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Effects of Additional Exercise Volume on Weight Loss, Oxidative Stress, and Inflammation in Young Wrestling Athletes

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A B S T R A C T

Background: Maintaining an optimal weight is essential for wrestlers, given their competition in weight-classified categories. However, many wrestlers resort to unhealthy methods of rapid weight loss, such as drastic caloric restriction and dehydration, which can adversely affect their overall wellbeing.
Objective: This study aimed to examine the impact of a two-week increase in exercise volume on weight loss, serum oxidative stress, and inflammation in young wrestlers.
Methods and Materials: Twenty wrestlers (aged 15-19, weight 63.47 kg) participated in a 2-week exercise intervention in addition to their regular weekly wrestling drills. The intervention consisted of resistance training, high-intensity interval training, and speed training. Wrestlers weighed daily over 2-week span. The participants' superoxide dismutase (SOD), malondialdehyde (MDA), total antioxidant capacity (TAC), and serum interleukin-6 (IL-6) were measured both before and after the intervention. Data were analyzed using the paired t-test conducted through SPSS software, with a significant level set at $p < 0.05$.
Results: The 2-week intervention resulted in significant weight loss ($p<0.001$). Within group comparisons found serum levels of IL-6, SOD, and TAC significantly increased from pre-to-post testing, but MDA did not change significantly.
Conclusion: In conclusion, the present study demonstrates that a two-week increase in exercise volume can be an effective strategy for promoting weight loss and reducing oxidative stress in young wrestlers. The findings suggest that the improvement in antioxidant status is likely a result of the body's response to increased inflammation, as indicated by changes in inflammatory markers.

Keywords: *Wrestlers, Additional Exercise Volume, weight loss, inflammation, oxidative stress.*

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1. Introduction

For athletes in weight-sensitive sports, maintaining proper weight is essential to optimize performance and maintain overall health (1, 2). In sports like wrestling, competitors are divided into weight classes, and making the desired weight category is crucial for competitive success (3). However, many wrestlers engage in rapid weight loss practices, such as severe calorie restriction, dehydration, and excessive exercise, which can have detrimental effects on their physical and mental well-being (3). Research indicates a strong correlation between rapid weight loss methods and significant adverse effects, including physiological, hormonal, psychological, and nutritional consequences. Physiological consequences include muscle loss and impaired cardiovascular function, and increased risk of injuries (4); while hormonal disruptions can lead to long-term health issues (5). Severe calorie restriction can also result in nutritional deficiencies, compromising health and performance (6). Additionally, these practices can disrupt the body's natural hormonal balance and metabolic processes, leading to long-term health consequences (7). Moreover, repeated cycles of weight loss and regain, known as "weight cycling," have been linked to an increased risk of eating disorders, body image issues, and psychological distress (8). In addition, rapid weight loss may exacerbate oxidative stress and inflammation, potentially compromising wrestlers health and performance (9) a state where free radicals overwhelm the body's antioxidant defenses, potentially damaging cells and tissues (10). This can be caused by nutrient deficiencies from restrictive diets and dehydration, a common weight-loss practice among wrestlers (11). Moreover, rapid weight loss triggers inflammation, a natural response that becomes problematic when excessive (11, 12). Muscle breakdown from rapid weight loss and gut microbiome disruption from restrictive diets are potential mechanisms for this inflammation. The combined effects of oxidative stress and inflammation create a vicious cycle, further compromising health and performance. Therefore, athletes and coaches should prioritize healthy weight management strategies that focus on long-term health and performance optimization (10). To mitigate these negative consequences, athletes in weight-sensitive sports should adopt a gradual and sustainable approach to weight management (13). Recent studies have shifted attention towards combining short-term weight loss with increased physical activity levels (14). This includes following a balanced diet, engaging in regular physical activity, and seeking guidance from qualified professionals, such as sports nutritionists and psychologists (15).. While calorie restriction alone can result in the loss of both fat and lean body mass, physical activity, particularly resistance training, helps preserve and increase lean body mass during weight loss (16). Physical activity increases energy expenditure, creating the necessary calorie deficit for weight loss (14). Also, regular exercise, combined with a controlled calorie intake, leads to a negative energy balance, where the body burns more calories than it consumes, leading to weight loss over time (17). This process is further facilitated by an increased metabolic rate associated with physical activity, which continues to burn calories even after exercise cessation (18). Maintaining or increasing lean body mass is important as it contributes to a higher resting metabolic rate, aiding in sustaining weight loss over the long term (19). Totally, proper weight maintenance not only enhances athletic performance but also promotes overall physical and mental well-being, reducing the risk of long-term health complications (6) This approach helps wrestlers to maintain a healthy weight and optimizes athletic performance while minimizing potential health risks.

