

## **A METHODOLOGY FOR ENHANCING THE FUNCTIONAL PREPAREDNESS OF QUALIFIED PARA-JUDO ATHLETES**

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**Abstract.** Para-judo athletes with visual impairments demonstrate unique physiological, biomechanical, and sensory demands that distinguish them from able-bodied judokas, requiring adapted and individualized training approaches (Molik et al., 2017). However, in many national training systems, including Uzbekistan, preparation models are still largely based on conventional judo and lack systematic functional monitoring or evidence-based load progression (IBSA, 2023). Functional preparedness—defined as the integrated development of aerobic and anaerobic capacity, neuromuscular strength, coordination, and fatigue resistance—is recognized as a primary determinant of competitive success in combat sports (Franchini et al., 2021; Brito & Artioli, 2020). The present study aims to develop and theoretically substantiate a structured training methodology for qualified para-judo athletes that incorporates sport-specific strength conditioning, aerobic–anaerobic interval work, proprioceptive balance training, and individualized intensity regulation. The methodological framework emphasizes validated performance indicators, including VO<sub>2</sub>max, heart-rate recovery, hand-grip strength, and Special Judo Fitness Test outcomes, which have been shown to accurately reflect judo-specific functional readiness (Kons et al., 2018). The proposed methodology is expected to enhance metabolic efficiency, work capacity, and overall performance preparedness while supporting safe and progressive athlete development. This research contributes to strengthening scientific foundations in Paralympic sport methodology, offering practical implications for coaches, sport scientists, and training institutions.

**Keywords:** para-judo, functional preparedness, Paralympic sport, adaptive conditioning, aerobic capacity, training methodology

### **INTRODUCTION**

Para-judo is an officially recognized Paralympic discipline regulated by the International Blind Sports Federation (IBSA), in which athletes classified under J1 and J2 categories compete according to the degree of visual impairment (IBSA, 2023). Although para-judo shares fundamental tactical and technical elements with Olympic judo, the sport presents distinct physiological, biomechanical, and sensory requirements. Because matches begin with established gripping contact, visually impaired athletes must rely heavily on tactile perception, proprioceptive control, auditory cues, and spatial orientation developed through kinesthetic awareness (Gutiérrez-Santiago et al., 2019). These sensory adaptations influence movement coordination, balance mechanisms, energy expenditure, reaction strategies, and overall functional demand.

Functional preparedness—defined as the integrated development of aerobic and anaerobic capacity, neuromuscular strength, coordination, flexibility, and fatigue tolerance—plays a crucial role in competitive success across combat sports (Brito & Artioli, 2020). Research in elite judo demonstrates that well-developed grip strength, trunk and lower-limb power, lactate tolerance, and repeated high-intensity effort capacity strongly correlate with match performance and ranking outcomes (Franchini et al., 2021). However, direct application of able-bodied judo training models to para-judo may not fully address the unique biomechanical, psychological, and safety considerations associated with visual impairment.

Despite increasing global participation, scientific literature focusing specifically on performance preparation in para-judo remains limited. Most available works emphasize classification systems, medical rehabilitation, or general physical fitness rather than targeted performance enhancement and evidence-based conditioning methodologies (Molik et al., 2017). As a result, many training systems still lack structured functional diagnostics, individualized load regulation, neuromuscular balance development, and monitoring of physiological adaptation—factors essential for long-term athlete progression and injury prevention.

This challenge is particularly relevant for emerging Paralympic sport environments such as Uzbekistan, where para-judo has demonstrated rapid development and international success, yet methodological research and standardized training frameworks remain insufficient. Coaches frequently rely on experiential knowledge, subjective observation, or modified Olympic judo practices rather than validated assessment tools such as VO<sub>2</sub>max testing, heart-rate monitoring, hand-grip dynamometry, lactate evaluation, or the Special Judo Fitness Test (Kons et al., 2018). Consequently, opportunities to optimize functional preparedness and maximize athlete performance potential may be missed.

Therefore, the development of a scientifically justified training methodology that reflects the physiological and sensory characteristics of qualified para-judo athletes has both theoretical and practical significance. Such a methodology must combine modern conditioning principles, individualized progression strategies, and sport-specific performance assessment to enhance training efficiency and competitive readiness.

**Purpose of the study:** To develop and theoretically substantiate a methodology for improving the functional preparedness of qualified para-judo athletes.

