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Effects of rapid weight loss on physiological and performance outcomes in female judo athletes

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Abstract
This study investigated the effects of a five percent body weight reduction over seventy-two hours on the physiological and performance outcomes of female judo athletes. Fifteen female judo athletes, aged seventeen to twenty years, with at least five years of judo training experience, participated in a within-subject crossover design. The study assessed isometric handgrip strength, blood lactate concentration, heart rate recovery, rate of perceived exertion, and performance on the Special Judo Fitness Test before and after rapid weight loss. Participants reduced body weight using self-selected methods, such as increased physical activity and controlled dietary intake, while extreme methods like fluid deprivation were prohibited. Daily weigh-ins ensured compliance. Results revealed significant reductions in left-hand and right-hand grip strength, indicating impaired neuromuscular function. Heart rate recovery was significantly delayed, reflecting increased cardiovascular stress. The rate of perceived exertion increased, suggesting greater psychological strain during physical tasks. Performance on the Special Judo Fitness Test declined, particularly in the number of throws and overall test index, highlighting reduced judo-specific fitness. Blood lactate recovery showed no significant changes, suggesting minimal impact on metabolic recovery. These findings demonstrate that rapid weight loss compromises neuromuscular capacity, cardiovascular efficiency, and sport-specific performance in female judo athletes. The increased physiological and psychological stress underscores the need for safer weight management strategies. Coaches and athletes are encouraged to adopt gradual weight reduction approaches to preserve health and optimize performance. Future research should explore long-term effects of repeated rapid weight loss and evaluate nutritional and rehydration strategies to mitigate adverse outcomes.

Keywords: Rapid weight loss, Female judo athletes, handgrip strength, heart rate recovery, rate of perceived exertion, special judo fitness test

Introduction
Rapid weight loss (RWL) is a common practice among combat sport athletes, particularly in judo, where athletes reduce body weight to qualify for lower weight categories to gain a competitive advantage [1-5]. This strategy is prevalent across genders, with studies reporting its use among female taekwondo and judo athletes. Smith, Naughton [6]. Baranauskas, Kupčiūnaitė [7] further confirmed the widespread use of RWL in combat sports, suggesting its prevalence is consistent regardless of gender. However, RWL poses significant health risks, especially for female athletes, who face heightened susceptibility to the female athlete triad disordered eating, irregular menstruation, and reduced bone density which can lead to long-term consequences such as stress fractures and fertility issues [8]. Thomas, Gonzalez [9] warns that this combination can severely affect health and performance, potentially leading to long-term issues such as stress fractures and fertility problems. These serious health risks underscore the need for deeper exploration into the impact of weight-cutting practices on female combat sport athletes [4, 10].
Beyond health concerns, RWL can impair performance by increasing blood lactate levels, reducing strength endurance, and elevating perceived exertion [4]. Brechney, Chia [11] investigated the biomechanical effects of weight cutting in mixed martial arts, noting its critical role in competition preparation and its impact on performance. The physiological stress from RWL often results in elevated blood lactate levels, signaling increased anaerobic metabolism and fatigue during intense activities [12]. Understanding these effects in female judo athletes is crucial for designing effective training and recovery protocols [13].

This study examines the impact of rapid weight loss on female judo athletes, focusing on physiological factors such as blood lactate concentration, isometric handgrip strength, and psychological responses assessed via RPE. By implementing a 72-hour period for a 5% body weight reduction, this research aims to clarify how RWL affects performance outcomes, contributing to the ongoing discussion on optimizing female athlete health and performance in combat sports.

Materials and Methods

Study Participants

Fifteen female judo athletes (age: 17-20 years; height: 147±8 cm; body mass: 44±8 kg) with a minimum of 5 years of judo training experience were recruited. Thirteen were national-level competitors, and two competed at the state level. All participants were proficient in the ippon-seoi-nage throwing technique and engaged in resistance training twice weekly for at least 5 years. Athletes were briefed on study procedures and potential risks, providing written informed consent in accordance with the Declaration of Helsinki [14]. Parental consent was obtained for participants under 18 years. Exclusion criteria included recent injuries or medical conditions affecting performance.

