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RESEARCH

Trends in weight loss strategies and sources of guidance for high-level judo athletes during the last four decades

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Abstract

Purpose This cross-sectional retrospective study aimed to examine trends in rapid weight loss (RWL) practices and sources of guidance among high-level judo athletes over the past four decades, considering sex, competitive period, and weight category.

Methods A total of 686 former elite judo athletes from Brazil, Italy, Japan, and Spain completed an adapted version of the Rapid Weight Loss Questionnaire (RWLQ). The questionnaire assessed RWL frequency, methods used, and influential figures. Generalized Linear Models and correspondence analyses were applied to evaluate temporal trends and associations.

Results Approximately 79% of athletes reported always or almost always engaging in RWL. The average pre-competition body mass loss was 5.7%, with higher values observed in lighter weight categories and among female athletes. Post-weigh-in body mass regain closely mirrored pre-competition losses. Over time, the influence of professionals (nutritionists, coaches, and physicians) increased, alongside greater use of structured strategies such as exercise, fasting, and food restriction. The use of extreme methods (vomiting, laxatives, diuretics) remained low and stable.

Conclusions RWL remains highly prevalent in competitive judo. Although guidance has shifted toward greater professional support and more structured practices, potentially reducing risk, weight cycling behaviors persist. These findings highlight the need for educational and policy interventions to promote safer weight management strategies, particularly during and after athletes' competitive careers.

Keyword Weight cycling · Post-retirement weight gain · Influential figures · Nutritional strategies · Health risks

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Introduction

Rapid weight loss (RWL) is a common practice among combat sport athletes, including judo athletes. Judo competitions are organized by weight categories to balance the body mass of the contestants and prevent significant differences in muscle strength and power generation between opponents [1–3]. However, in judo tournaments, many participants aim to compete in the lowest weight category possible and may try to reach body masses below their walk-in values to gain a relative advantage over their lighter and potentially weaker opponents [1–3].

Additionally, judo athletes often attempt to adjust their body mass before weigh-ins by employing aggressive strategies, such as severe caloric restriction, dehydration, and the use of sauna suits, and they quickly regain it by rehydration and consumption of a high amount of food [4]. The effects produced by RWL and rapid weight gain (RWG) require extensive research from various perspectives [5], ranging from changes in physical performance and fitness to the chances of sporting success and long-term health effects.

Regarding the impact on physical fitness, findings related to performance following rapid weight loss are contradictory. A recent study reported reductions in upper body strength and endurance after a 2.56% decrease in body mass [6], while others have observed reduced energy levels and impairments in both aerobic and anaerobic performances [7, 8]. In contrast, some authors argue that RWL of up to 5% of body mass within seven days does not impair performance in Olympic combat athletes, including judo athletes [9, 10]. Similarly, other studies have found no detrimental effects on aerobic and anaerobic performances following RWL [1–3, 11]. Notably, these studies conducted post-weigh-in measurements after a recovery period, allowing athletes to rehydrate and replenish energy stores, thereby increasing external validity by more closely simulating the actual conditions between weigh-in and competition. Despite the conflicting data, several research [12–14] concluded that RWL has a negative impact on both aerobic and anaerobic performances. While changes in aerobic performance are typically related to factors such as dehydration and reduced plasma volume, decreases in anaerobic performance are mainly attributed to reduced buffering capacity, glycogen depletion, and electrolyte imbalances [12].

The relationship between RWL, RWG, and competitive success in combat sports, particularly in judo, remains unclear. Competitive success is multifactorial and cannot be determined by a single variable alone [13]. Reale et al. [15] investigated the relationship between success in an international judo competition and RWG, finding that medal winners regained more body mass after weigh-in than non-medalists, suggesting that RWG may confer an advantage. Baribeau et al. [16] concluded that RWG and body mass difference after weigh-ins were associated with higher chances of winning in combat sports. The study found that winners in both mixed martial arts (MMA) and boxing regained more body mass, both in absolute and relative terms, compared to those who lost their matches. Additionally, athletes who reduced a greater amount of body mass compared to defeated athletes were more likely to win [17]. In another study on mixed martial arts, researchers found an inverse relationship between the amount of body mass lost and the probability of victory [18]. These findings suggest that rehydration after weigh-in plays a crucial role in competition performance, as does the time between weigh-in and competition [19].

Research has indicated that RWL leads to dehydration in judo athletes, posing health risks such as impaired thermoregulation and increased cardiovascular stress [12, 13]. This condition may persist during competitions or training, even with opportunities for fluid intake or rehydration [20]. However, recent findings by Bialowas et al. [21] suggested that the state of dehydration did not have a significant impact on competitive performance. Green et al. [22] highlighted an increased risk of injury in judo athletes who reduced their body mass by more than 5% prior to competition, emphasizing the potential dangers of RWL. Research has further demonstrated significant associations between frequent RWL and concussion among combat sports athletes [23]. In addition, MMA athletes may experience adverse effects on renal function [24] and the endocrine system [25] due to RWL practices. Lebron et al. [5] also noted that weight cycles involving RWL can result in reductions in metabolic rate, insulin, and leptin levels, which may be exacerbated by RWG through excessive caloric intake. These processes not only affect immediate performance and recovery but also carry long-term health risks, including the development of metabolic syndrome, indicating the need for careful consideration of weight management strategies in combat sports [26]. It is important to note that MMA athletes often undergo greater body mass reductions compared to other combat sports due to longer recovery periods between weigh-ins and matches, as well as fewer events per season and increased financial compensation. While these conditions allow more time for recovery, they also enable larger weight fluctuations, potentially increasing the risks associated with RWL. This highlights the need to address these practices distinctly from sports like judo and wrestling, where recovery times and competition formats differ.

In this context, the weigh-in rules have varied over time. Traditionally, competitions organized by the International Judo Federation (IJF) have set the weigh-in during the same day, 2–3 h before the competition. In 2015, the IJF

implemented new regulations regarding weigh-ins for competitions. These changes included setting the weigh-in the day before the competition [27], allowing athletes to carry up to 5% of their weight category's upper limit, and introducing a random weigh-in on the day of the competition. These changes likely prompted athletes and coaches to develop new strategies for body mass adjustment during different decades.