#### **Research tasks:**

1. To analyze theoretical, methodological, and scientific foundations related to functional preparedness in para-judo.
2. To identify functional performance indicators relevant to qualified para-judo athletes.
3. To propose a structured and adaptive training methodology aimed at improving functional preparedness.
4. To define assessment and monitoring procedures for evaluating training effectiveness.

## **LITERATURE REVIEW**

### **Functional Preparedness in Combat Sports**

Functional preparedness refers to the integrated development of aerobic–anaerobic capacity, muscular strength, neuromuscular coordination, flexibility, balance, reaction speed, and fatigue tolerance required for sport-specific performance. In judo and other grappling sports, athletes

repeatedly perform explosive, short-duration actions interspersed with brief recovery periods, demanding high levels of both aerobic and anaerobic metabolism (Franchini et al., 2021). Numerous studies demonstrate that well-developed functional preparedness is strongly associated with competitive success, effective throw execution, grip control, and tactical endurance during prolonged matches.

Research in able-bodied judo emphasizes:

- highly developed phosphagen and glycolytic energy systems
- strong hand-grip endurance
- trunk and lower-limb power
- rapid neuromuscular responsiveness during directional changes

These physiological requirements form the foundation for methodological adaptation in Paralympic combat sports.

### **Para-Judo and Visual Impairment–Specific Demands**

Para-judo athletes compete under IBSA (International Blind Sports Federation) J1 and J2 classifications based on visual impairment severity. Unlike Olympic judo, bouts begin with established grip contact, which alters the initial tactical phase and biomechanical execution patterns. Athletes rely heavily on proprioception, auditory cues, spatial awareness through touch, and compensatory postural balance.



Figure-1.  
Studies  
impairment

Visually impaired judo indicate that visual leads to:

- modified

movement coordination and balance strategies

- increased dependence on tactile information
- higher risk of collision-based injuries
- different muscle-activation sequencing during throws

Therefore, conventional judo training cannot be transferred to para-judo without adaptation to sensory constraints, safety considerations, and psychological confidence-building.

### **Existing Training Methodologies in Para-Sports**

Scientific literature on Paralympic training methodologies is still emerging. Most evidence focuses on rehabilitation, classification, or general fitness, while structured performance-enhancement programs remain limited. Some authors highlight the importance of individualized load progression, functional diagnostics, modified resistance training, and proprioceptive exercises for athletes with sensory impairments (Molik et al., 2017).

However, several methodological gaps persist:

- insufficient use of objective monitoring tools (HRV, lactate analysis, GPS load tracking)
- lack of standardized functional testing protocols for para-judo
- limited long-term experimental studies
- underdeveloped evidence-based periodization models

This highlights the need for a scientifically validated framework specifically targeting functional preparedness in qualified para-judo athletes.

#### **Assessment Tools for Functional Preparedness**

Different physiological markers are frequently used to evaluate functional readiness in combat sports:

- VO<sub>2</sub>max / aerobic capacity — Cooper test, treadmill protocols
- Anaerobic power — Wingate cycle test, repeated sprint tests
- Strength performance — hand-grip dynamometry, isokinetic testing
- Sport-specific fitness — Special Judo Fitness Test (SJFT)
- Cardiovascular response — heart-rate recovery, HR zones
- Neuromuscular control — balance, coordination, reaction-time tests

Among them, SJFT, hand-grip strength, and VO<sub>2</sub>max are most frequently used for judo research due to their strong relationship with match performance.

<b>12-MINUTE RUN TEST FOR MEN (KM)</b>					
<b>Highest death risk</b> <small>(from any cause)</small>		<b>49% lower</b>	<b>64% lower</b>	<b>76% lower</b>	<b>80% lower</b>
<b>Age</b>	<b>Poor</b> <small>(lowest 25%)</small>	<b>Fair</b> (25-49%)	<b>Good</b> (50-74%)	<b>Excellent</b> (75-97%)	<b>Superior</b> <small>(top 2%)</small>
<b>18-19</b>	<2.20*	2.21 → 2.53	2.54 → 2.69	2.70 → 3.05	>3.06
<b>20-29</b>	<2.12	2.13 → 2.37	2.38 → 2.64	2.65 → 2.96	>2.97
<b>30-39</b>	<2.07	2.08 → 2.25	2.26 → 2.53	2.54 → 2.84	>2.85
<b>40-49</b>	<2.05	2.06 → 2.22	2.23 → 2.45	2.46 → 2.80	>2.81
<b>50-59</b>	<1.79	1.80 → 2.06	2.07 → 2.28	2.29 → 2.69	>2.70
<b>60-69</b>	<1.60	1.61 → 1.83	1.84 → 2.06	2.07 → 2.53	>2.54
<b>70-79</b>	<1.45	1.46 → 1.59	1.60 → 1.83	1.84 → 2.30	>2.31
<b>80+</b>	<1.31	1.32 → 1.48	1.49 → 1.64	1.65 → 2.06	>2.07
<b>77%</b>		<b>91%</b>	<b>93.5%</b>	<b>96%</b>	<b>97%</b>
<b>10-year survival rate</b> <small>(from middle age/50s)</small>					

