amateur or novice athletes to combined training methods.

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