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Rapid weight loss strategies and performance impacts in powerlifting: A literature review

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Abstract
Rapid weight loss (RWL) is a prevalent strategy among power lifters aiming to gain competitive advantages by entering lower weight classes. Although widespread across weight-class sports, this practice presents significant risks and often undermines performance gains. Despite the potential for temporary competitive benefits, evidence suggests detrimental effects on athletes' performance capabilities. Research involving jockeys has shown that even a minimal RWL of only 2% body mass can significantly impair physical capabilities, with observed decreases in chest and leg strength (13.8% and 4.8%, respectively). Powerlifting lacks regulations, as seen in other sports, including NCAA wrestling or Olympic combat, which have implemented specific measures to mitigate risks associated with RWL. There is a need for guidelines and educational programs to safeguard athletes, advocating for research-driven policies to govern weight management practices effectively. The aim is to ensure that powerlifting remains a fair competition of strength rather than an unsafe contest to drop weight.

Keywords: Rapid weight loss, powerlifting, weight class sports, weight management strategies, performance impairment

1. Introduction
Powerlifting is a strength sport where competitors aim to achieve maximal lifts across three key events: The squat, bench press, and deadlift, as shown in Figure 1. Competitors are given three attempts per event to lift the highest weight possible, with the best lift in each category contributing to their total score. This total score is then used to rank athletes within their respective gender and weight class. The segmentation into weight classes is designed to align athletes with peers of similar body mass for a more equitable strength comparison. Therefore, weight categories in powerlifting are essential for maintaining competitive fairness by grouping athletes by body mass. This system encourages athletes to compete in a weight class where they believe they can perform most effectively, often leading to adopting RWL strategies [1]. These strategies raise important questions as athletes aim to qualify for a lower-weight category where athletes can leverage their strength against lighter competitors.

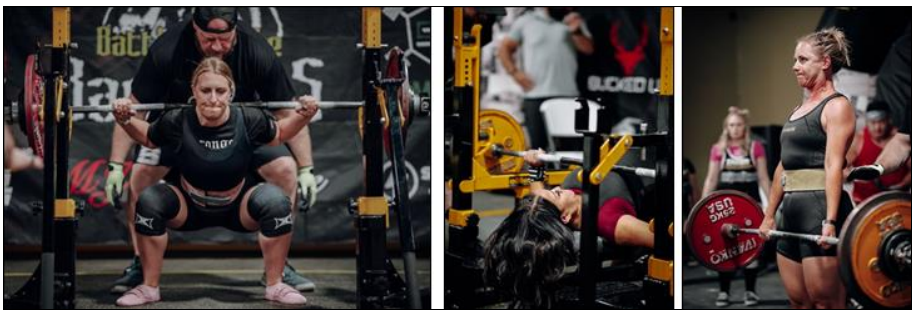

Fig 1: Squat, bench press, and deadlift events for the powerlifting competition held in Salt Lake City, Utah, US. Pictures courtesy of Strong Shots Strength Photography and with permission from those pictured

The practice of RWL is not unique to powerlifting. It is common across various weight-class sports such as judo, wrestling, taekwondo, karate, boxing, mixed martial arts (MMA), Olympic weightlifting, and non-combative sports, including horse racing [2-6]. Athletes engage in RWL for multiple reasons, including aligning with the sport's identity due to peer

pressure, adhering to traditional practices, conforming to cultural expectations, maintaining focus and commitment, staying competitive, and responding to encouragement from their coaches [7]. Often, these practices go beyond a desire to win competitions and persist due to a need for a more comprehensive understanding of their potentially adverse effects on performance and health.

2.1 Prevalence in Powerlifting

Rapid weight loss is a pervasive and culturally ingrained practice within the sport of powerlifting, and its prevalence is highlighted in various literature regardless of an athlete's gender, skill, or experience [8]. According to research from Campbell *et al*. [9], 97% of powerlifters engaged in RWL, highlighting its ubiquity across the sport. Further emphasizing this point, Kwan *et al*. [10] reported that 83% of world-class lifters engaged in weight-cutting before competitions. Moreover, significant participation rates were reported among both male and female athletes; 83% of male and 90% of female lifters have been documented using RWL techniques prior to competitions [8]. Notably, with research showing that female athletes participate in RWL more than male athletes. This widespread adoption is supported by the finding that RWL practices are equally prevalent among athletes at different tiers of competitive success, including those with lower Wilks scores, indicating that the necessity to cut weight is a universal aspect of the sport, not just confined to the elite's caliber [8].