Study Design

A quantitative, within-subject crossover design was employed to investigate the effects of a 5% body weight reduction over 72 hours on physiological and performance variables. Each participant served as their own control, with baseline testing conducted under normal weight conditions and post-RWL testing after weight loss. The study comprised three sessions: a familiarization session, a baseline testing session, and a post-RWL testing session 72 hours later. The control condition involved no weight manipulation, with athletes maintaining their usual diet and training. Variables assessed included isometric handgrip strength, blood lactate concentration, heart rate recovery, rate of perceived exertion (RPE), and Special Judo Fitness Test (SJFT) performance.

Familiarization Session

The familiarization session introduced participants to the experimental setup, including the SJFT, RPE scale [15], and testing instruments. Anthropometric measurements (height, body mass) were recorded using a stadiometer (Seca 213, Seca GmbH, Germany) and digital scale (Seca 803, Seca GmbH, Germany). Participants were guided on the RWL protocol, which involved a self-directed 5% body weight reduction over 72 hours using methods such as increased physical activity, controlled dietary intake, and sweat-inducing techniques (e.g., wearing extra clothing during exercise). Extreme methods, such as fluid deprivation or sauna use, were prohibited. A moderate caloric deficit of 500-700 kcal/day was recommended, with adequate protein (1.6-2.0 g/kg body mass) and carbohydrate (4-6 g/kg body mass) intake to support performance and recovery [16]. Daily weigh-ins at 8:00 AM using the Seca 803 scale ensured compliance. Table 1 summarizes the RWL methods reported by participants.

Table 1: Rapid Weight Loss Methods Used by Participants

Method	Number of Participants (%)
Increased physical activity	12 (80%)
Reduced caloric intake	10 (67%)
Sweat-inducing techniques	8 (53%)
Restricted fluid intake	5 (33%)