Coaches, nutritionists, parents, and peers play a pivotal role in shaping the body mass management strategies of judo athletes. Their guidance influences whether athletes adopt aggressive weight-cutting methods, such as dehydration and food restriction, or more recommended approaches like gradual dieting and slow caloric restriction. A study found that 80% of athletes relied on other judo athletes, 75% on coaches, and 64% on dietitians for information on RWL and nutrition, highlighting the significant impact these sources have on the methods athletes choose [8]. Conversely, pressure from coaches or peers to rapidly reduce body mass to compete in a lower weight category can push athletes toward extreme measures like severe caloric restriction and dehydration, leading to the adoption of weight cycling strategies that negatively affect metabolic function [1–3, 5, 8]. The influence of these figures is especially critical in combat sports like judo, where strategies for RWL and RWG can differ significantly based on the guidance and cultural norms within different teams or regions [5, 13].

These dynamics indicate the importance of educating all involved parties on the risks associated with aggressive weight-cutting practices and promoting safer, more sustainable approaches to weight management in combat sports. Therefore, the objective of this study was to retrospectively examine RWL habits among high-level judo athletes from several continents over the past 40 years with the hypothesis that differences exist by sex, competition period, and weight categories. Specifically, athletes in lighter weight categories would engage in more aggressive rapid weight loss (RWL) methods, while female athletes would exhibit different weight management patterns compared to males. Additionally, a higher prevalence and the use of more aggressive methods would be expected in more recent years, likely due to the increased time available for recovery between weigh-in and competition.

Material and methods

Participants

The study sample consisted of 686 participants from four different countries across three continents: Italy: 273 participants (39.8%), Japan: 224 participants (32.7%), Spain: 130 participants (19.0%), and Brazil: 59 participants (8.6%). The sex distribution was 279 females (40.7% of the total) and 407 males (59.3% of the total). Participants were from different weight categories, with the following distribution: Extra-lightweight: 117 participants (17.1%), Half-lightweight: 146 participants (21.3%), Lightweight: 135 participants (19.7%), Half-middleweight: 111 participants (16.2%), Middleweight: 92 participants (13.4%), Half-heavyweight: 66 participants (9.6%), and Heavyweight: 19 participants (2.8%). In cases where the athletic career spanned multiple categories, participants were asked to choose the category in which they had spent the longest period of their career. Weight categories were grouped according to standard international judo classifications. Due to changes in official categories over time, these groups represent equivalent competitive divisions across different periods rather than fixed weight ranges. Weight categories were grouped according to standard international judo classifications. Due to changes in official categories over time, these groups represent equivalent competitive divisions across different periods rather than fixed weight ranges. To ensure comparability, categories were harmonized across periods based on major International Judo Federation (IJF) classification changes introduced around 1999–2000. Detailed information on weight category ranges across competitive periods is provided in the Supplementary Material (Table S5).

Participants were divided into different time periods to establish categories based on when they predominantly competed. In cases where periods overlapped, they were asked to select the period in which they spent the most time competing. The distribution by periods was as follows: 1980–1990: 129 participants (18.8%), 1991–2000: 198 participants (28.9%), 2001–2010: 196 participants (28.6%), and 2011–2020: 163 participants (23.8%).

Instruments

All participants completed an adapted version of the rapid weight loss questionnaire (RWLQ) developed by 1–3), which assesses weight loss patterns in judo competitors. The questionnaire consists of 9 questions about the athlete's personal history and 9 questions about their weight history and dietary patterns. Additionally, the questionnaire includes 8 Likert scale questions (i.e., 0 = unsure, 1 = not influential, 2 = slightly influential, 3 = somewhat influential, 4 = very influential) that evaluate the influence of others on the athlete's weight management patterns, and 14 Likert scale questions (i.e., 0 = never used, 1 = no longer used, 2 = almost never used, 3 = sometimes used, 4 = always used) that explore specific body mass reduction methods. The scores are totaled to determine the level of harm and aggressiveness of the athlete's RWL patterns. Regarding its validity and reliability, the questionnaire has been evaluated for content validity, convergent validity ($r = 0.62$), and

reliability ($r = 0.98$), concluding that the questionnaire is both valid and reliable [1–3].

To complement the information gathered through the questionnaire, three additional questions were included corresponding to three independent variables described in the participants section: i) country of origin, ii) selection of the period in which the majority of the athlete's competitive career occurred, and iii) selection of the weight category in which the athlete competed for the majority of their career.

Procedures

A Google Form was designed based on the original English and Portuguese versions of the questionnaires, incorporating the content of the RWLQ questions. All participants were required to be able to understand the questions in English or Portuguese, although translated copies in Spanish, Italian, and Japanese, prepared by certified translators, were provided for reference in case of uncertainty. National federations, clubs, athlete associations, and high-performance training centers were contacted prior to distributing the form to potential participants. The questionnaire was aimed at judo athletes who had ended their athletic careers and had won a national medal (senior/junior) in their country while participating in international competitions (here defined as competitions involving more than 10 countries as part of a national team). The introduction text clarified that the survey was completely anonymous, and by responding, participants agreed to take part in the study and acknowledged that their data would be used anonymously. Data collection took place during the second half of 2024, and the research protocol was approved by the Ramon Llull University Institutional Review Board. Although the study involved only the administration of a questionnaire and no physical or clinical interventions, it adhered to relevant ethical standards, including the principles of the Declaration of Helsinki. Informed consent was obtained at the beginning of the questionnaire. The full dataset has been made openly available via Figshare: https://doi.org/10.6084/m9.figshare.29483099.

Statistical analysis

Total frequencies were calculated, along with frequencies based on dependent variables (sex, weight category, competition period, and country) for the questions regarding the need to lose weight and changes in weight category during the competitive career. The Chi-square test was applied to detect significant associations between the different variables.

To analyze the results related to participants' body mass variations, several dependent variables were recalculated and expressed as percentages. These included: the difference between participants' current body mass and their competition weight category; the usual percentage of body mass lost to compete; and the percentage of body mass regained in the week following competition, also expressed relative to the competition weight category. Additionally, the variable *period to adjust weight* was incorporated into these calculations. For each of these variables, descriptive statistics, the mean and standard deviation, were computed according to the competitive period to explore trends over time.