2.2 RWL Strategies

Powerlifting athletes adopt a variety of RWL strategies to meet weight class requirements before competitions. Research highlights that water loading followed by stringent fluid restriction is the most commonly used method, where athletes dramatically increase their water intake for 5-7 days and then eliminate water entirely the day before weighing in [8-10]. This tactic is widely utilized among powerlifters alongside other common strategies such as reducing fiber intake to modify gut contents, increasing physical activity, and fasting to achieve quick weight reduction.

Research suggests powerlifters sometimes resort to more extreme methods similar to those found in combat sports. These include using saunas, wearing rubber suits, and applying diuretics and laxatives to shed weight rapidly [10]. Such aggressive practices, though less researched in powerlifting compared to combat sports, where they are well-documented [3, 11], are known to pose significant risks. The health risks and even fatalities associated with these severe weight-loss tactics in combat sports suggest the need for additional research and stricter regulations in powerlifting [12].

The extent of RWL is essential to consider as more weight loss may have a higher risk on performance. This decision can be influenced primarily by factors such as the weigh-in schedule, the athlete's experience, gender, and initial body mass. Research from Nolan *et al*. [8] suggests that male powerlifters typically lose about 3.0±1.8% of body mass, whereas female lifters lose around 3.1±2.1%. Notably, the most extreme losses reported reach up to 4.9±2.4% for males and 5.4±3.1% for females. A more significant body mass loss among females aligns with research from Campbell *et al*. [9], where regional competitors reported higher typical losses compared to their international counterparts (5.5% vs. 3.3%, respectively). The difference highlights the pressures and strategic decisions athletes face, especially as different genders and different competition levels. A limitation of these studies was that most participants had only a 2-hour recovery period after weighing in. Athletes may have been less likely to cut more weight during a 24-hour recovery period. With many powerlifting federations following a longer, 24-hour recovery protocol for competitions, it would be useful to examine longer weigh-in times, as we may expect RWL percentages of body mass lost to be higher.

In other weight class sports, MMA, athletes often undertake reductions amounting to approximately 10% of their body mass, while 57% of taekwondo competitors have reported losing more than 5% of their body weight before competitions [5, 13]. Among judo participants, some extreme documented cases involve athletes losing up to 15% of body mass, which can present serious health risks [3]. These reductions have been associated with severe health and performance implications, including mortality (6.7% to 10%) [3]. With further research into powerlifting, we might expect to document more extreme RWL cases, similar to those found in other more extensively studied sports.

2.3 Performance Impacts

Research has demonstrated that RWL can have a profound negative impact on sport-specific skills, performance, and abilities [14, 15]. For example, evidence states that RWL protocols leading to a 3% body mass reduction can significantly reduce neuromuscular performance in both short and long contractions. Among competitive boxers in a controlled experimental study, maximal force production was lower by as much as 12%, voluntary activation diminished by 7%, time to exhaustion during sustained contractions shortened by 16 seconds, and peak lactate production lowered by 53% [16]. Such reductions support the various adverse impacts that RWL may have on select performance outcomes [17].

Further, in a randomized crossover study involving Great Britain male licensed jockeys, RWL of just 2% body mass, achieved through 45 minutes of moderate-intensity exercise in a sweatsuit, was observed to reduce physical performance metrics significantly. Post-RWL measurements revealed a decrease in chest strength by 13.8%, leg strength by 4.8%, and simulated riding performance, assessed by pushing frequency on a mechanical horse simulator, by 2.8% compared to controls wearing regular gym attire where euhydration was maintained. These findings support that even with smaller amounts of body weight lost, and potentially regardless of the specific RWL strategy employed, the rapid and aggressive weight reduction typically within a week can lead to negative performance effects [11].

