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BODY COMPOSITION, CARDIOPULMONARY FITNESS, AND DIETARY PRACTICES IN ELITE ALBANIAN BOXERS: A COMPREHENSIVE ANALYSIS FOR PERFORMANCE OPTIMIZATION

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Abstract

This study, led by Marsida Bushati with contributions from Sead Bushati, investigated body composition, cardiorespiratory fitness, and dietary habits in 24 elite male Albanian boxers across various weight classes. Using air displacement plethysmography (BOD POD GS-X), cardiopulmonary exercise testing (CPET), and a validated 15-item dietary questionnaire, the study found a mean body fat percentage of 16.2 ± 5.1%, a VO_2max of 4232 ± 355 mL/min, and a relative VO_2/kg of 56.2 ± 5.4 mL/min/kg. Significant inverse correlations were observed between VO_2/kg and body fat percentage ($r = -0.62$, $p = 0.012$) and BMI ($r = -0.58$, $p = 0.021$). Heavyweight boxers (>81 kg) exhibited higher body fat (19.8 ± 3.7%) and lower VO_2/kg (51.3 ± ± 3.2 mL/min/kg) compared to non-heavyweights ($p < 0.05$). Dietary analysis revealed that 83% practiced caloric restriction, 58% used dehydration methods, and 71% lacked professional nutritional guidance. These findings targeted interventions to optimize performance and mitigate health risks associated with rapid weight loss in combat sports.

Keywords: *elite boxers, body composition, cardiopulmonary fitness, rapid weight loss, dietary habits, combat sports*

Introduction

Boxing is a high-intensity combat sport requiring exceptional aerobic and anaerobic capacities, explosive power, agility, and precise weight management to meet weight class requirements (Durnin JVGA, Womersley J. 1974, 22). Elite boxers must maintain optimal body composition to balance strength, speed, and endurance while adhering to rigorous weight-cutting protocols (Styne D. M., Arslanian S. A., Connor E. L., et al. 2017; Reale, R., et al., 2017). Research indicates that body fat percentages of 8–18% are typical for elite combat sport athletes, with aerobic capacity (VO_2max) critical for sustaining high-intensity bouts and facilitating recovery

(Slimani, M., et al., 2017; Chaabène, H., et al., 2015). The sport's physiological demands, characterized by repeated high-intensity efforts interspersed with brief recovery periodse of aerobic fitness and lean body mass (Artioli, G.G., et al., 2010). Garthe, I., & Sundgot-Borgen, J., 2013).

Weight management in combat sports often involves rapid weight loss strategies, such as caloric restriction and dehydration, to achieve competitive weight limit (Artioli, G. G., et al., 2016; Brito, C. J., et al., 2012). These practices, while effective for short-term weight reduction, can compromise hydration status, muscle glycogen stores, and performance, increasing risks of fatigue, injury, and long-term health consequences (Sawka, M. N., et al., 2015; Lohman, T. G., et al., 2000). Studies report that 80–90% of combat sport athletes engage in rapid weight loss, often without professional nutritional guidance, leading to suboptimal outcomes (Sundgot-Borgen, J., & Garthe, I., 2011; Langan-Evans, C., et al., 2011). Dehydration methods, such as saunas and plastic suits, are particularly prevalent, despite risks like reduced aerobic capacity and impaired thermoregulation (Cheuvront, S. N., et al., 2010; Casa, D. J., et al., 2010).

Despite boxing's global prominence, data on elite Albanian boxers are scarce. Albania has a growing presence in international boxing, with athletes achieving successes like Balkan championships and World Championship medals. However, their physiological profiles and dietary practices remain underexplored. To characterize body composition and aerobic capacity and compare them to international standards.

1. To examine relationships between body composition parameters (e.g., body fat percentage, BMI) and cardiorespiratory fitness (VO_2/kg).
2. To assess dietary habits and weight management practices and their implications for performance and health.
3. training and nutritional strategies.

We hypothesized that Albanian boxers would exhibit body composition and aerobic capacity profiles comparable to international elite boxers but might rely on prevalent, potentially harmful weight-cutting behaviors.

Materials and Methods

Participants

The study included 24 elite male boxers (aged 18–35 years) from the Albanian National Boxing Team and the multisport club «Tirana.» The cohort represented all weight classes, from flyweight to heavyweight, and included internationally successful athletes, such as one World Championship bronze medalist, two Balkan champions, and three Balkan vice-champions. This sample accounted for 60% of licensed competitive boxers aged 18+ registered with the Albanian Boxing Federation for the 2023–2024 season, ensuring a 95% confidence level for statistical inference (Cochran, W. G., 1977; Faul, F., et al., 2007). Participants had at least three years of competitive experience and were actively training for competitions.

Ethical Considerations

All procedures adhered to the Declaration of Helsinki (Durnin JVGA, Womersley J., 1974). Participants provided written informed consent, and the study protocol was approved by the Institutional Ethics Committee of the Sports University of Tirana (Approval No.: Pending). Participants were informed of the study's objectives, procedures, anrisks, and could withdraw at any time without consequence.