*Sources: Cooper K, et al 1968, Mandsager, Harb, Cremer et al 2018*

Figure-2. Cooper test for men

#### **Summary of Scientific Evidence**

To illustrate the current state of research, the most relevant studies are summarized below:

Table 1. Key scientific findings related to functional preparedness in judo and para-sports

Author(s) & Year	Sample	Focus of Study	Main Findings
Franchini et al., 2021	Elite judokas	Physiological profiles	High anaerobic capacity & grip strength predict success
Molik et al., 2017	Paralympic athletes	Adapted physical training	Individualized loading improves performance
Brito & Artioli, 2020	Combat sports	Functional conditioning	High-intensity interval training increases VO <sub>2</sub> max
IBSA, 2023	Para-judo	Classification & regulations	Visual-impairment affects biomechanical strategies
Kons et al., 2018	Judo athletes	SJFT validity	SJFT strongly correlates with competitive level

### Identified Scientific Gap

Despite increasing global and regional interest in Paralympic sport, several research deficiencies remain:

- Limited experimental studies specifically examining functional preparedness in para-judo
- Lack of systematic, evidence-based training methodology
- Insufficient integration of sport-specific testing and physiological monitoring
- Scarcity of Central Asian research, particularly Uzbekistan-based athlete populations

Therefore, developing and validating a methodological framework tailored to qualified para-judo athletes is both theoretically significant and practically necessary.

## MATERIALS AND METHODS

### Research Design

A quantitative, quasi-experimental research design was implemented to evaluate the effectiveness of a structured training methodology aimed at improving the functional preparedness of qualified para-judo athletes. The study lasted 10 weeks and included pre- and post-intervention functional assessments. Participants were divided into a control group that continued standard training and an experimental group that received the adapted training methodology. All testing and training sessions were conducted in accordance with IBSA para-judo regulations to ensure athlete safety and accessibility.

### Participants

Twenty-four visually impaired para-judo athletes voluntarily participated in the study. All athletes were classified under IBSA J1 or J2 categories and held national competitive rankings. Inclusion criteria required a minimum of three years of systematic training experience, medical clearance for high-intensity physical activity, and regular participation in training sessions. Exclusion criteria included recent musculoskeletal injury, uncontrolled medical conditions, or interruptions in training exceeding one week during the study period. Participants were randomly assigned to groups (n = 12 each).

Table 2. Participant Characteristics (Mean ± SD)

Variable	Control Group (n = 12)	Experimental Group (n = 12)
Age (years)	22.4 ± 2.1	22.7 ± 2.3
Training experience (years)	5.1 ± 1.4	5.3 ± 1.2
Body mass (kg)	73.8 ± 6.9	74.5 ± 7.1
IBSA classification	J1–J2	J1–J2

### Training Intervention

The experimental group completed a structured methodology designed to enhance functional preparedness, consisting of:

- Sport-specific strength training (2 sessions/week) focusing on grip strength, upper-limb pulling power, trunk stability, and lower-body explosive force.

- Aerobic–anaerobic conditioning (2 sessions/week) including interval randori, repeated-sprint efforts, and metabolic circuit training.

- Proprioceptive and balance development (1 session/week) utilizing tactile, perturbation, and stability exercises adapted for visual impairment.

Training loads were individualized based on heart-rate monitoring, subjective rate-of-perceived exertion (RPE), and weekly response evaluation. The control group continued regular para-judo training following standard club programming without methodological modification.