Additionally, RWL has been linked to significant decrements in balance performance and reaction time. Specifically, athletes subjected to a rapid weight loss protocol of more than 3% body mass reduction within one week of competition exhibited marked decreases in balance, as measured by ellipse area, mean mediolateral velocity, and mean anteroposterior velocity, and slower reaction times as assessed on a contact platform [18]. These changes were noted both one week prior to and immediately following the official weigh-in. Notably, these decrements occurred without any observed changes in isometric strength, including hand grip and trunk traction strength. However,

posttest assessments were conducted immediately after the official weigh-in rather than just before the competition. Some studies have also suggested minimal or no significant effects on strength and power performance with up to a 5% reduction of body mass with RWL [19]. Yet, these findings are limited by the variability of RWL practices and methodologies across studies, and some studies are excluded due to quality concerns or incomplete data, which could skew the overall understanding of RWL impacts.

Adding to this body of knowledge, a study among elite Congolese judoists demonstrated significant impairments due to RWL, including oxidative stress, electrolyte imbalance, hormonal changes, and glycogen depletion. These physiological shifts were associated with a marked increase in energy expenditure and declines in judo performance, as evidenced by a reduced number of uchi-komi and lower heights of uke's center of gravity during throws [20]. Such impairments have been directly associated with decreased oxygen consumption, aerobic and anaerobic capacity, and targeted sport-specific performance of combat sports athletes. Therefore, the authors of this study have recommended the development of personalized long-term weight loss plans in conjunction with federations enforcing stricter regulations on weight-cutting practices.

Further, research involving elite judo athletes demonstrated that a combination of gradual and RWL strategies can impair physical performance and psychological state, although the performance of judo movements over 5-second durations remains unaffected [21]. Adding to this discussion, a study among amateur boxers highlighted similar concerns where participants experienced significant mood disturbances and performance decrements after undergoing RWL [22]. Boxers lost an average of 5.16% body weight through restrictive fluid and food intake, resulting in increased anger, fatigue, tension, and reduced vigor, alongside poorer performance in circuit training sessions, demonstrating the pervasive negative impact of RWL strategies across different sports disciplines.

Moreover, research with elite wrestlers showed that a 5% RWL negatively affected the fatigue index, further having the potential to impact anaerobic performance [23]. Adding to fatigue and reduced energy, in a study examining elite judokas (N=138), participants reported an average body mass loss of 5.8±2.3% [24]. Notably, 91% of these athletes experienced a significant drop in energy, underscoring the adverse effects of RWL. It is also worth noting that 21% of the respondents encountered severe episodes of collapse during the period of weight reduction.

Impaired performance after cutting weight may not be as surprising when athletes participating in RWL have been considered "significantly dehydrated" (39% of participants) and presented with a Usg of >1.021 immediately before the competition, indicating significant dehydration, even after a 22-hour rehydrating period [14]. A Usg value > 1.021 is associated with significant dehydration [25]. Within the same study, only 23% of the participants could be considered "well" hydrated (Usg < 1.010) after recovery protocols. Findings are significant to consider, as competing in a dehydrated state may negatively impact performance and increase the risk of an adverse health event.

2.4 Health Impacts and RWL Regulations

Athletes who engage in RWL can present notable health risks, including symptoms like headache, nausea, and disorientation, alongside psychological stresses such as fatigue, anger, and anxiety, as documented in various studies [10, 11]. More concerning are dehydration effects, a common result of RWL. Studies indicate that competing in a dehydrated state can severely impair performance and elevate the risk of serious health events, with documented instances where severe dehydration led to mortality in sports [26, 27]. Despite these risks, the lack of stringent regulations in powerlifting around RWL practices contrasts with other sports. For example, NCAA wrestling has implemented specific bans on hazardous weight-cutting practices and dehydration methods, and organizations like ONE Championship and UFC have made significant rule changes to enhance athlete safety [9, 12]. This discrepancy highlights a critical gap in powerlifting governance, supporting the need for enhanced research and, potentially, regulatory measures to safeguard athlete health and ensure fair competition practices.

