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WAYS TO OPTIMIZE TRAINING PLANS TO ACHIEVE A HIGH RESULT IN PARA-ATHLETICS

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Abstract:
Para-athletics has seen rapid growth and increasing competitiveness in international competitions. Achieving high performance requires individualized training programs that consider athletes' functional impairments, biomechanical efficiency, and physiological adaptation. Traditional training often fails to address these unique needs, limiting athletes' performance potential.

Keywords: Para-athletics; Training optimization; Individualized load management; Sprint performance; Jump performance; Functional strength; Biomechanical feedback; Recovery strategies.

Introduction

Para-athletics, encompassing track and field events for athletes with physical impairments, has experienced significant growth in recent decades. Achieving high performance in para-athletics requires a combination of individualized training programs, biomechanical efficiency, and optimized physical and psychological preparation. Traditional training approaches often fail to account for the unique physiological and biomechanical characteristics of para-athletes, which can limit performance potential.

Research suggests that structured, evidence-based training programs can significantly enhance functional capacity, muscle strength, coordination, and

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endurance among para-athletes. Moreover, the integration of biomechanical analysis and adaptive techniques is critical for improving performance in events such as sprinting, long jump, and throwing. Despite this knowledge, few studies provide systematic guidelines for optimizing training plans specifically for para-athletics.

Despite the availability of standardized training programs, many para-athletes face limitations in achieving their performance potential due to inadequate individualization of training loads and insufficient attention to functional and biomechanical adaptations. Previous studies have shown that para-athletes may exhibit unique patterns of muscle activation, reduced joint mobility, or asymmetrical movement due to their impairments. These factors necessitate the careful design of training plans that balance intensity, volume, technical execution, and recovery to prevent overtraining and injury while promoting optimal functional adaptation.

Recent research emphasizes the importance of individualized load management, strength and conditioning, and biomechanical feedback in maximizing performance outcomes. For example, studies by Vanlandewijck et al. (2010) and Goosey-Tolfrey et al. (2014) highlight the need for sport-specific, classification-sensitive training protocols that account for the heterogeneity of impairments among para-athletes. Additionally, physiological monitoring tools, including heart rate tracking and perceived exertion scales, have been shown to enhance training precision and ensure that athletes work within optimal intensity zones.[1,2,3]

Furthermore, para-athletics performance is not solely dependent on physical capacity. Technical proficiency, including sprint mechanics, jumping technique, and throwing coordination, is critical for translating strength and endurance gains into competitive results. Biomechanical analysis and targeted drills can correct movement inefficiencies, improve energy transfer, and increase performance consistency, thereby addressing limitations that are often magnified in athletes with impairments.

Despite these advances, there remains a paucity of research providing systematic guidelines for optimizing training plans for para-athletes. Most existing studies

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focus on single-event outcomes or general recommendations, leaving a gap in comprehensive, evidence-based strategies that integrate load management, technical refinement, functional adaptation, and recovery.

Therefore, the purpose of this study is to investigate and identify effective strategies to optimize training plans in para-athletics, with a particular focus on individualized load prescription, biomechanical efficiency, and functional adaptation. The findings of this research aim to provide practical guidance for coaches, sports scientists, and rehabilitation specialists seeking to enhance performance in para-athletic sprinting, jumping, and throwing events.

Methods

Study Design. A controlled experimental design with pre-test and post-test measurements was employed to evaluate the effectiveness of optimized training plans in para-athletics. The study aimed to compare performance outcomes between an experimental group receiving individualized, optimized training and a control group following conventional training practices. The intervention period lasted 8 weeks, allowing sufficient time to observe measurable changes in physical performance, functional strength, and physiological adaptation.

Participants. A total of 40 para-athletes (18–35 years old) participated in the study. Participants were recruited from regional and national para-athletics programs and competed in sprinting and jumping events. Inclusion criteria included:

Classification according to **T/F para-athletics categories**

Minimum **2 years of competitive experience**

Medically cleared for high-intensity training

No history of recent injuries or surgeries affecting performance

Participants were randomly assigned into two groups:

Experimental Group (EG, n = 20): received an optimized training plan based on individualized physiological and biomechanical assessment.

Control Group (CG, n = 20): followed a conventional training program commonly used in para-athletics coaching.

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All participants provided informed consent, and the study protocol was approved by the institutional ethics committee in accordance with the Declaration of Helsinki.

Training Intervention.

The **experimental group** underwent a structured, **optimized training program** comprising 4 sessions per week over 8 weeks. Key components included:

1. **Individualized load management:** Training intensity and volume were adjusted based on heart rate monitoring, session RPE (Rating of Perceived Exertion), and recovery status.
2. **Strength and conditioning:** Functional strength exercises were tailored to athletes' impairments, emphasizing lower limb and core stability.
3. **Technical drills:** Event-specific exercises targeting sprinting mechanics, long jump take-off and flight phases, and throwing techniques.
4. **Biomechanical feedback:** Video analysis and corrective guidance were used to refine technique and optimize movement efficiency.
5. **Recovery strategies:** Active recovery, stretching, and mobility work were incorporated to promote adaptation and prevent overtraining.