***Note*:** Participants could use multiple methods; percentages reflect usage prevalence.

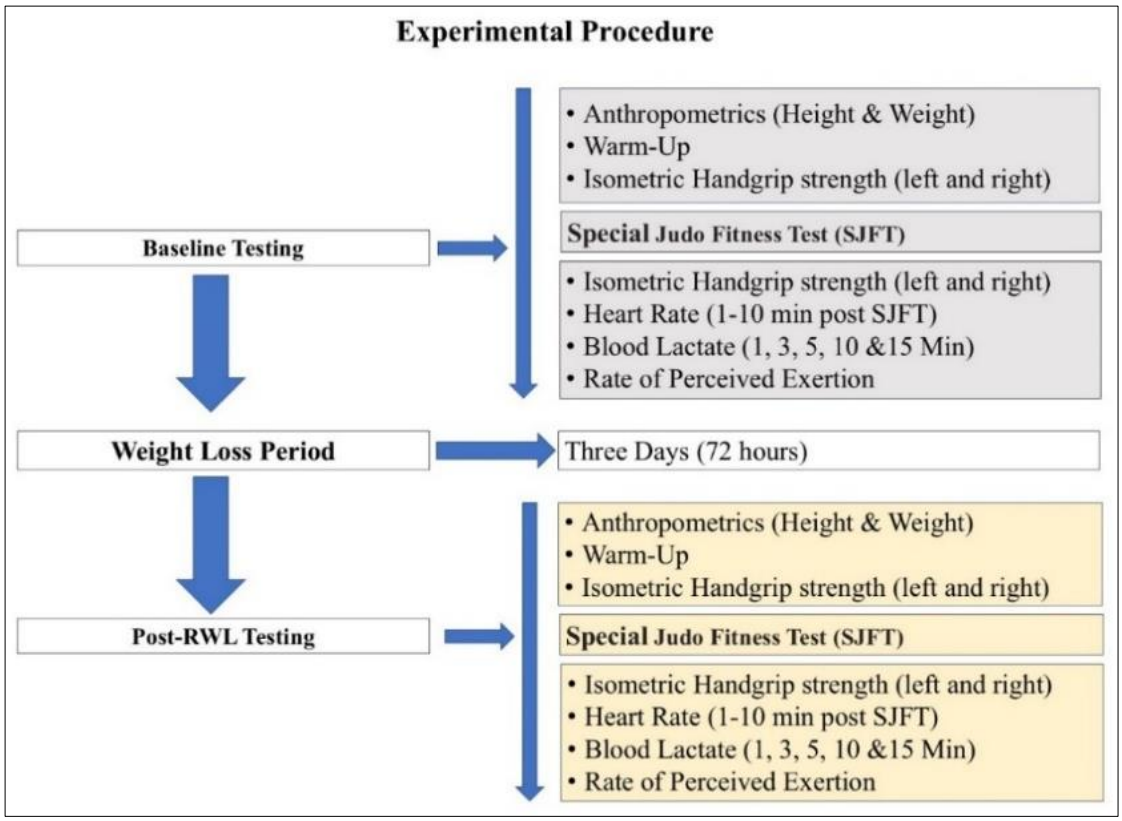

Fig 1: Experimental Procedure for the study

Experimental Protocols and Tests

The study was conducted at the judo training facility (Dojo) of Rashtriya Raksha University, Arunachal Pradesh Campus, located in Pasighat, Arunachal Pradesh, India. The facility is equipped with standard judo mats and training equipment, providing a controlled environment for testing. All sessions occurred between 9:00 AM and 11:00 AM at an ambient temperature of 28 °C to minimize environmental variability.

Protocols and Tests

The Special Judo Fitness Test (SJFT), originally developed by Sterkowicz in 1995, was used to assess judo-specific performance [17]. Each athlete acted as the *tori* and performed the *ippon seoi-nage* throw on two *ukes* positioned 3 meters apart. The test was structured into three sets of increasing duration, and the total number of throws was recorded. Heart rate was monitored immediately after the test and one-minute post-exercise using a Polar RS400 heart rate monitor. The SJFT index was calculated by dividing the sum of the immediate and one-minute heart rate values by the total number of throws.

The Rate of Perceived Exertion (RPE) was assessed immediately following each SJFT session using the Borg CR-10 scale (1998). Athletes rated their exertion on a scale from 0 (no exertion) to 10 (maximum exertion) [15]. Familiarity with the scale was ensured during the familiarization session.

Isometric handgrip strength was measured using a hydraulic handgrip dynamometer (Carci®, SH 5001). Athletes were seated in a chair with feet flat on the floor and back supported, while the arm was placed on the armrest with the elbow flexed at 90 degrees. Participants performed three maximal voluntary contractions for each hand, holding each contraction for five seconds. The highest recorded value for each hand was used for analysis, as per the protocol described by [1].

Blood lactate levels were assessed using the Lactate Pro 2 analyzer (Arkray, Japan). Capillary blood samples were collected immediately after the SJFT and at 1, 3-, 5-, 7-, and 10-minutes during recovery. During this period, athletes remained in a supine position to facilitate passive recovery and optimize lactate clearance. This recovery protocol was based on the recommendations of [18].

Heart rate recovery was evaluated using the Polar H10 heart rate monitor (Polar Electro Oy, Finland), which offers ECG-level accuracy as documented by [19]. Heart rate was recorded at 0, 1, 3, 5, 7, 10, and 15 minutes following SJFT completion under passive resting conditions. These time points were selected in accordance with standard recovery analysis protocols proposed by Daanen *et al.* (2012), and heart rate data were collected through the Polar Flow application for subsequent evaluation [20].

Statistical Analysis

All data were expressed as means±standard deviations. The Kolmogorov-Smirnov test was utilized to determine the normality of distributions, while Levene's test assessed the homogeneity of variances. To evaluate the influence of Time (Baseline, Post-RWL, Recovery) and Condition (RWL vs. Control) on handgrip strength, heart rate, blood lactate levels, RPE, and SJFT performance, a two-way repeated-measures ANOVA was employed. In cases where the assumption of sphericity was not met, adjustments were made using the Greenhouse-Geisser correction. Paired-sample t-tests were conducted for specific within-subject comparisons, and the Games-Howell post-hoc test was applied when required. Effect sizes were reported using partial eta squared (η^2) for ANOVA outcomes and Cohen's d for pairwise comparisons. A significance level of $p<.05$ was considered statistically meaningful for all analyses.

Results

Descriptive statistics for all measured variables are presented as means±standard deviations. Normality of data distribution and homogeneity of variances were verified using the Kolmogorov-Smirnov and Levene's tests, respectively. The data met the assumptions for parametric testing. A two-way repeated-measures ANOVA was conducted to assess the effects of Time (Baseline, Post-RWL, Recovery) and Condition (RWL vs. Control) on selected performance and physiological variables. Where Mauchly's test indicated a violation of the sphericity assumption ($p<.001$), Greenhouse-Geisser corrections were applied to adjust the degrees of freedom. Significant effects and interactions were observed and are detailed below, with a summary of key results provided in Table 1.