Body Composition Assessment

Body composition was measured using the BOD POD GS-X (COSMED, Italy; REF: A-661–230–040, 2021 model), employing air displacement plethysmography (ADP) to assess body fat percentage, fat mass, fat-free mass (FFM), body volume, body density, and predicted thoracic gas volum (McCrory, M. A., et al., 1995; Fields, D. A., et al., 2002). Testing followed standardized conditions:

- Athletes wore tight-fitting swimwear and a swim cap to minimize air trapping;
- Participants fasted for ≥2 hours and maintained normal hydration status;
- Measurements occurred in a controlled environment (temperature: 20–24 °C, humidity: 40–60%);
- Each session lasted approximately 10 minutes, with participants in-

structed to remain still and avoid speaking or laughing.

Body mass was measured to the nearest 0.1 kg, and height to the nearest 0.1 cm using a calibrated stadiometer. Body mass index (BMI) was calculated as body mass (kg) divided by height squared (m^2).

Cardiopulmonary Exercise Testing (CPET)

Cardiorespiratory fitness was assessed using the COSMED Quark RMR system with a treadmill ergometer, following a maximal incremental running protocol (starting speed: 10 km/h, progressive incline) per American College of Sports Medicine (ACSM) guidelines (Norton, K., & Olds, T., 1996). The protocol continued until volitional exhaustion or the achievement of maximal effort, confirmed by a respiratory exchange ratio (RQ) ≥1.1, a VO_2 plateau, or a heart rate within 10 bpm of the age-predicted maximum (Styne D. M., Arslanian S. A., Connor E. L., et al., 2017). Measured variables included:

- Maximal oxygen uptake (VO_2max, mL/min);
- Relative oxygen uptake (VO_2/kg, mL/min/kg);
- Maximal heart rate (HRmax, bpm);
- Minute ventilation (VE, L/min);
- End-tidal CO_2 pressure ($PetCO_2$, mmHg);
- Respiratory exchange ratio (RQ).

Tests were supervised by certified sports physicians and physiologists.

Dietary Habits Assessment

Dietary habits were evaluated using a 15-item questionnaire adapted from validated instruments in combat sports research (Artioli, G.G., et al., 2016; 24). The questionnaire, nutrition covered:

1. Number of daily meals and meal timing.
2. Presence of a structured diet plan (self-managed or professionally guided).
3. Use of sports supplements (e.g., protein, creatine, branched-chain amino acids).
4. Frequency and methods of weight loss practices (e.g., caloric restriction, dehydration via saunas or plastic suits).
5. Daily water intake volume during training and competition preparation.
6. Frequency of fast food consumption.
7. Self-perceived diet quality (5-point Likert scale).
8. Symptoms associated with rapid weight loss (e.g., fatigue, dizziness, irritability).

post-BOD POD assessment to minimize recall bias. Responses were anonymized to ensure honest reporting.

Statistical Analysis

Data were analyzed using SPSS v28.0 (IBM Corp., Armonk, NY) and Python 3.12 (Python Software Foundation). Normality was tested via the Shapiro-Wilk test. Descriptive statistics (mean ± SD, minimum, maximum) were calculated. Between-group comparisons (heavyweight vs. non-heavyweight) used independent t-tests or ANOVA. Pearson's correlation coefficient assessed relationships among VO_2/kg, body fat percentage, and BMI. Linear regression modeled VO_2/kg dependence on body composition parameters, adjusting for age and training experience. Significance was set at $p < 0.05$.

Results

Body Composition Characteristics

Table 1 presents body composition data for 24 boxers. The mean body fat percentage was 16.2 ± 5.1% (range: 10.4–24.5%), BMI was 23.4 ± 2.1 kg/m^2, and fat-free mass was 65.1 ± 8.3 kg, indicating a lean physique typical of elite combat sport athletes.

Table 1.

Parameter	Mean ± SD	Min	Max
Body mass (kg)	76.3 ± 11.4	59.0	96.0
Height (cm)	179.2 ± 5.8	170.0	191.0
BMI (kg/m^2)	23.4 ± 2.1	19.7	28.7

Parameter	Mean ± SD	Min	Max
Fat mass (kg)	11.5 ± 5.6	6.2	23.7
Fat-free mass (kg)	65.1 ± 8.3	53.6	73.0
Body Fat (%)	16.2 ± 5.1	10.4	24.5

Cardiopulmonary Exercise Testing Outcomes

Table 2 summarizes CPET results. The mean VO2max was 4232 ± 355 mL/min, relative VO2/kg was 56.2 ± 5.4 mL/min/kg, and HRmax was 193 ± 8 bpm, reflecting robust aerobic capacity.

Table 2.