On the other hand, even this combined approach may have drawbacks (20) (21), including muscle loss (which can result in compromising strength and performance) (22), and hormonal disruptions (which can cause reductions in testosterone, IGF-1, and thyroid hormones), particularly when coupled with severe calorie restriction (4). In addition, increasing training volume, which can lead to overtraining, may have significant effects on oxidative stress and inflammation. Research indicates that excessive exercise can result in an imbalance between reactive oxygen species (ROS) production and antioxidant defense mechanisms, leading to oxidative stress (23). This imbalance can trigger inflammatory responses in the body, contributing to tissue damage and impairments in physiological functions (24). Moreover, overtraining-induced oxidative stress can impact mitochondrial function and increase the production of pro-inflammatory cytokines, exacerbating inflammation (25). Therefore, it is crucial to consider the potential negative impact of excessive training volume on oxidative stress and inflammation to prevent detrimental effects on athletes' health and performance. However, the interplay between weight loss strategies, physical activity, and their impact on inflammatory and oxidative stress markers in adolescent wrestlers has not been extensively studied. The existing research on caloric restriction and exercise has primarily focused on more on the negative effects of rapid weight loss on performance, physiology, and psychology in wrestlers(26-28). It is important to recognize that the physiological responses and adaptations of adolescents may differ significantly from those of adults. Therefore, specific investigations tailored to this age group are necessary. Additionally, the unique demands and stressors faced by wrestlers during weight loss periods may influence the effectiveness of caloric restriction and exercise interventions. Addressing these research gaps is crucial for developing evidence-based strategies to support the health and performance of adolescent wrestlers during weight loss. This study aims to contribute valuable insights that can guide safe and effective weight management practices for this unique athletic population.

2. Materials and Methods

2.1 Participants

Twenty adolescent male wrestlers aged 15 to 19 years from Soltanieh city were recruited for this quasi-experimental study with a pre-test and post-test design. Participants voluntarily provided their medical history and personal information by completing medical history (29) and food frequency (30) questionnaires after agreeing to participate and providing informed consent (parental/guardian consent was obtained for participants under 18 years old). Convenience and purposive sampling methods were employed for participant selection. The inclusion criteria were as follows:

- Adolescent wrestlers aged 15 to 19 years
- Residents of Soltanieh city
- Willingness to participate and provide informed consent
- No history of chronic diseases, metabolic disorders, or conditions that may affect the study outcomes
- No current use of medications or supplements that could interfere with the study interventions or measurements
- Meeting the required body fat percentage range for randomization into intervention groups

Exclusion criteria included withdrawal of consent, non-compliance with the study protocol, development of medical conditions or adverse events, significant changes in lifestyle factors, missing assessments or measurements, and other circumstances deemed appropriate by the researchers.

2.2 Study Design and Protocols

Baseline assessments were conducted, including anthropometric measurements of stature and one-repetition maximum (1RM) strength assessment. Dietary intake was evaluated using a validated 168-item food frequency questionnaire, which informed the development of individualized meal plans for the intervention period.