Table 2: Results of statistical analyses for grip strength, physiological responses, and SJFT performance.

Variable	Source	F-value	p-value	Partial η^2
Left-Hand Grip Strength	Time	18.59	.0007	.570
	Time × SJFT	4.69	.048	.251
Right-Hand Grip Strength	Time	4.98	.043	.262
Blood Lactate Levels	Time	62.34	<.001	.817
	Condition	1.49	.243	.096
	Time × Condition	1.17	.335	.077
Heart Rate	Time	152.35	<.001	.916
	Condition	1.43	.252	.092
	Time × Condition	197.24	<.001	.934
SJFT Performance		t-value	p-value	Effect Size
Set 1	t-test	-1.47	.16	—
Set 2	t-test	1.82	.089	—
Set 3	t-test	2.87	.012	—
Total Throws	t-test	2.29	.038	—
Index	t-test	-2.91	.011	—
RPE	t-test	-4.00	.0013	—

Note. SJFT = Special Judo Fitness Test; RPE = Rating of Perceived Exertion. F-values and t-values are reported where applicable. Partial η^2 denotes effect size for ANOVA; dashes (—) indicate where effect sizes were not applicable or not computed.

Isometric Hand Grip Strength
A significant main effect of Time was found for left-hand grip strength, F (2, 28) = 18.59, p =.0007, η^2 =.570. A Time × SJFT interaction was also significant, F (2, 28) = 4.69, p =.048, η^2 =.251, indicating the SJFT timing influenced strength outcomes. Right-hand grip strength also showed a significant main effect of Time, F (2, 28) = 4.98, p =.043, η^2 =.262, with no significant interaction.

Rate of Perceived Exertion (RPE)
RPE increased significantly post-RWL, t (14) = -4.00, p =.0013. Mean RPE rose from 5.73±1.39 (pre-RWL) to 7.07±1.34 (post-RWL), reflecting greater perceived effort during the same activity following weight loss.

Blood Lactate Levels: A repeated-measures ANOVA showed a significant effect of Time, F (4, 56) = 62.34, p<.001, η^2 =.817, with decreasing levels during recovery. However, no significant main effect of Condition (F (1, 14) = 1.49, p =.243) or Time × Condition interaction (F (4, 56) = 1.17, p =.335) was observed, suggesting RWL did not significantly influence overall lactate recovery patterns.

Heart Rate Recovery: Heart rate exhibited a significant main effect of Time, F (2.95, 41.35) = 152.35, p<.001, η^2 =.916. Although Condition alone was not significant (F (1, 14) = 1.43, p =.252), a significant Time × Condition interaction was found, F (3.50, 49.05) = 197.24, p<.001, η^2 =.934, indicating altered recovery dynamics post-RWL (Figure 1).

Fig 2: Heart Rate Recovery Before and After Weight Loss. The figure illustrates a delayed heart rate recovery following rapid weight loss, as evidenced by consistently elevated heart rate values across all post-exercise time points compared to the pre-weight loss condition.

Special Judo Fitness Test (SJFT)
SJFT performance declined following RWL. No significant difference was noted in Set 1 (t(14) = -1.47, p =.160). Set 2 approached significance (t (14) = 1.82, p =.089), while Set 3 showed a significant decrease in throws (t (14) = 2.87, p =.012). Total throws dropped significantly (t (14) = 2.29, p =.038), and the SJFT Index increased (t (14) = -2.91, p =.011), reflecting reduced performance efficiency.