The **control group** performed standard training sessions without individualization, biomechanical feedback, or tailored load management.

Assessment Protocol.

Performance assessments were conducted 1 week before and 1 week after the intervention period under standardized conditions. The following metrics were measured:

Sprint performance: 100 m sprint time

Jump performance: Long jump distance

Functional strength: Sit-to-stand repetitions, medicine ball throw distance

Physiological indicators: Heart rate recovery (1-minute post-exercise), session RPE.

All tests were administered by certified coaches and sports scientists familiar with para-athletics testing protocols.

Statistical Analysis. Data analysis was performed using SPSS 28.0. Descriptive statistics were calculated as mean ± standard deviation (SD). Within-group

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comparisons were conducted using paired t-tests, and between-group comparisons were analyzed with independent t-tests. Statistical significance was set at $p < 0.05$. Percentage changes were calculated to quantify the magnitude of performance improvements.

Results

After the 8-week intervention, the experimental group (EG) demonstrated significant improvements in performance, functional strength, and physiological adaptation compared to the control group (CG). Baseline pre-test comparisons indicated no statistically significant differences between groups ($p > 0.05$), confirming group homogeneity.[4,5]

Sprint Performance

The experimental group showed a significant reduction in 100 m sprint time compared to the control group:

Sprint Performance

Table 1.

Parameter	Group	Pre-test	Post-test	Change (%)
100 m sprint (s)	EG	14.8 ± 0.6	13.6 ± 0.5	↓ 8.1%
	CG	14.7 ± 0.5	14.2 ± 0.5	↓ 3.4%

The results indicate a statistically significant improvement in sprint performance for the experimental group ($p < 0.05$), suggesting the optimized training plan enhanced speed more effectively than conventional training.

Long Jump Performance.

Improvements in long jump distance were observed in both groups, with the experimental group achieving a substantially greater increase:

Long Jump Performance Table 2.

Parameter	Group	Pre-test	Post-test	Change (%)
Long jump (m)	EG	3.45 ± 0.22	3.87 ± 0.20	↑ 12.2%
	CG	3.46 ± 0.21	3.58 ± 0.20	↑ 3.5%

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The enhanced performance in the EG highlights the effectiveness of individualized technical drills and biomechanical feedback in improving jump mechanics.

Functional Strength

The experimental group also exhibited significant gains in functional strength:

Functional Strength Indicators

Table 3.

Parameter	Group	Pre-test	Post-test	Change (%)
Medicine ball throw (kg)	EG	6.8 ± 0.7	7.9 ± 0.6	↑ 16.2%
	CG	6.9 ± 0.6	7.3 ± 0.5	↑ 5.8%
Sit-to-stand (reps)	EG	12.4 ± 1.3	14.8 ± 1.1	↑ 19.4%
	CG	12.6 ± 1.2	13.5 ± 1.1	↑ 7.1%

These findings suggest that strength and conditioning exercises tailored to the athletes' functional abilities significantly enhanced muscular performance.

Physiological Adaptation

Heart rate recovery after maximal exertion improved markedly in the experimental group, indicating enhanced cardiovascular efficiency:

Physiological Indicators

Table 4.

Parameter	Group	Pre-test	Post-test	Change (%)
HR recovery (bpm, 1 min)	EG	32.4 ± 4.1	24.7 ± 3.9	↓ 23.8%
	CG	33.0 ± 4.0	30.5 ± 3.8	↓ 7.6%
RPE (session)	EG	6.8 ± 0.7	5.2 ± 0.6	↓ 23.5%
	CG	6.7 ± 0.6	6.1 ± 0.6	↓ 9.0%

The decrease in heart rate recovery time and session RPE indicates that para-athletes in the experimental group adapted more efficiently to training loads, supporting the effectiveness of individualized load management and structured recovery strategies.

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Summary

The optimized training program combining individualized load management, biomechanical feedback, strength and technical drills, and recovery strategies led to statistically significant improvements in sprinting, jumping, functional strength, and cardiovascular adaptation compared to conventional training. Percentage improvements across all metrics were consistently higher in the experimental group, confirming the efficacy of the proposed training optimization strategies.

Discussion

The results of this study demonstrate that optimized, individualized training plans significantly improve performance outcomes in para-athletics, including sprint speed, long jump distance, functional strength, and cardiovascular recovery. The experimental group (EG) achieved greater improvements across all metrics compared to the control group (CG), confirming the importance of personalized load management, technical drills, biomechanical feedback, and recovery strategies.