2.2.1 Diet

Participants were instructed to maintain their food plan from the last two weeks during the training protocol.

2.2.2 Exercise Intervention

Participants underwent a two-week structured exercise intervention, consisting of wrestling drills, resistance training, high-intensity interval training (HIIT), and speed training, in addition to their regular weekly wrestling drills. The exercise program was implemented with specific training sessions on Saturdays, Mondays, and Wednesdays, and one rest day per week (Fridays).

Wrestling drills, including technical exercises and movements, were performed three days per week (Sundays, Tuesdays, and Thursdays).

2.2.2.1 Resistance Training

Resistance training was conducted once a week and incorporated various exercises such as squats, bench press, standing shoulder press, leg extensions, and weightlifting movements. The training followed a circuit format with five stations, allowing one minute of rest between stations and three minutes between circuits. Participants performed 15 repetitions at each station. The exercises were organized as follows: station one - bench press, station two - leg extensions, station three - standing shoulder press, station four - squats, and station five - weightlifting. The training intensity was carefully modulated, starting at 50% of one-repetition maximum (1RM) in the first week and progressing to 55% of 1RM in the second week (31).

2.2.2.2 High-Intensity Interval Training (HIIT)

High-intensity interval training (HIIT) was included into the exercise program once a week. In the first week, participants performed two sets of four 35-meter sprints at maximum effort, with a brief rest period of 10 seconds between each sprint. The HIIT routine was progressed in the second week, consisting of two sets of five 35-meter sprints at maximum effort, maintaining the same rest interval of 10 seconds between sprints.

- **Speed training** was implemented once a week as part of the exercise regimen. During the first week, participants performed two sets of four 50-meter sprints, with a rest interval of 15 seconds between each sprint and two to three minutes of rest between sets. In the second week, the routine was progressed to two sets of five 50-meter sprints, maintaining the same rest intervals. Each speed training session included a 10-minute warm-up and cool-down period, ensuring proper preparation and recovery for the participants (32).

2.3 *Blood Sampling*

Participants refrained from physical activity during the pre-test and post-test phases. Blood samples were collected 48 hours after the final exercise session, following a 12-hour overnight fast. Venous blood was drawn, centrifuged, and the serum was stored at -20°C until laboratory analysis.

Post-intervention assessments, identical to baseline testing, were carried out 48 hours after the final exercise session to allow for acute physiological normalization.

2.4 *Kits and Laboratory Analysis*

Interleukin-6 (IL-6) levels were measured in serum samples using human enzyme-linked immunosorbent assay (ELISA) kits from DuoSet® ELISA DEVELOPMENT SYSTEM (China). Superoxide dismutase (SOD), malondialdehyde (MDA), and total antioxidant capacity (TAC) levels were quantified using human ELISA kits from Randox (England).

2.5 *Statistical Analysis*

Data normality was assessed using the Shapiro-Wilk test. Paired t-tests were performed to compare pre-test and post-test groups. Statistical analyses were conducted using IBM SPSS version 26 software, with statistical significance set at $p < 0.05$. Figures were generated using Microsoft Excel 2016.

3. Results

Table 1 shows the demographic characteristics of the participants

Table 1. Participant demographic characteristics.

Variable Groups	age (years)	height (cm)	weight (kg)	BMI(kg/m2)
exercise + Caloric restriction	15.50±1.84	168.20±9.78	61.57±19.00	22.48±5.20

Table 2. Inflammatory and Oxidative Stress Markers and weight in Pre-Post test

Groups	Variable	Mean±SD	
		Pretest	Posttest
Physical exercise + Caloric restriction(PE+CR)	(pg/ml)IL-6	23.92±47.12	52.78±132.07
	(u/ml)SOD	107.79±1246.00	121.94±1337.02
	(mmol/L) TAC	0.29±1.48	0.19± .1.47
	MDA(Nmol/ml)	0.10±1.59	0.19±1.64
	Weight(Kg)	14.72±63.46	10.86±59.43

Table 3 presents the results of the dependent t-test, showcasing the changes in inflammatory and oxidative stress markers, as well as weight, between the pre-test and post-test interventions.