Discussion: This study investigated the effects of a 5% body weight reduction over 72 hours on female judo athletes, hypothesizing negative impacts on physiological and performance outcomes. The results confirmed significant declines in isometric handgrip strength, heart rate recovery, rate of perceived exertion, and Special Judo Fitness Test performance, but no changes in blood lactate recovery, partially supporting the hypothesis. These findings were compared to a control condition where athletes maintained their baseline weight, providing a robust within-subject crossover design to isolate rapid weight loss effects.
The notable decrease in handgrip strength, especially in the left hand, highlights the negative impact of RWL on neuromuscular function, which is essential for judo's gripping requirements. These results are consistent with Rossi, Roklicer [21], who observed muscle weakness and cramps in martial artists after RWL, and Artioli, Saunders [22], who noted early grip strength declines due to dehydration and reduced calorie intake. Franchini, Brito [23] suggest that dehydration reduces muscle hydration, impairing force generation and worsening performance in combat sports.
Post-RWL, athletes reported higher RPE despite performing the same physical tasks, indicating increased psychological strain. This aligns with previous research by Franchini, Brito [23], who found that combat athletes feel greater effort and fatigue after RWL, and Cheah, Bo [24], who reported increased anxiety and mood changes in judokas. He also links these effects to central nervous system fatigue, which may lead to early exhaustion. These findings emphasize the connection between physiological and psychological stress in RWL.
Unexpectedly, blood lactate recovery showed no significant changes after RWL, challenging assumptions about metabolic disruption. Similar results were reported by

Brechney, Chia [11], suggesting that moderate weight loss (5%) might not drastically affect lactate clearance in well-trained individuals. Various factors, such as genetics, training status, and nutrition, likely contribute to individual variations in lactate metabolism. Moreover, the lack of controlled rehydration protocols post-RWL, as highlighted by Artioli, Saunders [22], may have led to variability in the results, reinforcing the need for standardized recovery measures for athletes subjected to RWL.

Heart rate recovery was significantly impaired after RWL, with higher heart rates and slower recovery indicating autonomic nervous system dysfunction. These observations suggest dysfunction within the autonomic nervous system (ANS), aligning with studies indicating that dehydration and energy restriction due to RWL can lead to decreased parasympathetic activity [25, 26]. A notable Time × Condition interaction was identified, indicating prolonged cardiovascular stress during RWL periods. Research by (Borresen & Lambert, 2008) highlights that delayed heart rate recovery can be a predictor of mortality, suggesting that chronic cardiovascular stress may be significant.

SJFT performance significantly deteriorated, particularly in the latter sets, reflecting a decline in judo-specific fitness. Research by Franchini, Brito [23] attributes this decline to factors such as glycogen depletion and dehydration coupled with psychological stress experienced during RWL [27]. The elevated SJFT index following RWL supports evidence of impaired anaerobic performance, consistent with prior findings in combat sports literature [28].

The findings presented herein are crucial for the health and performance of athletes, as rapid weight loss (RWL) has been shown to detrimentally affect strength, cardiovascular recovery, and judo-specific capabilities [29]. This highlights the significant risks associated with existing weight-cutting practices. From a practical standpoint, these results endorse the adoption of safer weight management techniques, including gradual weight loss and enhanced rehydration strategies, to mitigate declines in performance and associated health hazards. Coaches and sports organizations are thus encouraged to devise education initiatives that promote evidence-based weight management guidelines, as recommended by [20].

A key limitation is the small sample size (n=15), which may limit statistical power and generalizability, particularly given variability in self-selected rapid weight loss methods. Additionally, the study focused on acute effects, leaving long-term consequences like bone density loss or hormonal disruptions unexplored [9]. Future research should investigate repeated rapid weight loss cycles, incorporate larger samples, and evaluate controlled rehydration and nutritional strategies. Psychological interventions to reduce perceived exertion and stress during weight cutting could also enhance athlete well-being.

These findings highlight the risks of rapid weight loss, supporting calls for safer weight management practices (30). Coaches and sports organizations should prioritize gradual weight reduction and education on evidence-based guidelines to protect female judo athletes' health and performance.

Conclusion

This study demonstrates that a 5% body weight reduction over 72 hours adversely affects female judo athletes' physiological and performance markers. Significant declines in isometric handgrip strength and Special Judo Fitness Test performance indicate impaired neuromuscular and sport-specific capacity. Increased rate of perceived exertion and delayed heart rate recovery reflect elevated psychological and cardiovascular stress, while blood lactate recovery remained unaffected, possibly due to maintained aerobic fitness or nutritional strategies. Compared to male athletes, female judokas may face amplified risks due to physiological differences, underscoring the need for gender-specific interventions. The small sample size limits generalizability, but the findings highlight the urgent need for sustainable weight management approaches. Coaches and athletes should adopt gradual weight reduction and enhanced rehydration strategies to mitigate health and performance risks. Future research should explore long-term effects, such as bone health and hormonal changes, to inform evidence-based practices in combat sports.

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Conflict of Interest

The author declares no conflict of interest related to the publication of this research.

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