# Development of strength qualities of para powerlifting athletes in indoor training conditions

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**Abstract.**
The current study focuses on the scientific and practical foundations for the development of strength qualities in para powerlifting athletes during their annual training cycle under indoor training conditions. Para powerlifting is one of the most demanding Paralympic sports, requiring exceptional levels of maximal strength, muscular coordination, and strength endurance in the upper limbs and shoulder girdle. Despite the growing popularity of this sport, there remains a lack of systematic and experimentally verified methodologies that integrate weightlifting-based resistance training and isometric exercises tailored to the specific functional and physiological characteristics of para athletes.

The purpose of this research was to develop and experimentally justify a comprehensive indoor strength training methodology for para powerlifters that enhances maximal strength, strength endurance, and technical stability. The study involved 12 athletes aged 18–28 years, classified according to Paralympic standards, all medically cleared for participation. The 12-week experimental program consisted of structured micro- and mesocycles emphasizing progressive overload (from 60–70% to 85% of 1RM), controlled tempo bench press variations, isometric holds, dumbbell-based isolation movements, and auxiliary core stabilization exercises.

Performance evaluation included pre- and post-tests measuring one-repetition maximum (1RM) in bench press, isometric hold duration, triceps strength, and recovery time. Statistical analysis (paired *t*-tests, $p < 0.05$) revealed significant improvements: bench press 1RM increased by 12.1%, triceps strength by 17.6%, isometric endurance by 25.6%, while recovery time decreased by 25.8%. These results confirm the effectiveness of the proposed methodology in optimizing both neuromuscular and metabolic adaptations in para athletes.

The findings highlight that combining weightlifting tools with isometric training methods within a controlled indoor environment enhances performance and reduces physiological stress caused by environmental factors. Furthermore, the integrated approach improves recovery dynamics, psychological focus, and overall training consistency.

This research contributes to the scientific understanding of strength development in para sports and provides practical guidance for coaches and sport scientists in designing individualized and evidence-based training programs for para powerlifting athletes. The developed methodology may serve as a model for further studies and as a foundation for developing national para sport training standards in Uzbekistan and beyond.

**Keywords:** para powerlifting, Paralympic sport, strength training methodology, maximal strength, strength endurance, isometric exercise, resistance training, neuromuscular adaptation, weightlifting tools, indoor training program, rehabilitation and recovery, physiological development in para athletes.

## Introduction

Para sport has become an integral part of the modern sports system, reflecting inclusivity, determination, and high-level athletic performance. Among Paralympic disciplines, para powerlifting stands out as one of the most demanding sports, where athletes with various physical impairments compete based on upper-body strength and control. The event's core component — the bench press — requires not only maximal muscle power but also precise neuromuscular coordination, technical stability, and strength endurance under competitive conditions.

In recent years, Uzbekistan's national para powerlifting team has demonstrated remarkable progress on the international stage, affirming the country's growing commitment to Paralympic sports. At the 2025 World Para Powerlifting Championships in Cairo, Uzbek athletes achieved 17 medals (10 gold, 5 silver, and 2 bronze), ranking among the top-performing nations. Previously, Uzbekistan's representatives had secured multiple podium finishes in international Grand Prix tournaments and World Cups, further establishing the nation as a competitive force in Paralympic strength sports. These results highlight both the technical mastery and the systematic training methodology applied in national programs.

Such achievements are closely linked to the strategic state initiatives aimed at promoting sports among individuals with disabilities. The Decree of the President of the Republic of Uzbekistan (2017) on the development of physical culture and mass sports, and subsequent resolutions addressing Paralympic preparation, have laid the foundation for comprehensive training systems, rehabilitation programs, and international integration of para athletes. However, despite these institutional advances, the scientific and methodological aspects of training, particularly in the context of para powerlifting, remain underexplored.

Para powerlifting athletes face specific challenges due to functional limitations such as lower-limb impairments, restricted mobility, and asymmetric muscle activation patterns. These conditions require specialized load distribution, training periodization, and biomechanical adaptation to ensure safe yet effective progression in strength performance. While many studies address general powerlifting principles, few have examined systematic, evidence-based methodologies for para athletes, especially within controlled indoor training environments that reduce environmental variability and injury risk.

Considering Uzbekistan's climatic conditions and

the limited accessibility of specialized facilities in some regions, indoor training offers a consistent and controlled environment for developing maximal strength, endurance, and coordination. Integrating weightlifting tools (barbells, dumbbells, resistance machines) and isometric training provides a unique opportunity to enhance performance while accounting for the physiological and biomechanical individuality of para athletes.

Therefore, the purpose of this study was to develop and experimentally validate a scientifically grounded methodology for the development of strength qualities in para powerlifting athletes under indoor training conditions. The study aimed to design an optimized program based on weightlifting and isometric exercises that enhances maximal strength, muscular endurance, and neuromuscular efficiency, while improving overall training safety and effectiveness.