Sprint and Jump Performance

The 8.1% reduction in 100 m sprint time and 12.2% increase in long jump distance observed in the experimental group align with prior research emphasizing the value of individualized training in para-athletics. Vanlandewijck et al. (2010) and Goosey-Tolfrey et al. (2014) highlighted that athletes with impairments respond differently to generic training loads, and that event-specific, classification-sensitive training enhances neuromuscular efficiency and performance. The incorporation of biomechanical feedback in the present study likely contributed to improved movement patterns, consistent with Daly et al. (2019), who reported that video-assisted technique correction significantly enhances jumping mechanics and sprint efficiency in athletes with disabilities.[6,7]

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Functional Strength

Functional strength improvements, such as a 16.2% increase in medicine ball throw distance and 19.4% increase in sit-to-stand repetitions, support evidence that strength and conditioning tailored to the athlete's impairment profile is critical for performance enhancement. These findings are consistent with studies by Goosey-Tolfrey and Leicht (2013), which suggest that targeted resistance training enhances both upper and lower limb strength while improving event-specific performance in para-athletes. In contrast, the control group, which followed standard training without individualized adaptation, achieved substantially smaller improvements (5–7%), indicating that generic programs may be insufficient to elicit maximal functional gains.

Physiological Adaptation

The experimental group exhibited improved cardiovascular adaptation, evidenced by a 23.8% reduction in heart rate recovery time and a 23.5% reduction in session RPE. These results corroborate previous findings by Impellizzeri et al. (2004), demonstrating that structured load management using heart rate monitoring effectively balances training intensity and recovery, thereby enhancing adaptation while minimizing overtraining risk. Such physiological improvements are particularly important in para-athletes, who may experience higher metabolic stress due to biomechanical limitations or asymmetrical movement patterns.

This study emphasizes the need for a multifactorial optimization strategy in para-athletics. Integrating individualized load prescription, strength and conditioning, technical and biomechanical training, and recovery interventions provides a comprehensive approach to maximize performance. The findings suggest that even within a short 8-week intervention, tailored programs can elicit significant adaptations that generic training cannot achieve. Coaches and sports scientists should prioritize assessment-driven planning and real-time monitoring to ensure athletes train effectively within safe physiological limits.

Despite the positive findings, this study has limitations. The sample size was relatively small (n = 40), and all participants were male, limiting the

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generalizability of results. Future studies should include female para-athletes, longer intervention periods, and additional monitoring tools such as lactate analysis or motion capture systems to further refine training optimization. Moreover, comparative studies across different impairment classifications and event types would provide a broader understanding of individualized training effects in para-athletics.[8,9,10]

Overall, the study confirms that optimized, evidence-based training plans offer superior performance outcomes for para-athletes compared to conventional training. These findings contribute to the development of scientifically grounded guidelines for coaches and practitioners aiming to achieve high performance in para-athletics.

Conclusion

The present study provides strong evidence that optimized, individualized training plans can significantly enhance performance in para-athletics. Athletes who followed the experimental program demonstrated superior improvements in sprint speed, long jump distance, functional strength, and cardiovascular recovery compared to those undergoing conventional training. The combination of individualized load management, biomechanical feedback, event-specific technical drills, strength and conditioning, and structured recovery strategies proved essential in maximizing performance outcomes.

The findings highlight that para-athletes benefit from personalized, classification-sensitive training, as generic programs often fail to address the unique physiological and biomechanical needs arising from different impairments. Heart rate monitoring, session RPE assessment, and biomechanical analysis allowed precise adjustment of training intensity, volume, and technique, leading to safer and more effective adaptations. Functional and physiological improvements observed within an 8-week intervention indicate that even short-term, evidence-based training can produce meaningful performance gains in para-athletes.

From a practical perspective, coaches and sports scientists should integrate assessment-driven planning into para-athletics programs, ensuring that all

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components—including speed, power, technique, and recovery—are tailored to the athlete's functional abilities. The use of real-time monitoring and feedback tools enhances training efficiency while reducing the risk of overtraining or injury. These strategies can be generalized across sprinting, jumping, and throwing events to support high-performance outcomes in both training and competition.

Limitations of this study include a relatively small, male-only sample and the short intervention duration. Future research should include female para-athletes, a larger and more diverse cohort, and advanced monitoring technologies such as motion capture or lactate analysis. Additionally, longitudinal studies assessing the long-term impact of optimized training plans on performance and injury prevention would further strengthen the evidence base.

In conclusion, this study demonstrates that systematic, individualized optimization of training plans is a highly effective approach for achieving superior performance in para-athletics. The integration of physiological monitoring, biomechanical correction, technical skill development, and structured recovery offers a comprehensive framework that can guide coaches, sports scientists, and rehabilitation specialists in maximizing the athletic potential of para-athletes.

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