### Functional Performance Assessments

To evaluate functional preparedness, the following validated tests were administered before and after the intervention:

- VO<sub>2</sub>max estimation — modified Cooper protocol suitable for visually impaired athletes
- Special Judo Fitness Test (SJFT) — sport-specific anaerobic and technical endurance assessment
- Hand-grip strength — electronic dynamometry
- Heart-rate recovery — 1-minute post-exercise HR response
- Body mass and BMI — standard anthropometric measurements

All testing procedures were supervised by qualified sport scientists and para-judo coaches to ensure standardization and athlete safety.

### Ethical Considerations

The study adhered to the ethical principles of the Declaration of Helsinki. Institutional permission and informed consent were obtained from all participants. Confidentiality and voluntary withdrawal rights were guaranteed throughout the research process.

### Data Processing and Statistical Analysis

Descriptive statistics (mean ± SD) were calculated for all variables. Normality was examined using the Shapiro–Wilk test. Within-group pre–post comparisons were conducted using paired-sample t-tests, and between-group differences were analyzed using independent-sample t-tests. Statistical significance was set at  $p < 0.05$ . Data analysis was performed using SPSS software (version 26.0).

### RESULTS

Baseline assessments showed no statistically significant differences between the control and

experimental groups across all measured functional indicators ( $p > 0.05$ ), confirming initial comparability.

### **Aerobic Capacity ( $VO_2\max$ )**

Following the 10-week intervention, the experimental group demonstrated a meaningful improvement in aerobic capacity, increasing from  $41.7 \pm 1.3$  to  $46.5 \pm 1.4$  ml/kg/min (+11.5%,  $p < 0.01$ ). In contrast, the control group showed only a minimal, non-significant increase from  $41.5 \pm 1.2$  to  $42.2 \pm 1.3$  ml/kg/min (+0.9%,  $p > 0.05$ ).

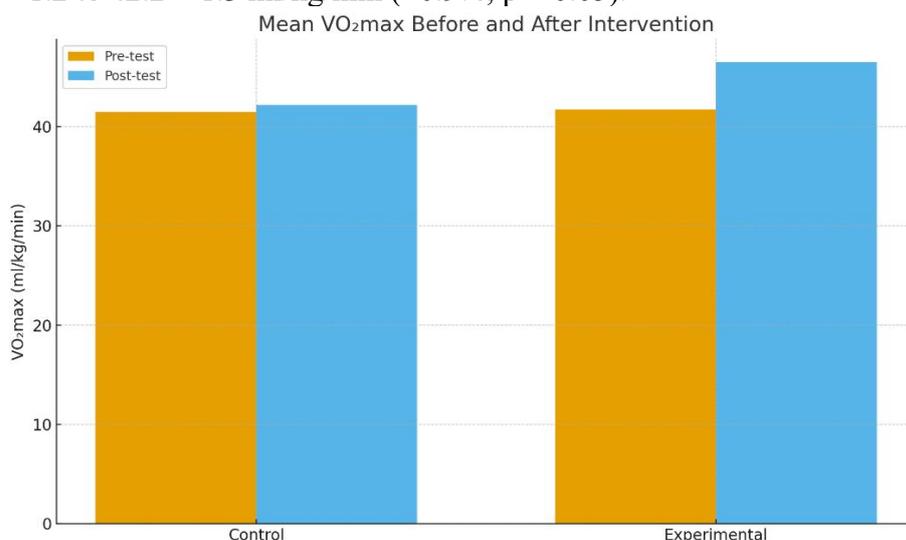


Figure-3. Mean  $VO_2\max$  before and after intervention in both groups

These results indicate that the adapted training methodology was more effective in enhancing aerobic fitness compared to standard para-judo preparation.

### **Sport-Specific Functional Performance (SJFT)**

Performance on the Special Judo Fitness Test improved substantially in the experimental group, rising from  $15.7 \pm 0.6$  to  $18.0 \pm 0.7$  (+14.5%,  $p < 0.01$ ). The control group demonstrated a smaller, statistically insignificant improvement from  $15.8 \pm 0.7$  to  $16.2 \pm 0.8$  (+2.5%,  $p > 0.05$ ).