A generalized linear model (GLM) was applied to examine the main effects and interactions of the predictor variables, sex, competition period, and weight category, on the aforementioned dependent variables. Post-hoc comparisons were conducted using Bonferroni corrections when appropriate. The analysis included both main effects and first- and second-order interactions.

The variables related to individuals influencing weight loss and the methods used were also analyzed using a generalized linear model (GLM), with competition period as the independent variable. This allowed us to identify significant patterns in how different groups perceived external influence and selected weight loss strategies.

Subsequently, to explore potential associations between influencing figures, weight loss methods, and participant characteristics in more detail, a correspondence analysis was conducted. For analytical clarity, weight categories were grouped as follows: the Lightweights group included extra-lightweight, half-lightweight, and lightweight divisions, while the Heavyweights group comprised half-middleweight, middleweight, and half-heavyweight divisions. Heavyweights were excluded, as they typically do not engage in RWL methods. It is important to note that the exact weight thresholds within these categories varied across competitive eras. The analysis considered the sex of the judo athletes, the grouped weight categories, and the different competition periods.

Correspondence analysis was conducted in R via RStudio (RStudio Team, 2024) using the FactoMineR and factoextra packages. Although biplots of the first two dimensions were produced for each sex, weight category, and competitive period, their complexity hindered interpretation. Therefore, Euclidean distances between categories were calculated with FactoMineR, and heatmaps were generated using the heatmap and gridExtra packages. The analysis focused on responses indicating a high level of influence (level 4) and on weight loss methods reported with the same frequency, retaining only the most influential and commonly adopted categories for visualization.

All other statistical analyses were performed using Jamovi software (version 2.3) [28]. The GLM analyses were conducted using the GAMLj module, which implements the R-based syntax for mixed effects modeling. Results with p values less than 0.05 were considered statistically

significant. Partial eta squared (η^2_p) was used as a measure of effect size and interpreted as small (0.01), medium (0.06), and large (0.14), based on conventional thresholds proposed by Cohen (1988).

Results

Of the 687 participants who completed the RWLQ, 2.8% reported that they never had to lose weight before competing, 18.4% stated that they had to lose weight occasionally, and 78.7% indicated that they always or almost always had to lose weight prior to a competition. These data ($n = 667$) exclude the heavyweight category ($n = 20$). Table 1 presents the frequencies according to sex, weight category, competition period, and country.

There were significant associations between the response levels to the question of whether participants had ever needed to lose weight and the weight category variable ($\chi^2 = 85.4$, df = 15, $p < 0.001$) and the country ($\chi^2 = 49.6$, df = 9, $p < 0.001$). Regarding weight category changes during participants' competitive careers, 68.8% reported changing categories, while 31.2% stated they never changed categories. Table 1 shows the relative frequencies for each category, grouped by sex, weight category, competition period, and country (Fig. 1).

The GLM applied to the variable usual body mass lost showed a moderate fit ($R^2 = 0.220$, adj. $R^2 = 0.161$). Significant main effects were found for sex ($F_{(1, 619)} = 9.041$, $p = 0.003$, $\eta^2_p = 0.014$, indicating a small effect size), competitive period ($F_{(3, 619)} = 2.686$, $p = 0.046$, $\eta^2_p = 0.013$, indicating a small effect size), and weight category ($F_{(5, 619)} = 18.051$, $p < 0.001$, $\eta^2_p = 0.127$ indicating a large effect size) (See Fig. 2). Additionally, significant interactions were observed between sex and competitive period ($F_{(3, 619)} = 3.750$, $p = 0.011$, $\eta^2_p = 0.018$, indicating a small effect size) and between sex and weight category ($F_{(5, 619)} = 2.690$, $p = 0.020$, $\eta^2_p = 0.021$). Post hoc analyses revealed that male athletes reported significantly lower percentages of usual body mass lost compared to females ($B = -0.008$, $t = -3.01$, $p = 0.003$). Athletes who competed between 1991 and 2000 reported significantly greater body mass lost than those from 1980–1990 ($B = 0.011$, $t = 2.68$, $p = 0.008$). Regarding weight categories, middleweight and half-heavyweight athletes reported significantly lower values than those in the extra-lightweight category (both $p < 0.001$).

A significant interaction was found between male athletes and the 2011–2020 competitive period ($B = 0.017$, $t = 2.07$, $p = 0.039$), suggesting a change in behavior over time. Additional interactions indicated that sex differences in usual body mass lost were more pronounced in certain

Table 1 Distribution of responses regarding the frequency with which participants needed to lose weight before competitions, by sex, weight category, competitive period, and country

Variable	Category	Never	Occasionally	Almost always	Always	YES Change of weight category	NO Change of weight category
Sex	FEMALE	1.9% (5)	14.8% (40)	40.0% (108)	43.3% (117)	62.2% (168)	37.8% (102)
	MALE	3.5% (14)	20.9% (83)	35.8% (142)	39.8% (158)	73.0% (290)	27.0% (107)
Weight category	Extra lightweight	0.9% (1)	16.2% (19)	29.9% (35)	53.0% (62)	59.8% (70)	40.2% (47)
	Half lightweight	0.7% (1)	6.8% (10)	42.5% (62)	50.0% (73)	66.4% (97)	33.6% (49)
	Lightweight	0.0% (0)	11.9% (16)	38.5% (52)	49.6% (67)	75.6% (102)	24.4% (33)
	Half middleweight	4.5% (5)	22.5% (25)	40.5% (45)	32.4% (36)	71.2% (79)	28.8% (32)
	Middleweight	6.5% (6)	30.4% (28)	35.9% (33)	27.2% (25)	67.4% (62)	32.6% (30)
	Half heavyweight	9.1% (6)	37.9% (25)	34.8% (23)	18.2% (12)	72.7% (48)	27.3% (18)
Competition period	1980–1990	2.4% (3)	26.0% (33)	36.2% (46)	35.4% (45)	62.2% (79)	37.8% (48)
	1991–2000	2.1% (4)	15.1% (29)	38.5% (74)	44.3% (85)	66.7% (128)	33.3% (64)
	2001–2010	1.6% (3)	17.9% (34)	38.4% (73)	42.1% (80)	73.7% (140)	26.3% (50)
	2011–2020	5.7% (9)	17.1% (27)	36.1% (57)	41.1% (65)	70.3% (111)	29.7% (47)
Country	BRAZIL	3.6% (2)	5.5% (3)	47.3% (26)	43.6% (24)	78.2% (43)	21.8% (12)
	ITALY	1.1% (3)	22.6% (60)	45.5% (121)	30.8% (82)	73.7% (196)	26.3% (70)
	JAPAN	6.4% (14)	19.1% (42)	28.6% (63)	45.9% (101)	65.5% (144)	34.5% (76)
	SPAIN	0.0% (0)	14.3% (18)	31.7% (40)	54.0% (68)	59.5% (75)	40.5% (51)
Total	N = 667	2.8% (19)	18.4% (123)	37.5% (250)	41.2% (275)	68.8% (458)	31.2% (209)