The results revealed that the two-week exercise program had significant effects on multiple parameters in young wrestlers. Specifically, from pre-test to post-test, there was a significant decrease in weight ($p = 0.026$) (Figure 1-E), indicating successful weight management. Additionally, serum interleukin-6 (IL-6) levels significantly increased ($p = 0.001$) (Figure 1-A), Superoxide dismutase (SOD) levels also exhibited a significant upward trend ($p = 0.032$) (Figure 1-B). Furthermore, total antioxidant capacity (TAC) levels significantly rose ($p = 0.004$) (Figure 1-C).

However, there was no significant change in malondialdehyde (MDA) levels, from pre-test to post-test (P=696) (Figure 1-D).

Table 3. The results of the dependent t-test of Changes Inflammatory and Oxidative Stress Markers and weight

Variable	t	Df	Sig
IL-6 (pg/ml)	-5.68	19	0.001
SOD (u/ml)	-2.31	19	0.032
TAC (mmol/L)	-3.26	19	0.004
MDA (Nmol/m)	-0.39	19	0.696
Weight (Kg)	2.40	19	0.026

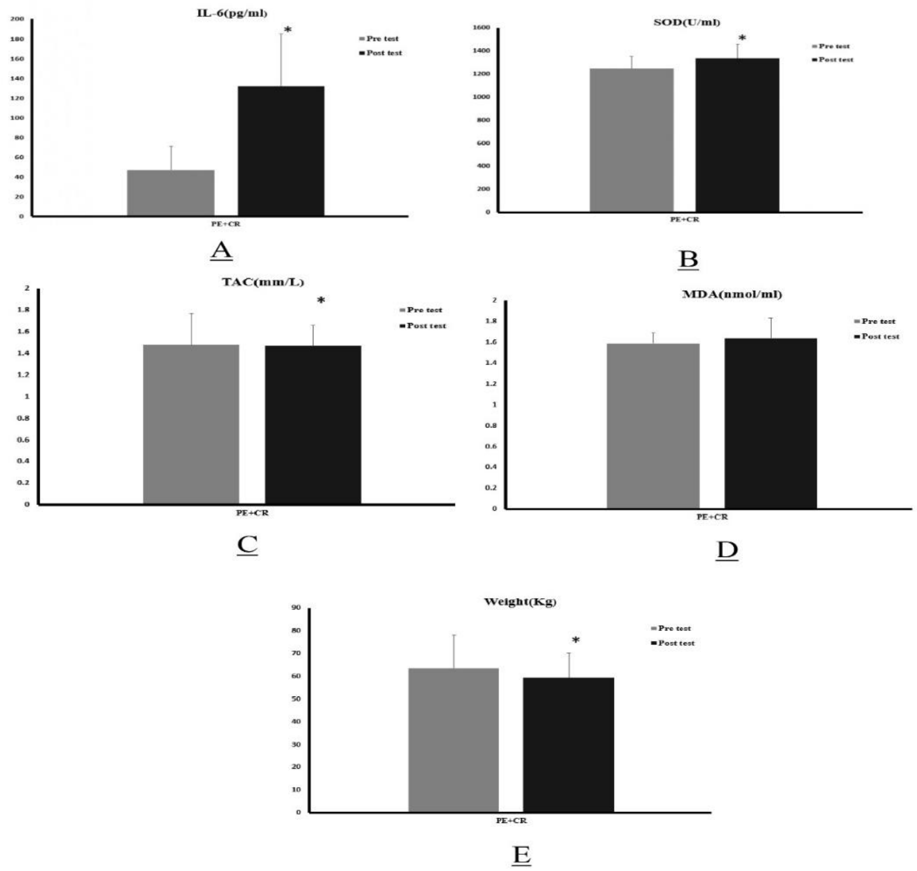

Figure 1. Pre-test and post-test changes in IL-6 (A), SOD (B), TAC (C), MDA (D), and Weight Loss (E), *: p<0.05