Parameter	Mean ± SD	Min	Max
VO2max (mL/min)	4232 ± 355	3689	4878
VO2/kg (mL/min/kg)	56.2 ± 5.4	47.2	64.4
HRmax (bpm)	193 ± 8	172	206
VE max (L/min)	135.5 ± 24.3	104.4	176.2
PetCO2 (mmHg)	37.6 ± 5.3	30	47
RQ	0.98 ± 0.06	0.88	1.07

Correlation Analysis

Table 3 significant correlations were found between VO2/kg and body composition parameters. VO2/kg was inversely correlated with body fat percentage ($r = -0.62$, $p = 0.012$) and BMI ($r = -0.58$, $p = 0.021$). A positive correlation was observed between body fat percentage and BMI ($r = 0.71$, $p = 0.005$).

Table 3.

Variables	r	p-value
VO2/kg vs. % Fat	– 0.62	0.012 *
VO2/kg vs. BMI	– 0.58	0.021 *
% Fat vs. BMI	0.71	0.005 **

**Significant at $p < 0.05$, **Significant at $p < 0.01$*

Between-Group Comparison

Table 4. Heavyweight boxers (>81 kg) had higher body fat (19.8 ± 3.7% vs. 13.9 ± + 3.0%, $p = 0.007$) and lower VO2/kg (51.3 ± + 3.2 vs. 58.7 ± 4.1 mL/min/kg, $p = 0.018$) compared to non-heavyweights.

Table 4.

Parameter	Heavyweight (>81kg)	Non-heavyweight (≤81kg)	p-value
VO2/kg (mL/min/kg)	51.3 ± 3.2	58.7 ± 4.1	0.018 *
% Fat (%)	19.8 ± 3.7	13.9 ± 3.0	0.007 **

**Significant at $p < 0.05$, **Significant at $p < 0.01$*

Dietary Habits

The dietary questionnairerevealed 83%% of boxers practiced caloric restriction before competitions, 58% used dehydration methods (e.g., saunas, plastic suits), 67% consumed < 2 L of water/day during training, 71% self-managed diets without professional guidance, and 65% reported fatigue during rapid weight loss.

Discussion and Conclusion

The mean body fat percentage (16.2 ± ± 5.1%) aligns with ranges reported for elite combat sport athletes (8–18%) (Slimani, M., et al., 2017, 25), indicating a physique suited to the sport's demands. The VO_2max (4232 ± ± 355 mL/min) and relative VO_2/kg (56.2 ± ± 5.4 mL/min/kg) are consistent with international boxers, suggesting robust aerobic capacity essential for match endurance and recovery (Chaabène, H., et al., 2015).

Body Composition and Aerobic Capacity

The inverse correlation between VO_2/kg and body fat percentage ($r = -0.62$, $p = 0.012$) underscores the detrimental impact of excess adiposity on aerobic efficiency, corroborating findings in combat sports (Davis, P., et al., 2014; Franchini, E., et al., 2019). Excess body fat increases metabolic demand, reducing relative aerobic capacity and potentially impairing performance in prolonged bouts (Reale, R., et al., 2017). The positive correlation between body fat percentage and BMI ($r = 0.71$, $p = 0.005$) suggests BMI as a practical, albeit imperfect, proxy for adiposity (Slimani, M., et al., 2017). However, BMI's limitations, such as its inability to distinguish fat and lean mass, highlight the value of ADP (Chaabène, H., et al., 2015).

Heavyweight boxers (>81 kg) exhibited higher body fat (19.8 ± 3.7%) and lower VO_2/kg (51.3 ± 3.2 mL/min/kg) compared to non-heavyweights ($p < 0.05$), reflecting physiological trade-offs in heavier weight classes (Reljic, D., et al., 2013; Morton, J.P., et al., 2010). These findings align with Reljic et al. (Artioli, G.G., et al., 2010), who noted that larger body mass often correlates with reduced relative aerobic capacity due to increased fat mass.

Dietary Practices and Health Implications

Dietary findings revealed concerning trends: 83% of boxers employed caloric restriction, and 58% used dehydration methods, practices associated with fatigue (65%) and health risks (Artioli, G.G., et al., 2016, 35). The high prevalence of self-managed diets (71%) without professional guidance is alarming, as unsupervised weight-cutting can impair performance and increase injury risk (Burke, L.M., & Hawley, J.A., 2018; Barley, O.R., et al., 2019). Low water intake (<2 L in 67% of boxers) exacerbates dehydration risks, potentially compromising thermoregulation and cardiovascular function (Garthe, I., & Sundgot-Borgen, J., 2013). These patterns align with global combat sports trends, where rapid weight loss is common despite its detrimental effects (Sawka, M.N., et al., 2007).

The fatigue reported by 65% of boxers during rapid weight loss is consistent with reduced energy availability and psychological stress Artioli et al. (Artioli, G.G., et al., 2016) noted that rapid weight loss can reduce performance by up to 10%, suggesting safer strategies.

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