The last two columns show the percentage of participants who reported changing weight categories during their competitive careers. All values are expressed as relative frequencies (%) with absolute frequencies in parentheses

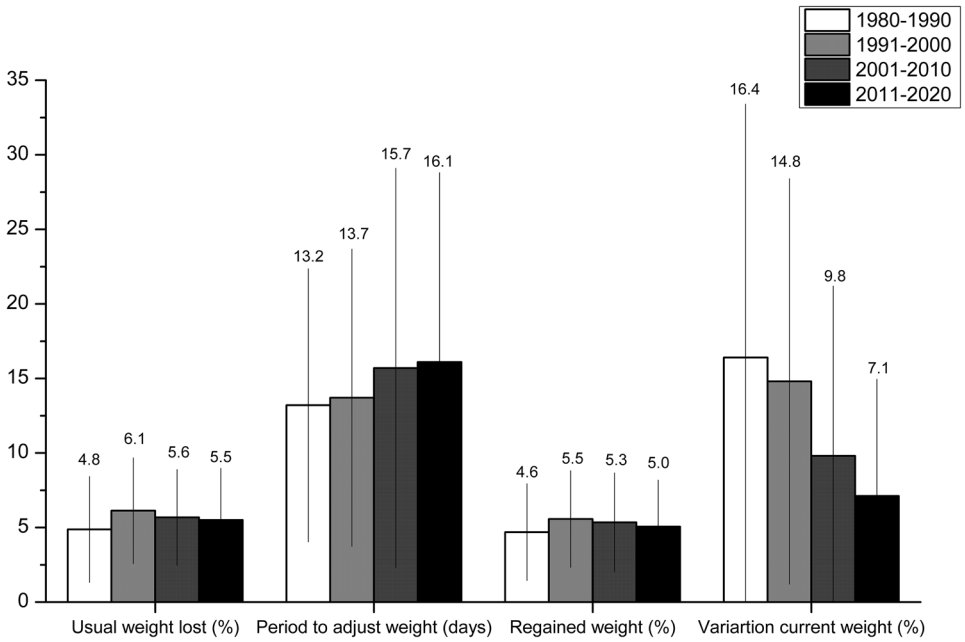

Fig. 1 Mean values of four weight management variables across competitive periods: (1) the usual percentage of body mass lost to reach competition weight, (2) the average number of days used to adjust body mass before competition, (3) the percentage of body weight regained in the week following competition, and (3) the difference between current body mass and official competition category

weight categories, such as half-lightweight ($p = 0.005$) and middleweight ($p = 0.010$) (See Fig. 2).

In contrast, the model for period to adjust body mass showed a limited fit ($R^2 = 0.076$, adj. $R^2 = 0.006$). The only significant main effect was observed for weight category ($F_{(5, 619)} = 2.52$, $p = 0.029$, $\eta^2_p = 0.020$), whereas sex ($F_{(1, 619)} = 0.03$, $p = 0.863$), competitive period ($F_{(3, 619)} = 1.66$, $p = 0.175$), and all interaction terms were not significant (all **p** > 0.05) (See Fig. 2).

Within the fixed effects, athletes in the half-heavyweight category began their weight-cutting process an average of 5.12 days earlier than those in the extra-lightweight category (B = −5.12, $t = -2.57$, $p = 0.010$). No significant differences were found based on sex (B = −0.18, $p = 0.863$) or competitive period (all $p > 0.16$) (See Fig. 2).

The full statistical model predicting body mass regain was statistically significant ($F_{(47, 619)} = 2.880$, $p < 0.001$). Among the main effects, weight category was the only significant predictor ($p < 0.001$), showing notable differences in post-weigh-in body mass regain. Specifically, athletes in lighter categories reported higher percentages of body mass regain compared to those in heavier categories. Compared to the extra-lightweight category, middleweight athletes regained significantly less weight ($B = -0.030$, $p < 0.001$), as did those in half-lightweight ($B = -0.018$, $p < 0.001$) and half-heavyweight ($B = -0.032$, $p < 0.001$).

A significant interaction between sex and weight category was found (p = 0.036), indicating specific differences depending on the combination of these factors. For instance, male athletes in the half-lightweight category showed significantly lower regain values than their female counterparts ($B = -0.020$, $p = 0.017$). Neither the competitive period nor its interactions with sex or weight category were statistically significant.

The full model for the dependent variable variation in current body mass revealed a significant effect ($F_{(47, 618)} = 3.472$, $p < 0.001$), with $R^2 = 0.209$ and adjusted $R^2 = 0.149$. The ANOVA showed significant main effects for sex ($F_{(1, 618)} = 15.037$, $p < 0.001$, $\eta^2_p = 0.024$), competitive period ($F_{(3, 618)} = 17.155$, $p < 0.001$, $\eta^2_p = 0.077$, indicating a moderate effect), and weight category ($F_{(5, 618)} = 6.262$, $p < 0.001$, $\eta^2_p = 0.048$). A significant interaction was also observed between competitive period and weight category ($F_{(15, 618)} = 2.287$, $p = 0.004$, $\eta^2_p = 0.053$), while interactions involving sex were not significant (all p > 0.05). Model coefficients indicated that male athletes reported a higher percentage of current weight compared to their competition body mass ($B = 0.041$, $p < 0.001$). Athletes competing during the 2001–2010 and 2011–2020 periods reported significantly lower Variation in Current Weight values compared to those from 1980–1990 (both $p < 0.001$). Regarding weight categories, athletes in heavier categories, such as middleweight ($B = -0.080$, $p < 0.001$) and half-heavyweight ($B = -0.097$, $p < 0.001$), reported significantly smaller weight increases compared to the extra-lightweight group. Significant differences were also found for intermediate categories such as half-lightweight and lightweight, compared to the extra-lightweight category (both $p < 0.01$) (Fig. 2).