3. Discussion

Research across various sports consistently shows that RWL can have performance impacts even down to only 2% of body mass lost within the week before the competition [28]. Even with rehydrating methods, many athletes are still competing in a dehydrated state, which can increase the risk of unwanted events [14]. Such impacts include impaired strength, maximal strength, and high-intensity performance capabilities and significant reductions in maximal force production, directly correlating with decreases in athletes' abilities to perform [16, 17, 28]. Given these findings, it is reasonable to hypothesize that RWL could similarly affect powerlifters, potentially compromising their main lift events.

Despite comprehensive documentation of RWL's effects in various sports, focused research on powerlifting remains scarce. Understanding how RWL influences specific outcomes like squat, bench press, and deadlift performance is crucial, given the sport's emphasis on maximal strength outputs. Considering the rapid nature of powerlifting movements, which typically take only seconds to complete, comparisons can be drawn with findings from other sports involving short-duration efforts. For instance, drawing from research by Koral *et al.* [21] on elite judo athletes found that a combination of gradual and RWL strategies can impair physical performance and psychological state and the performance of judo movements under 5-second durations. This suggests that for powerlifting, where lifts are executed in brief, intense bursts, performance might be hindered from RWL. Further, Türkyılmaz and Yarar's [23] recent research with elite wrestlers showed that a 5% RWL, a common percentage for body mass lost in powerlifting, negatively affected the fatigue index, in addition to research from Štangar *et al.* [24] demonstrating reduced energy impacts, could imply similar consequences for powerlifters. This could affect powerlifters' ability to sustain performance across multiple attempts and lift events in a competition.

A detailed summary of how RWL impacts performance across different sports, with potential relevance to powerlifting, is compiled in Table 1. This table provides a comprehensive overview, collating data from multiple studies to illustrate how RWL strategies affect key performance metrics across athletic disciplines.

Table 1: Impact of Rapid Weight Loss (RWL) on Sports Performance

Study Reference	Sample Studied	RWL Strategy	Performance-related Outcomes	Key Findings
Zubac, 2019	Elite Olympic-style Boxers (N=9)	RWL (3%)	Maximal force production, voluntary activation, time to exhaustion during sustained contraction, peak lactate concentration.	Significantly decreased maximal force production by 12%, reduced voluntary activation by 7%, shortened time to exhaustion during sustained contractions by 16 s, and reduced peak lactate production by 53%
Hall, 2001	Amateur Boxers (N=16)	Various RWL	Performance, mood.	Negative impact on performance; increased anger, fatigue, and tension, and reduced vigor.
Wilson, 2014	Jockey Athletes (N=8)	RWL (2%)	Maximal chest and leg strength, simulated riding performance (pushing frequency), simple reaction time	Decreased chest strength by 13.8%, leg strength by 4.8%, and simulated riding performance by 2.8%.
Morales, 2018	Elite Judo Athletes (N=38)	RWL (3%)	Balance (ellipse area, mean mediolateral velocity, mean anteroposterior velocity), reaction time, and isometric strength (hand grip and trunk traction strength	Significant decreases in balance and reaction time, with no change in strength.
Mauricio, 2022	Olympic Combat Sport Athletes	Various RWL	Strength and power.	No significant effects observed up to 5% body mass loss, with limitations noted in study methodologies.
Yang, 2017	Congolese judoists (N=21)	Various RWL	Oxidative stress, electrolyte imbalance, hormonal changes, glycogen depletion, blood flow changes, plasma volume decrease, red blood cell deformability and aggregation, nitric oxide generation impairment, PAI-1 levels, oxygen consumption, aerobic and anaerobic capacity, muscle strength, psychological concentration, sport-specific performance.	Related impairments included impaired oxygen consumption, aerobic and anaerobic capacity, muscle strength, psychological concentration and targeted sport-specific performance of combat sports athletes.
Koral, 2009	Elite Judo Athletes (N=20)	Combination of gradual and RWL	Judo movement repetitions, mood states.	Combination can impair physical performance and psychological state in elite judo athletes, but performance of judo movements over 5 seconds remains unaffected.
Türkyılmaz, 2023	Elite Wrestlers (N=10)	RWL (5%)	Anaerobic performance, reaction time.	Negatively affected the fatigue index.
Štangar, 2022	Elite Judokas (N=138)	RWL 5.8 ± 2.3%	Consequences of RWL and RWG.	Negative consequences including reduced energy, 21% collapsing during RWL period

In strength sports, research has shown that female athletes often exhibit higher maximum weight losses before competition compared to their male counterparts [7, 9]. This trend may be influenced by the natural weight fluctuations that women experience due to menstrual cycles, making them potentially more vulnerable to the effects of aggressive weight loss strategies [29]. Consequently, these factors could predispose female athletes to more pronounced performance detriments related to rapid weight loss practices.