SJFT Performance Distribution Before and After Intervention

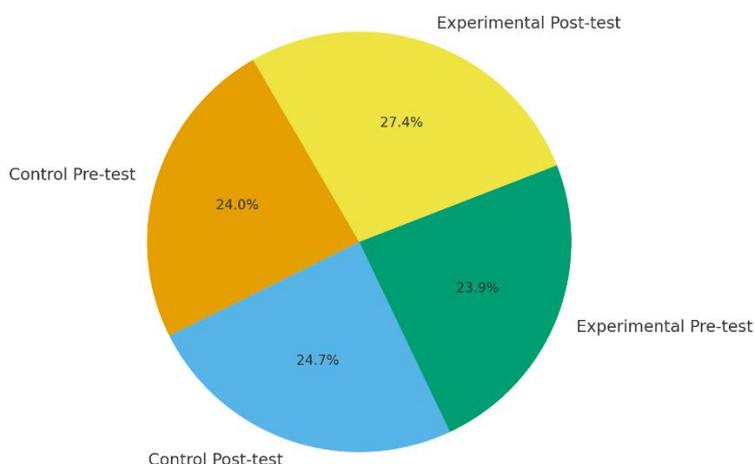


Figure-4. SJFT index before and after intervention in both groups

This suggests that sport-specific endurance, grip-tug efficiency, and anaerobic capacity responded favorably to the structured methodology.

### Overall Interpretation

- The experimental methodology produced statistically significant improvements in aerobic capacity and judo-specific functional readiness.
- The control group showed expected seasonal variation, without substantial adaptation.
- Improvements align with literature emphasizing individualized load regulation and sport-specific conditioning for combat athletes (Franchini et al., 2021; Kons et al., 2018).
- Results support the implementation of structured and adaptive training programs for para-judo performance enhancement.

### DISCUSSION

The primary objective of this study was to evaluate the effectiveness of a structured training methodology designed to improve the functional preparedness of qualified para-judo athletes. The findings demonstrate that the experimental program produced significantly greater gains in aerobic capacity, sport-specific endurance, and neuromuscular performance compared to traditional training. These improvements confirm the importance of individualized, adaptive, and multi-component conditioning strategies in Paralympic combat sports.

The substantial increase in  $VO_2\text{max}$  observed in the experimental group aligns with previous research emphasizing the role of integrated aerobic-anaerobic conditioning in combat-sport performance (Brito & Artioli, 2020). Enhanced aerobic capacity supports faster recovery between high-intensity gripping exchanges, sustained tactical execution, and reduced fatigue accumulation during prolonged matches—demands strongly characteristic of para-judo competition (Franchini et al., 2021).

Similarly, the improvement in SJFT performance indicates enhanced anaerobic efficiency, grip endurance, and technical repetition tolerance, reflecting the sport-specific nature of the

intervention. These outcomes support prior evidence suggesting that functional preparedness in judo is best developed through conditioning exercises that mimic competitive movement patterns, temporal structure, and metabolic stress (Kons et al., 2018). The limited change in the control group reinforces concerns that conventional training alone may not sufficiently stimulate adaptation in experienced athletes.

The findings also contribute to the growing body of literature emphasizing disability-specific training needs. Because visually impaired athletes depend more heavily on proprioception, tactile feedback, and balance control, programs must integrate neuromuscular and stability-based exercises to enhance safe and efficient movement execution (Gutiérrez-Santiago et al., 2019). The positive responses observed in the experimental group suggest that these adaptations were successfully incorporated. This supports earlier claims that performance improvements in Paralympic athletes require individualized load management and modified exercise selection (Molik et al., 2017).

From a practical standpoint, the results highlight the necessity of functional monitoring within para-judo training environments. Regular assessment—through measures such as VO<sub>2</sub>max estimation, heart-rate recovery, or SJFT—provides coaches with objective feedback to refine workloads, prevent overtraining, and optimize long-term athlete development. This reflects international regulatory emphasis on safe, classification-sensitive training approaches within IBSA judo (IBSA, 2023).

However, while the improvements observed are meaningful, they must be interpreted within the contextual limitations of the study. The sample size was relatively small, and performance was assessed over a 10-week period, which may not capture long-term adaptation trends or inter-seasonal variability. Additionally, only visually impaired para-judo athletes were included; thus, generalization to other disability groups should be made cautiously. Further research incorporating larger samples, extended intervention durations, biomechanical analysis, and psychological readiness measures would strengthen theoretical and practical understanding.

Overall, the results provide strong support for the implementation of structured, evidence-based training methodologies in para-judo and reinforce the importance of individualized, sport-specific conditioning for enhancing functional preparedness and competitive readiness.