The influence attributed to nutritionists showed significant variation across competitive periods ($F_{(23, 623)} = 3.76$, $p < 0.001$, $R^2 = 0.122$, adj. $R^2 = 0.090$), with the most recent cohort (2011–2020) reporting significantly higher influence than the reference group from 1980–1990 ($B = 1.39$, $p < 0.001$). Similarly, the perceived influence of coaches also

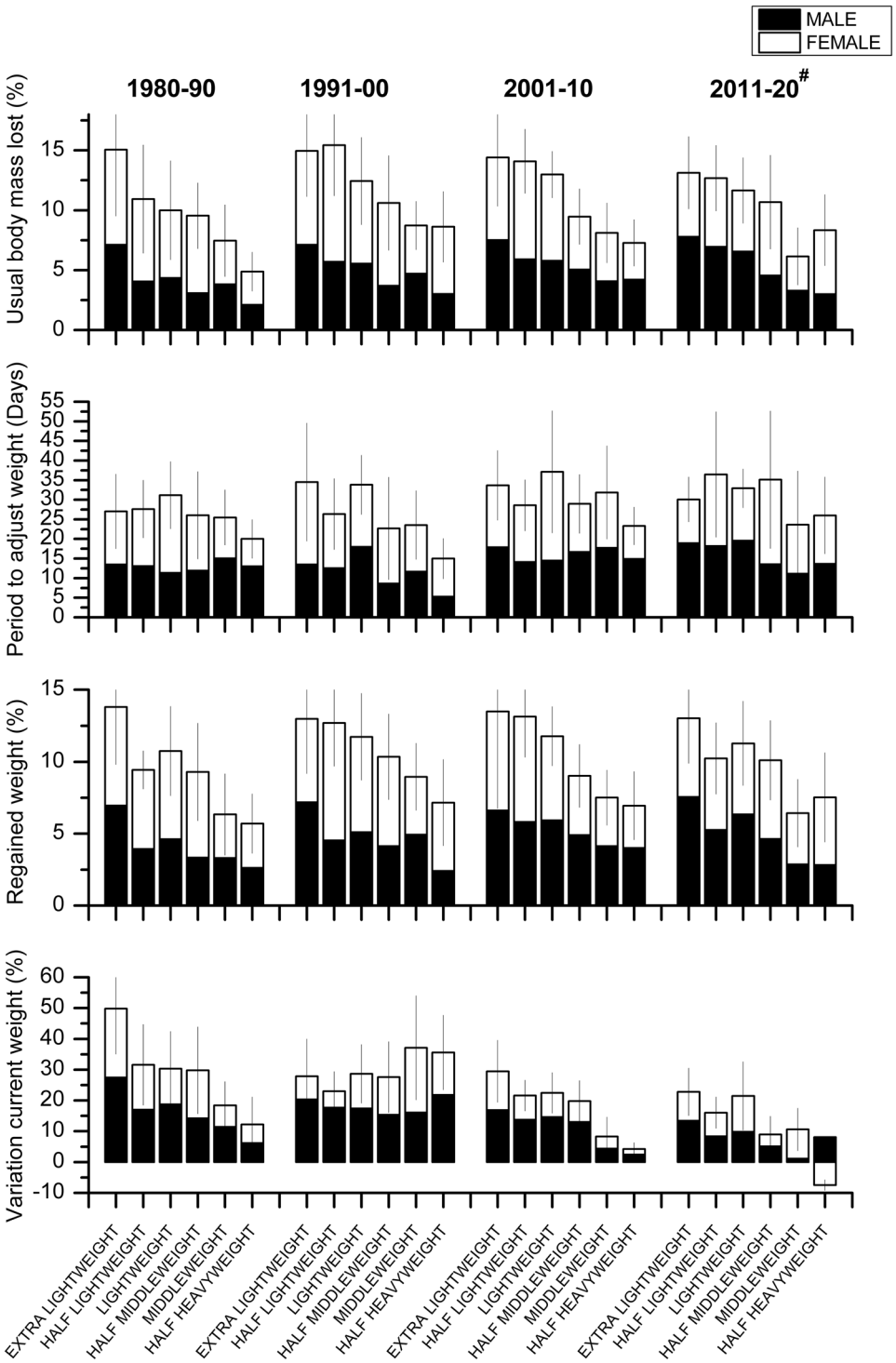

Fig. 2 Mean values of four weight management variables across competitive periods: **A** usual body mass loss (%), **B** weight adjustment period (days), **C** body mass regain (%), and **D** change in current body mass (%), are presented by weight category and sex. Dark bars represent male athletes and light bars represent female athletes. Error bars indicate standard deviations

increased over time ($F_{(23, 623)} = 2.36$, $p < 0.001$, $R^2 = 0.080$, adj. $R^2 = 0.046$), with a marked difference observed in the 2011–2020 group ($B = 1.10$, $p < 0.001$). For physicians, the model was also significant ($F_{(23, 623)} = 1.89$, $p = 0.008$, $R^2 = 0.065$, adj. $R^2 = 0.031$), and again, athletes from the most recent period reported greater influence ($B = 0.62$, $p < 0.001$). In contrast, the models assessing the influence of partners/teammates ($F(23, 623) = 1.05$, $p = 0.396$, $R^2 = 0.037$), other judo athletes ($F_{(23, 623)} = 0.85$, $p = 0.667$, $R^2 = 0.030$), and other people ($F_{(23, 621)} = 0.55$, $p = 0.957$, $R^2 = 0.020$) were not statistically significant. Across all models, weight category and the interaction term (competitive period × weight category) failed to reach significance (all $p > 0.16$) (See Fig. 3).