3.1 Practical application

Practical applications within powerlifting, particularly concerning RWL, necessitate a focused approach to safeguard health while supporting the performance of athletes. Despite its known risks, the pervasive culture of RWL in powerlifting calls for immediate and effective interventions. Educational programs are crucial in order to achieve this goal. As research from Nolan *et al.* [8] suggested that coaches and online resources are very influential in RWL practices among powerlifting athletes, these should be developed and endorsed by national powerlifting committees to enhance awareness among coaches, trainers, and athletes about the risks of extreme RWL and the availability of healthier alternatives. Similarly, in other weight-class sports, coaches, and trainers are primary influencers, often encouraging athletes to cut weight before competitions, highlighting the need for comprehensive education and policy enforcement across all levels [30, 31]. Such educational efforts are imperative for shifting the sport's current norms and practices surrounding weight-cutting.

Further, regulatory reforms should be considered to discourage harmful weight loss practices. Drawing on successful models from other sports, such as the NCAA's approach to controlling weight cutting among wrestlers, powerlifting organizations could implement similar measures. These might include mandatory hydration assessments before competitions and stricter weight reduction and recovery practices guidelines. Moreover, continuous feedback and monitoring mechanisms should be established to provide athletes and coaches real-time data on hydration status and body mass changes. This approach will aid in making informed decisions that align with long-term health and optimal performance.

Finally, there is a significant need for further research to develop new, safe protocols for achieving competition weight goals, with an emphasis on female athletes understanding that they may be at greater performance risks. The existing research on weight cutting in powerlifting reveals several limitations supporting this need [8-10]. Current research primarily relies on self-reported data, which introduces potential biases such as recall inaccuracies and subjective interpretations. Further, the cross-sectional nature of most research limits the ability to establish causality. Additionally, there is a lack of directly measuring the impact of these practices on performance outcomes, meaning we do not understand the full scope of the impacts of rapid weight loss in powerlifting. These issues highlight the need for more robust research to understand the implications of weight-cutting practices in powerlifting. This research should explore the psychological reasons behind weight cutting and the physiological impacts of various RWL strategies and tailor interventions to powerlifters' unique needs. Such measures will deepen the understanding behind these decisions, safeguard athletes' health, and enhance the integrity and fairness of competitions.

4. Conclusion

The widespread adoption of RWL techniques in powerlifting, paired with the performance impacts in the literature, supports the pressing need for more research and

comprehensive educational and regulatory interventions. Recognizing the extensive use of RWL by athletes across various levels, from amateurs to world-class competitors, it becomes evident that educational initiatives are crucial. Further, it appears that women may be participating in RWL more often than men, and losing more body mass during the week before competition. Therefore, these interventions should target athletes, emphasizing women, coaches, and trainers, informing them of the dangers associated with extreme weight loss practices, and promoting safer, more sustainable methods.

Further, the absence of stringent regulations in powerlifting contrasts sharply with measures taken in other sports, where rules have been implemented to protect athlete health and maintain fair competition standards. Drawing on successful regulatory frameworks from other sports and organizations, powerlifting could benefit from similar interventions.

The sport's governing bodies are urged to collaborate with health professionals and researchers to develop guidelines informed by scientific evidence, focusing on the health impacts and performance implications of RWL. Given the high prevalence of RWL before powerlifting competitions and possible performance risks, we need research to examine the effects. Future research should aim to fill the current gaps in our understanding of how RWL affects powerlifting performance, aiming to foster a safer competitive environment. This approach enhances athlete welfare and preserves the sport's integrity, ensuring that powerlifting remains a test of strength, skill, and strategy rather than a harmful weight manipulation contest.

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