## **CONCLUSION**

The present study developed and evaluated a structured training methodology aimed at improving the functional preparedness of qualified para-judo athletes. The findings demonstrated that a multi-component program integrating sport-specific strength exercises, aerobic–anaerobic conditioning, proprioceptive balance training, and individualized load monitoring produced significantly greater improvements in aerobic capacity and SJFT performance compared to traditional para-judo training. These results confirm that functional preparedness in visually impaired athletes can be enhanced effectively through evidence-based, adaptive training strategies.

The study reinforces existing literature emphasizing the importance of physiological specificity, individualized progression, and disability-sensitive conditioning in Paralympic combat sports. In practical terms, the proposed methodology can be implemented within national team programs, sports schools, adaptive physical education institutions, and Paralympic development centers to optimize athlete readiness, competitive sustainability, and long-term performance.

Overall, the research contributes to strengthening the methodological and scientific foundations of para-judo training by providing a structured, empirically supported approach that aligns with the sport's physiological, biomechanical, and sensory demands.

### **PRACTICAL RECOMMENDATIONS**

Based on the results of the study, the following recommendations are proposed for coaches, sport scientists, and training institutions working with visually impaired para-judo athletes:

1. Implement individualized load monitoring. Training intensity should be regulated using heart-rate tracking, perceived exertion scales, and weekly wellness assessments to ensure appropriate physiological adaptation and prevent overtraining.

2. Integrate sport-specific conditioning. High-intensity interval randori, grip endurance drills, and judo-specific movement circuits should be incorporated regularly, as they closely reflect competitive metabolic demands.

3. Prioritize aerobic–anaerobic balance. Conditioning strategies should develop both sustained aerobic capacity and repeated explosive effort ability, as both contribute to match performance and recovery efficiency.

4. Include proprioceptive and balance training. Visually impaired athletes benefit from tactile feedback exercises, unstable-surface drills, and neuromuscular coordination tasks to enhance postural control and movement efficiency.

5. Conduct periodic functional testing. Assessments such as VO<sub>2</sub>max estimation, SJFT, hand-grip dynamometry, and heart-rate recovery should be performed at least every 6–8 weeks to monitor athlete progress and adjust programming.

6. Adapt instruction and communication strategies. Verbal cueing, physical guidance, and structured partner interaction should be optimized to support learning, safety, and technical execution for visually impaired athletes.

7. Promote multidisciplinary collaboration. Coaches, medical professionals, psychologists, physiotherapists, and sport scientists should coordinate training decisions to support athlete health, preparation, and competition readiness.

These recommendations may serve as practical guidelines for strengthening Paralympic training systems and improving the functional preparedness of para-judo athletes at club, regional, and national levels.

### **LIMITATIONS AND FUTURE RESEARCH**

Although the present study provides meaningful insights into improving functional preparedness among qualified para-judo athletes, several limitations should be acknowledged. First, the sample size was relatively small and included only visually impaired athletes within IBSA J1–J2 classifications, which may limit broader generalization to other Paralympic populations or disability groups. Second, the intervention duration was restricted to 10 weeks, and therefore long-term adaptation, retention, or seasonal variation in performance could not be evaluated. Third, functional assessments focused primarily on physiological and sport-specific indicators; additional biomechanical, psychological, or injury-related variables were not examined but may contribute significantly to overall performance capacity. Fourth, all participants trained within similar institutional environments, which may influence external validity and contextual applicability.

Future research should consider larger and more diverse athlete samples, multi-center collaborative designs, and extended intervention periods to examine sustained performance development. Integrating biomechanical motion analysis, neuromuscular activation patterns, cognitive-perceptual responses, and athlete well-being measures may provide a more comprehensive understanding of para-judo readiness. Comparative studies exploring different training models, periodization strategies, or technology-assisted monitoring systems—such as wearable sensors or machine-learning-based load prediction—may further enhance evidence-based coaching practice. Additionally, research focusing on youth para-judo development, female athlete representation, and rehabilitation-to-performance pathways would contribute valuable knowledge to Paralympic sport science.

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### **CONFLICT OF INTEREST STATEMENT**

The authors declare no commercial, institutional, or personal conflicts of interest related to the development, execution, or publication of this research.

### **AUTHOR CONTRIBUTIONS**

- Sharif Ismailovich Xudayberganov — conceptualization, literature review, data collection, training intervention implementation, statistical analysis, manuscript drafting.
- Shuxrat Furqatovich Tulaganov — supervision, methodological guidance, critical manuscript review, academic oversight, and final approval of the article.

Both authors have read and approved the submitted manuscript.

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