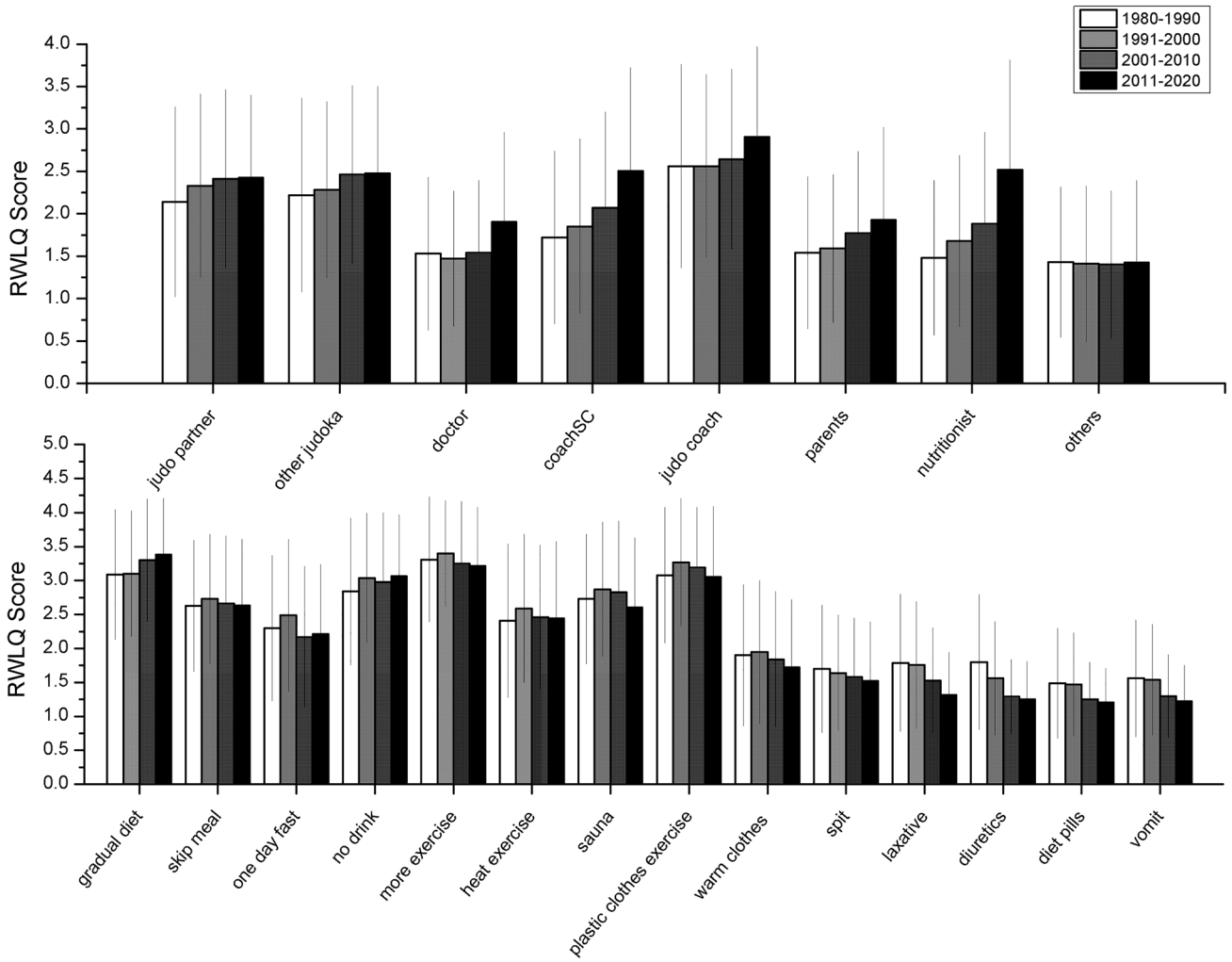

Fig. 3 Average scores and dispersion of the dependent variables concerning influential individuals in rapid weight loss and the strategies employed, categorized by competitive period across the last four decades

The dependent variables included both behavioral and physiological strategies: increased exercise, food restriction, fasting, use of plastic suits or sauna, self-induced vomiting, use of laxatives, and use of diuretics.

Significant differences were found primarily across competitive periods. The use of exercise as a weight-cutting strategy showed a significant increase over time ($F_{(23, 623)} = 2.61$, $p < 0.001$, $R^2 = 0.088$, adj. $R^2 = 0.055$), with higher scores observed in the 2011–2020 cohort compared to 1980–1990 ($B = 0.92$, $p = 0.006$). Similarly, food restriction increased significantly in recent decades ($F_{(23, 623)} = 2.45$, $p < 0.001$, $R^2 = 0.083$, adj. $R^2 = 0.050$), with the most recent group reporting the highest values ($B = 0.97$, $p < 0.001$). Fasting also showed a significant rise ($F_{(23, 623)} = 1.78$, $p = 0.016$, $R^2 = 0.062$, adj. $R^2 = 0.027$), particularly in the 2011–2020 group ($B = 0.60$, $p = 0.003$). The use of plastic suits or sauna followed a similar pattern ($F_{(23, 623)} = 1.96$, $p = 0.006$, $R^2 = 0.067$, adj. $R^2 = 0.033$), with significant increases observed in both 2001–2010 ($B = 0.42$, $p = 0.035$) and 2011–2020 ($B = 0.60$, $p = 0.003$).

In contrast, extreme and potentially harmful methods such as self-induced vomiting ($F_{(23, 623)} = 0.76$, $p = 0.791$, $R^2 = 0.027$), laxative use ($F_{(23, 623)} = 0.61$, $p = 0.912$, $R^2 = 0.022$), and diuretic use ($F_{(23, 623)} = 1.05$, $p = 0.397$, $R^2 = 0.037$) showed no significant variation across competitive periods or weight categories. In all models, neither weight category nor the interaction between period and category reached statistical significance (all $p > 0.13$).

To further explore the relationships between influential figures and weight loss methods, a multiple correspondence analysis was conducted. Due to the complexity of the graphical outputs, detailed heatmaps are provided in the Supplementary Material (Figures S1–S4). Overall, the results indicate that earlier competitive periods (1980–1990) were characterized by stronger associations with traditional figures such as coaches and strength and conditioning

professionals. In contrast, more recent periods (2011–2020) showed a broader distribution of influence, including increased proximity of nutritionists, physicians, and other figures to a wider range of weight loss strategies. These patterns varied by sex and weight category, with lighter weight categories generally showing stronger associations between multiple influential figures and a greater variety of methods. This suggests a progressive diversification of both guidance sources and weight management practices over time.