4. Discussion

The present study aimed to investigate the Effects of Additional Exercise Volume on Weight Loss, Oxidative Stress, and Inflammation in Young Wrestling Athletes. The key findings of this study were that a two-week intervention involving increased exercise volume led to significant weight loss in young wrestlers aged 15-19 years old. Specifically, the wrestlers who participated in the added resistance training, high-intensity interval training, and speed training in addition to their regular wrestling drills over a two-week period experienced a statistically significant reduction in body weight. In terms of the physiological markers assessed, the results showed that serum levels of superoxide dismutase (SOD), an antioxidant enzyme, significantly increased from pre- to post-intervention. Additionally, total antioxidant capacity (TAC) also exhibited a significant increase, indicating an overall improvement in antioxidant status after the two-week exercise program. However, malondialdehyde (MDA), a marker of oxidative stress, did not change significantly. These results align with some previous studies while contradicting others. The weight loss finding is supported by a meta-analysis by Vissers et al. (2013), which showed that combining aerobic and resistance training was more effective for weight loss and fat mass reduction compared to either modality alone (33). The increase in antioxidant enzymes and TAC is consistent with the work of Gomez-Cabrera et al. (2008), who reported upregulation of antioxidant genes and increased antioxidant enzyme activities in response to moderate exercise training (34). Additionally, the increase in IL-6 levels after the intervention corroborates the findings of Nehlsen-Cannarella et al. (1997), who observed a significant increase in IL-6 following prolonged running exercise (35). On the other hand, the lack of a significant change in MDA levels contradicts the findings of Bloomer et al. (2005), who reported a significant increase in MDA after acute aerobic and anaerobic exercise (36). Furthermore, while our study showed an increase in IL-6, some studies, such as Petersen and Pedersen (2005), have suggested that regular exercise can have an anti-inflammatory effect and reduce systemic inflammation, which is inconsistent with our findings (37). The significant weight loss observed in the wrestlers can be attributed to the increased energy expenditure resulting from the added exercise volume. The combination of resistance training, high-intensity interval training, and speed training likely created a substantial caloric deficit, leading to a reduction in body weight over the two-week period (38-40). The increase in antioxidant enzymes like SOD and the overall improvement in TAC can be interpreted as the body's adaptive response to the increased oxidative stress induced by the exercise intervention. During exercise, the production of reactive oxygen species (ROS) increases, and the body's antioxidant defense system is activated to counteract the potential harmful effects of these ROS (34, 41, 42). The observed increase in antioxidant capacity may have helped mitigate oxidative damage and maintain cellular homeostasis. The lack of significant change in MDA levels despite the increased exercise volume aligns with previous research. Michailidis et al. reported that although intense exercise induced oxidative stress, MDA levels did not change significantly in well-trained individuals (43). Similarly, Bloomer et al. observed that while acute aerobic and anaerobic exercise increased other oxidative stress markers, MDA levels remained unchanged (36).These findings suggest that MDA might not be the most sensitive marker of exercise-induced oxidative stress, and other markers like protein carbonyls or catalase activity may be more responsive to the acute effects of exercise. The elevated levels of IL-6 after the intervention suggest that the increased exercise volume triggered an inflammatory response in the wrestlers' bodies. Exercise, particularly intense or prolonged exercise, can induce inflammation as a normal physiological response to muscle damage and metabolic stress (35, 37). The observed increase in IL-6 could be a transient response to the added exercise stimulus, potentially contributing to muscle repair and adaptation processes (44). Regarding the increase in IL-6 and its potential relationship with the observed increase in antioxidants, Pedersen and Febbraio proposed that IL-6 released from contracting skeletal muscles during exercise could act as a "myokine" and mediate metabolic and anti-inflammatory effects (44). Furthermore, Ropelle et al. demonstrated that IL-6 infusion in rats increased the expression of antioxidant enzymes like superoxide dismutase and catalase in skeletal muscle, suggesting that IL-6 could play a role in regulating antioxidant defenses (45). Based on these findings, the increase in IL-6 observed in the present study could potentially mediate the upregulation of antioxidant enzymes like SOD and contribute to the overall improvement in antioxidant capacity, acting as a protective mechanism against exercise-induced oxidative stress. In conclusion, while MDA did not exhibit a significant change, the increase in IL-6 levels could provide a plausible explanation for the observed enhancement in antioxidant capacity in the young wrestlers following the two-week exercise intervention.