The scientific novelty of this research lies in creating a structured and adaptive model that aligns with Paralympic sport classifications and physiological demands. The findings are expected to contribute to the modernization of para powerlifting training in Uzbekistan and provide a methodological framework for coaches, sports scientists, and rehabilitation specialists seeking to optimize athletic performance within the Paralympic movement.

## Methods

Participants. The study involved 12 para powerlifting athletes aged between 18 and 28 years. All participants were medically approved for physical training and classified according to Paralympic functional categories (classes 1–3). Individual physical and medical characteristics were taken into account for each athlete.

Design and Procedures. The experiment lasted 12 weeks and was organized in an indoor training environment. The program included weightlifting exercises (bench press variations), isometric holds, dumbbell and expander-based isolation movements, and core stabilization exercises.

Training load progression was gradual: the initial phase (weeks 1–4) involved 60–70% of the athletes' 1RM, followed by 75–85% in the subsequent stages. Each training session included a 10-minute warm-up and a 10-minute recovery and stretching phase.

Measurements. Pre- and post-intervention measurements included:

*Bench press 1RM (kg)*
*Isometric hold time (seconds)*
*Triceps strength test (kg)*
*Recovery time (minutes)*
*Perceived recovery and physiological monitoring (subjective and heart rate-based)*

Data were expressed as means (X) ± standard deviations (σ). Statistical significance was determined using paired t-tests, with a significance level of $p < 0.05$.

Weekly Training Program (Example)

(Loads and intensities were individualized according to each athlete's 1RM and medical conditions.)

Monday – Upper body strength focus

Standard Bench Press — 4–6 sets × 3–6 reps (moderate to high intensity)

Close-Grip Bench Press — 3–4 sets × 6–10 reps

Isometric Bench Hold (6–8 seconds) — 3 sets × 3 reps

Pullover / Lat Pulldown — 3 sets × 8–12 reps

Wednesday – Shoulder and core balance

Seated Shoulder Press or Barbell Press — 4 sets × 6–10 reps

Triceps Extensions — 3 sets × 8–12 reps

Core Isometric Stability — 3–4 sets × 30–45 seconds

Friday – Strength endurance and technical development

Tempo Bench Press (3–1–3 rhythm) — 3–4 sets × 8–12 reps

Lockout (Partial Range Work) — 3 sets × 3–5 reps

Dumbbell Flys / Rows — 3–4 sets × 8–12 reps

Supplementary Work: Recovery techniques (swimming, stretching, hydrotherapy) and physiotherapeutic rehabilitation were applied for optimal muscle recovery.

## Results and discussion

The experimental results clearly demonstrate that the proposed training methodology produced significant improvements in the strength and endurance indicators of para powerlifting athletes. Over the 12-week intervention period, athletes in the experimental group showed consistent and measurable progress across all major performance parameters.

Quantitative analysis revealed that the one-repetition maximum (1RM) in the bench press increased by 12.1%, confirming a meaningful rise in maximal strength. The isometric hold duration, which reflects neuromuscular control and muscle stability under static contraction, improved by 25.6%, indicating enhanced muscular endurance and coordination. Additionally, triceps strength increased by 17.6%, while average recovery time decreased by approximately 26%, demonstrating faster physiological adaptation and improved energy restoration.

Further observation revealed individual improvements in technical execution, including greater control in bench press phases (eccentric–pause–concentric) and reduced movement asymmetry, particularly among athletes with unilateral upper-limb dominance. Athletes also exhibited better breathing coordination, stabilization of the shoulder girdle, and psychological readiness during competitive simulations.

Comparative analysis between pre- and post-tests confirmed statistical significance ($p < 0.05$) across all variables. Moreover, correlations between 1RM improvement and isometric endurance gains ($r = 0.71$, $p < 0.01$) suggest that enhanced static stability contributed directly to dynamic strength performance.

Qualitative feedback from athletes and coaches highlighted improved confidence, reduced fatigue perception, and greater tolerance to high-intensity loads, indicating positive psychological adaptation alongside physiological progress.

Overall, the findings support the hypothesis that integrating weightlifting and isometric training modalities within an indoor environment can optimize both strength capacity and neuromuscular efficiency in para powerlifting athletes.

The results of this study reinforce the effectiveness of combining dynamic resistance exercises and isometric contractions as a dual mechanism for improving strength qualities in para powerlifters. The significant increases in maximal strength and endurance suggest that

**Table 1.** Quantitative changes in maximal strength, neuromuscular control, and recovery dynamics after the training intervention

| Performance Indicator | Before (Mean ± SD) | After (Mean ± SD) | Change (%) |
|---|---|---|---|
| Bench Press 1RM (kg) | 105.2 ± 6.3 | 117.8 ± 5.9 | +12.1 |
| Isometric Hold (sec) | 7.4 ± 1.1 | 9.3 ± 0.9 | +25.6 |
| Triceps Strength (kg) | 42.6 ± 4.5 | 50.1 ± 4.0 | +17.6 |
| Recovery Time (min) | 5.8 ± 0.9 | 4.3 ± 0.8 | −25.8 |

this hybrid approach produces favorable neuromuscular and structural adaptations.