Discussion

The aim of this study was to examine trends in RWL practices and sources of guidance among high-level judo athletes over the past four decades, considering sex, competitive period, and weight category. Overall, the findings indicate that RWL remains highly prevalent, with some stabilization in recent decades and a progressive shift toward more professionally guided practices.

The present study found that 78.7% of judo athletes reported "always" or "almost always" engaging in RWL before competition, while 18.4% did so occasionally and 2.8% never engaged in RWL. These data exclude athletes from the heavyweight category (n = 20), suggesting that RWL has been a highly prevalent practice in judo over the past four decades. These findings are consistent with previous research documenting high rates of RWL among elite judo athletes. For instance, Štangar et al. [8] reported that 96% of elite athletes engage in RWL, with an average weight reduction of 5.8% ± 2.3% prior to competition. Similarly, a recent scoping review [29] found that between 40% and 92.9% of judo athletes use RWL strategies. Temporal variation in RWL prevalence is also noteworthy. The comparatively lower prevalence observed in this study may be partially explained by the inclusion of data spanning four decades. In the 1980s–1990s, 71.6% of judo athletes reported "always" or "almost always" cutting weight. This proportion increased in the 1991–2000 period and remained relatively stable in subsequent decades, with minor fluctuations.

Although female judo athletes reported a similar prevalence of consistent RWL compared to their male counterparts (43.3% vs. 39.8%). This finding aligns with previous research by 1–3 and Malliaropoulos et al. [30], which also found similar RWL prevalence rates between male and female judo athletes.

A key aspect in weight management for combat sports athletes involves the interplay between the amount of body mass lost prior to competition, the time frame of the reduction, post-weigh-in body mass regain, and long-term effects on body composition. This study examined these variables with respect to sex, competition period and weight category. A key point when interpreting these findings is that the practical meaning of RWL is not limited to the amount of body mass lost, but also includes the physiological cost of the methods used and the extent to which recovery after weigh-in restores homeostasis [15].

Athletes in this study reported an average pre-competition weight loss of 5.7%, which is consistent with findings from Reale et al. [15], Dos Santos et al. [29], Štangar et al. [8], and Lakicevic et al. [31]. The highest values were recorded during the 1991–2000 period, coinciding with the growing prominence of international judo competitions, partly driven by the emergence of strong national teams following the dissolution of the Soviet Union. These values were significantly higher than those of the preceding period, but not compared to the following decades, despite slight differences in the results as indicated. In the decades that followed, average RWL either stabilized or showed a slight decrease, possibly influenced by the changes in official weight categories introduced at the 1999 World Championships and the 2000 Sydney Olympic Games. Further regulatory changes by the IJF [27], particularly the move to official weigh-ins the day before competition, may have aimed to reduce the severity of RWL practices. While these changes likely prevented further increases in weight-cutting aggressiveness, they did not result in a significant reduction in the percentage of body mass lost before weigh-ins.

The evolution of RWL practices should also be interpreted in light of changes in IJF regulations. The introduction of weigh-ins the day before competition and the implementation of random weigh-ins likely influenced athletes' strategies by increasing recovery time while also attempting to limit excessive weight regain. These regulatory changes may partly explain the stabilization of RWL magnitude observed in recent decades. Additionally, our findings indicated that athletes competing in more recent periods reported a greater influence of nutritionists and physicians, whereas earlier generations were primarily influenced by coaches and strength and conditioning professionals. This shift likely reflects the increasing professionalization of high-level sport and the integration of multidisciplinary support teams. In parallel, although structured strategies such as exercise, fasting, and dietary restriction became more common, the use of more extreme methods remained low and stable over time. Therefore, the change in influential figures for RWL may have contributed to a more controlled and evidence-based approach to weight management, potentially limiting the adoption of more aggressive practices. Furthermore, these trends may also be influenced by greater awareness of the physiological risks associated with RWL and by regulatory changes in judo that have shaped athlete behavior in recent decades.

From a physiological perspective, a body mass reduction of this magnitude is highly likely to involve a substantial dehydration component, particularly when achieved over a

short period through fasting, fluid restriction, increased exercise, or thermal strategies. Previous work in judo and other combat sports has shown that acute dehydration contributes to reductions in plasma volume, increased cardiovascular strain, impaired thermoregulation, and decrements in aerobic performance, while repeated or more severe restriction may also compromise buffering capacity, glycogen availability, and neuromuscular function [7, 12, 13]. Thus, even when average values remain within the range commonly reported in the literature, the physiological cost of repeatedly losing approximately 5–6% of body mass should not be considered trivial, especially for athletes who combine several methods simultaneously or who perform these practices repeatedly across a season. Additionally, for athletes competing in more recent periods, particularly after the introduction of the Judo World Tour in 2009, the number of competitions per season likely increased, which may have made it more difficult to repeatedly implement highly aggressive RWL strategies. In this context, the need to achieve weight category limits multiple times within the same season may have encouraged more sustainable or controlled approaches to weight management.

The percentage of body mass regained within the week following competition was nearly equivalent to that lost prior to weigh-in, with consistent values across competitive periods. Similar patterns have been reported in elite judo athletes, who can regain up to 5.8% after weigh-in [15], and in MMA athletes, where recovery can reach substantially higher values, particularly when longer recovery periods are available [19]. Post-weigh-in body mass regain appears to be a key factor in performance, as higher recovery has been linked to better competitive outcomes [19]. Recovery is significantly influenced by weight category, with lighter-weight athletes regaining a greater percentage, no significant interactions were observed with sex or competition period. Evidence on differences by sex, weight category, or competitive period remains limited. Pélissier et al. [32] found that lighter weight categories regained an average of 3.5% within one-week post-competition. Regarding sex differences, Ceylan and Balci [20] reported higher recovery in males than females, whereas Reale et al. [15] found no significant differences, though females regained 3.1% compared to 2.3% in males.

The near-equivalence between pre-competition body mass loss and post-weigh-in regain is also relevant from a physiological standpoint. In practice, this pattern suggests that many athletes were not simply reducing fat mass gradually, but rather oscillating between acute depletion and rapid recovery of body water, glycogen, and gastrointestinal content. Such recovery may partially restore performance, particularly when sufficient time is available between weigh-in and the first contest, because rehydration and carbohydrate intake can improve plasma volume, substrate availability, and perceived readiness [1–3, 19]. However, recovery is rarely complete in all physiological systems. Residual hypohydration, incomplete electrolyte restoration, and insufficient glycogen resynthesis may persist, especially after more aggressive cuts, which helps explain why the literature reports mixed findings regarding the effect of RWL on performance [9, 13]. Therefore, our findings should not be interpreted as evidence that successful body mass regain fully neutralizes the physiological stress induced by rapid weight loss.