By interpreting these findings together, it appears that the two-week exercise intervention challenged the wrestlers' bodies, leading to adaptations in weight loss, antioxidant capacity, and inflammatory responses. These physiological changes may have implications for the young wrestlers' performance, recovery, and overall health during periods of increased training or competition (46, 47). The inconsistency in results could be related to the timing of measurements, for example MDA may peak at different time points depending on the exercise intensity and duration (48). Gender differences may also play a role, as studies have shown variations in oxidative stress responses between males and females (36). Additionally, the specific exercise protocol employed in our study, combining resistance training, high-intensity interval training, and speed training, may have elicited a different physiological response compared to other exercise modalities investigated in previous studies (40). Variations in nutritional status and dietary antioxidant intake could also influence antioxidant capacity and oxidative stress markers (49). Furthermore, the increase in IL-6 levels observed in our study may be a transient response to the acute exercise stimulus, while the anti-inflammatory effects reported in other studies could be a result of chronic exercise adaptations (44). In addition, the research was constrained by time limitations such as Covide-19 pandemic. A 2-week training program was deemed feasible given the time constraints and other commitments of the student-athlete participants. The relatively short intervention period may have limited the magnitude of physiological and performance changes observed but permitted an initial investigation of the effects of interest within the practical constraints of the research design. Going forward, longer training periods should be considered to maximize the likelihood of beneficial adaptations and performance gains. On the other hand, the study involved a relatively small sample size of 20 wrestlers aged 15-19 years. A larger and more diverse sample could have provided more generalizable results.

5. Conclusion

The study found that a two-week intervention involving increased exercise volume through resistance training, high-intensity interval training, and speed training was an effective strategy for promoting significant weight loss in young wrestlers aged 15-19 years. Additionally, the intervention led to improvements in antioxidant capacity, evidenced by increased serum levels of superoxide dismutase (SOD) and total antioxidant capacity (TAC), likely as an adaptive response to exercise-induced oxidative stress. Interestingly, while the oxidative stress marker malondialdehyde (MDA) did not change, the inflammatory marker interleukin-6 (IL-6) increased significantly, suggesting a transient inflammatory response potentially contributing to muscle repair and adaptation processes. The observed improvement in antioxidant status appears to be a result of the body's response to the increased inflammation induced by the exercise intervention. Despite limitations like a small sample size, the study provides insights into the benefits of increased exercise volume for weight loss and modulating antioxidant and inflammatory responses in young wrestlers, warranting further research to expand on these findings.

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Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

R.K. conceptualized the study, designed the research methodology, and supervised the implementation of the exercise intervention. A.R., the corresponding author, conducted the data analysis using SPSS, interpreted the results, and led the drafting and revising of the manuscript. A.G. assisted in the development of the exercise intervention protocol, supported participant recruitment, and contributed to data collection. E.S.E. facilitated the biochemical measurements and assisted in the analysis of oxidative stress and inflammatory markers. A.S. helped with the literature review, data entry, and manuscript preparation. All authors participated in discussing the findings, critically reviewed the manuscript for important intellectual content, and approved the final version for publication.

Data Availability Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Ethical Considerations

Informed consent was obtained from all individual participants included in the study.

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