Neuromuscular Adaptations. The improvement in 1RM performance aligns with findings from Zatsiorsky (2020) and Bompa & Haff (2019), who reported that structured resistance periodization enhances the recruitment of high-threshold motor units and synchronization of muscle firing patterns. In para powerlifters, where motor control may be partially compromised due to neurological or orthopedic impairments, the inclusion of isometric holds helps stabilize neural pathways responsible for force generation and intermuscular coordination.

This study's data indicate that isometric training enhances the athletes' ability to generate tension under static load, which translates into more efficient force transfer during dynamic lifts. The increase in triceps and shoulder muscle endurance also suggests improved local circulation and metabolic resilience, consistent with long-term muscular adaptation.

Physiological and Recovery Mechanisms

The 26% reduction in recovery time reflects enhanced aerobic–anaerobic balance and better energy substrate utilization, likely due to repeated submaximal efforts and controlled tempo training. These adaptations are consistent with findings in adaptive strength sports, where energy efficiency is crucial for athletes with limited muscle mass recruitment potential.

Furthermore, the indoor environment minimized external stressors (e.g., temperature, humidity, and accessibility limitations), allowing for more precise load control and better recovery cycles. The controlled conditions promoted consistent load progression, a key factor in the observed performance improvements.

Technical and Psychological Aspects

Technical execution during the bench press improved through increased stability of the shoulder girdle and torso, which is particularly critical for para athletes who rely heavily on upper-body mechanics. Athletes reported a greater sense of stability and confidence, reducing compensatory movements and potential injury risk.

Psychologically, the structured approach and measurable progress boosted motivation and self-efficacy, both of which are vital for sustained engagement in Paralympic training environments.

Comparative Context. When compared to international benchmarks in para powerlifting, the rate of strength improvement (10–15% over 12 weeks) aligns closely with previous studies conducted on able-bodied powerlifters, indicating that the adaptive potential of para athletes is comparable when proper methodology is applied. These findings contribute to growing evidence that, given the right biomechanical adjustments and recovery support, para athletes can achieve elite-level strength adaptations.

Limitations and Future Directions. The study's limitations include a relatively small sample size and the lack of a formal control group, which limits broader generalization. Future studies should expand the participant base and examine long-term periodization effects, including hormonal responses, psychological stress tolerance, and electromyographic analysis of muscle activation patterns. Additionally, further exploration into rehabilitation -integrated training cycles could enhance both performance and health outcomes in para athletes.

In summary, the discussion underscores that a scientifically structured indoor training system—integrating weightlifting and isometric methods—creates a safe, adaptable, and highly effective model for developing maximal strength and endurance among para powerlifting athletes. The findings provide a robust foundation for the modernization of Paralympic strength training methodologies in Uzbekistan and beyond.

## Conclusion

The findings of this study confirm that a scientifically grounded, structured, and individualized training program can significantly improve the strength performance, endurance, and recovery capacity of para powerlifting athletes. The integration of weightlifting tools and isometric exercises within indoor training conditions proved to be an effective methodological solution for enhancing the neuromuscular, technical, and psychological aspects of athletic performance.

Over the course of the 12-week experimental period, para athletes demonstrated measurable progress in maximal strength (+12%), isometric endurance (+25%), and triceps force (+17%), along with a notable reduction in recovery time (−26%). These results validate the efficacy of combining dynamic and static load modalities to develop both absolute and sustained strength in athletes with physical impairments.

The study's methodological approach contributes to the advancement of adaptive strength training theory, offering a scientifically substantiated framework tailored to the functional characteristics of para powerlifters. Furthermore, it highlights the critical role of controlled indoor environments, which facilitate consistent load management, reduce external interference, and promote efficient recovery mechanisms.

From a practical perspective, the developed training model can serve as a guideline for coaches, sport scientists, and rehabilitation specialists involved in Paralympic strength sports. Implementing structured indoor training systems not only enhances athletic performance

but also supports long-term physical health, psychological stability, and social inclusion of athletes with disabilities.

For future research, it is recommended to extend the analysis to longer training cycles, include hormonal and electromyographic assessments, and explore the integration of rehabilitation-based load modulation into strength periodization for para athletes. Such interdisciplinary approaches will further improve performance outcomes and contribute to the global evolution of Paralympic sport methodologies. In summary, this study provides empirical evidence that indoor weightlifting and isometric training integration is an effective and safe strategy for improving strength performance in para powerlifting. The model can serve as a foundation for national and international training standards, particularly within the rapidly developing field of adaptive physical education and Paralympic sports in Uzbekistan.

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