It is well established that combat sport athletes can recover a large portion of the body mass lost after competition, largely due to post-RWL hyperhydration strategies. However, RWG may negatively impact body composition. Bagot et al. [33] described the “fat overshooting” phenomenon, in which fat mass is regained after RWL exceeds the amount originally lost. This may result in long-term alterations to body composition, reduced fat-free mass, and impaired metabolic function. Nonetheless, the extent and consequences of this recovery vary depending on the magnitude of the RWL, the strategies used for recovery, and individual athlete characteristics.

Post-retirement body mass gain is common among combat sport athletes, with repeated RWL cycles potentially causing long-term metabolic disturbances and increasing chronic health risks [26]. Athletes in weight-class sports often experience significant fluctuations during their careers, and subsequent weight gain depends largely on post-competition physical activity levels [34]. Longitudinal evidence indicates that body mass changes after retirement are more strongly linked to activity levels than to the number of RWL cycles completed [35]. Variability is also observed in body composition changes, with some athletes maintaining stability and others experiencing substantial increases due to reduced activity and dietary shifts [36].

Athletes from earlier competitive periods showed greater post-retirement body mass gain relative to competition weight, consistent with evidence that earlier generations relied on more aggressive RWL methods, leading to long-term metabolic disruption [34]. More recent athletes have tended toward structured, professionally supervised approaches, potentially reducing variability in weight regain. Weight category also plays a role: lighter-class athletes exhibit greater relative fluctuations post-retirement [35], whereas heavier-class athletes gain more absolute mass but with less relative variation. These patterns underscore the importance of post-career monitoring programs promoting physical activity and nutritional education to mitigate the health risks of chronic weight cycling.

A key finding of this study is the identification of the main figures influencing RWL decisions in judo: teammates (80%), coaches (75%), and nutritionists (64%). Coaches have historically been the primary source of

information, with their influence on extreme weight-cutting well documented in combat sports [1–3], while teammates often shape practices through imitation of experienced or successful peers [37]. Notably, in 2011–2020, perceived influence increased significantly for nutritionists, coaches, and medical professionals, reflecting greater professionalization and the integration of multidisciplinary support in elite judo.

The increased involvement of nutritionists has promoted safer, evidence-based approaches such as gradual caloric restriction and hydration control [4]. In contrast, the influence of informal sources (partners, teammates, other judo athletes, or unspecified individuals) remained stable over time, suggesting a secondary role compared to qualified professionals. Neither weight category nor its interaction with the competition period significantly affected perceived influence, indicating the consistent relevance of professional guidance across divisions. These findings suggest a shift toward more technical and supervised weight management, while highlighting the need to further educate athletes and coaches to ensure safe and effective RWL practices.

This study confirms that the predominant RWL strategies among judo athletes remain caloric restriction, plastic suit use, intense training, and sauna-induced heat exposure, methods consistently reported in previous research, with over 85% of athletes using them before weigh-ins [1–3, 12]. Similarly, Ranisavljev et al. [4] found that 85.2% of grapplers relied on dehydration and fluid restriction. Our findings also reveal a temporal shift, with the 2011–2020 period showing increased reliance on exercise, dietary restriction, fasting, and thermal techniques, possibly reflecting greater emphasis on body composition, the adoption of structured training programs, and improved access to sports science professionals in elite judo.

The greater use of fasting, food restriction, and thermal strategies in more recent decades also deserves physiological consideration. Although these approaches can be effective for achieving short-term weight targets, their repeated use may induce endocrine and metabolic disturbances that extend beyond the immediate competitive context. Recent reviews have highlighted that recurrent weight cycling may reduce resting metabolic rate and alter key hormonal signals involved in appetite regulation and energy balance, including insulin and leptin, while more aggressive energy restriction may also contribute to endocrine disruption and impaired anabolic balance [5, 33]. When combined with dehydration-based strategies, these responses may increase fatigue, worsen recovery quality, and potentially contribute to adverse long-term outcomes, including unfavorable body composition changes and elevated metabolic health risk after retirement (Miles-Chan and Isacco, 2021 [26]). In this context, the apparent shift toward more professionally guided practices should be viewed positively, but it does not eliminate the need to minimize the frequency and magnitude of repeated weight cycling.

The growing prevalence of caloric restriction and fasting, although effective for short-term weight loss, raises concerns about long-term health and performance when unsupervised. The continued, albeit low or possibly underreported, use of methods such as self-induced vomiting, laxatives, and diuretics shows little variation over time or across weight categories. The absence of significant interaction effects between competitive period and weight category suggests that weight-cutting practices have evolved similarly across divisions. Overall, the findings indicate a shift toward more systematic yet still risky weight-control strategies, underscoring the need for targeted educational and preventive measures in competitive judo.

Furthermore, the heatmaps and correspondence analysis conducted in this study provide a complementary visualization of the relationship between commonly used RWL methods and the figures who influence their adoption. While traditional figures such as coaches and doctors remain important, recent decades have seen a diversification of influential sources. In the most recent competitive periods, non-traditional influences, such as teammates or "other people", show greater proximity to weight-control practices. This suggests a shift in the guidance sought by judo athletes, reflecting broader acceptance of varied sources of advice and a more holistic approach to weight management in contemporary judo.

Future research should further explore the long-term physiological and metabolic consequences of repeated rapid weight loss cycles, as well as the effectiveness of educational and regulatory interventions aimed at promoting safer weight management practices. In addition, prospective studies are needed to better understand how evolving competition rules and professional support systems influence athlete behavior over time.

Conclusions

RWL remains a highly prevalent practice in competitive judo across decades. Although recent trends suggest a shift toward greater professional guidance and more structured approaches, weight cycling behaviors persist. These findings highlight the need for continued educational efforts and regulatory strategies to promote safer and more sustainable weight management practices among judo athletes.

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Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all participants prior to their participation in the study. Specifically, participants provided their consent before starting the questionnaire.

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