

CALORIC CONSUMPTION, ENERGY NEEDS AND FAT MASS IN BOXERS AT START OF THE PHYSICAL PREPARATION

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ABSTRACT

Background: the purpose of this study is to compare the nutritional intake, fat mass and VO₂max between amateur and professional boxers at the beginning of the season, as well as the nutritional requirement and consumption within and between groups and the percentage of intergroup nutritional adequacy. **Methods:** a non-experimental, cross-sectional cohort study was conducted with 41 male boxers (26 professionals and 15 amateurs; M=20.29±3.29 years). The sample was selected for convenience and was stratified by sports mastery Student's t tests were applied to compare the inter- and intra-group variables and significance of p≤0.05. **Results:** greater energy needs were observed in professional boxers, although deficient in both groups with respect to daily caloric intake (p<0.05), mainly due to carbohydrate intake (5.68±1.72gr/kg/body weight; amateurs and 5.63±2.18gr/kg/body weight; professionals). Both groups presented imbalance in the intake of micronutrients, mainly iron, sodium, zinc, ascorbic acid, tocopherol and retinol. **Conclusions:** there was a deficient daily caloric intake in both groups of boxers with intra- and intergroup micronutrient imbalances, which could negatively affect the physical performance of the boxers at some stage of training.



KEY WORDS

boxers, nutritional intake, nutrients, fat mass, physical preparation.



INTRODUCTION

Nutrition in athletes plays a fundamental role in daily vital functions and physical performance during athletic preparation (1,2). In recent years, scientific studies have highlighted that proper nutritional intervention during physical preparation in athletes guarantees a good state of health and physical performance, Furthermore, it reduces the rate of injury or alterations in the immune system caused by nutritional deficiencies resulting from the physical load or insufficient food consumption (2,3,4,5,6). Likewise, considering that the daily calorie intake (DCI) in athletes is higher than in sedentary individuals due to the energy demand generated during training sessions, adequate nutritional intervention is essential to cover metabolic needs, restore glycogen, adjust micronutrient intake (6,7,8,9), repair and build tissues and keep the body's metabolism regulated (2,3,10,11,12,13).

Therefore, the sports nutritionist is a fundamental part of the multidisciplinary team that intervenes in the structure of the training macrocycle by having to periodise the DCI to the training loads and body composition of each athlete (14) avoiding adverse factors that limit physical performance (9,15). For this, it is important that, at the beginning, during and at the end of physical preparation, all athletes receive exhaustive evaluations by a multidisciplinary team that allow the prediction of physical performance (16,17) through anthropometric, biochemical, clinical, dietary, psychological and physiological studies (3,16,18). In addition, with the evaluation of physical fitness, it will be possible to estimate the maximum oxygen consumption (VO₂max), which will provide information on metabolic units (METs), calorie expenditure and metabolites generated according to training intensity (12,19). It also avoids nutritional or calorie deficits that are detrimental to physical performance by affecting the athlete's bone health, immune function, mood and cognition (18).

In sports that compete in body weight division, nutrition plays a very important role, because through it energy substrates are replenished, in addition, the athlete can gradually decrease body weight without negatively affecting physical performance and health (6,16,20), however, about 86% of these athletes decrease it quickly days before the competition (21), generating performance problems the fight and in the case of adolescents, also impairing growth and development (22). In boxing, usually weeks or days before the official weigh-in, boxers lose 5-10% of their body weight by restricting fluids and food in their diet, self-induced sweating, increasing training minutes and using saunas or waterproof clothing to promote dehydration (1,21). These common

practices for boxers are used to gain an advantage over the opponent during sparring, although they can lead to substrate depletion fatigue, affect the ability to concentrate and induce loss of cognitive functions and short-term memory (23,24,25).

In addition to causing hormonal and electrolyte disturbances, hyperthermia, cardiovascular disorders, increased bone resorption and immunosuppression (21).

In any case, nutritional assessment at the beginning of physical preparation allows us to know the nutritional status of boxers (25,26,27) and to adapt the DQI according to the microcycle of training or physiological needs, as the body weight must be adequately adjusted to the competition division (16,28,29). For this reason, the purpose of the present study was to compare nutritional intake, fat mass and VO₂max between amateur and professional boxers at the beginning of physical preparation, as well as the intra- and inter-group nutritional requirement and intake and the inter-group nutritional adequacy percentage (NAP).



MATERIALS Y METHODS

Study area

The study was conducted in two boxing gyms located in the cities of Navojoa and Hermosillo, Sonora, Mexico.

Study design and participants

Cross-sectional, non-experimental cohort study conducted between August and November 2016 on a total sample of 41 male boxers (26 professionals; age 18 to 26 years, height 160.5 to 185.3 cm and body weight 59 to 87.8 kilograms (kg) and 15 amateurs; age 15 to 17 years, height 158 to 186 cm and body weight 43.9 to 81.5 kg) who trained uninterruptedly six days a week and had more than one year of boxing experience. The sample was selected by convenience and stratified by sporting expertise (amateur and professional). Exclusion criteria were subjects who were taking dietary supplements or who were out of season for training. Prior to the intervention, all participants were informed about the characteristics of the research and measurement instruments and signed an informed consent form in accordance with the Helsinki declaration, adhering the research to the regulations of the General Health Law on Health Research (30).

Variables and instruments

All measurements were taken during the first microcycle of physical preparation, one hour before the start of each training session. The instruments and measurements were applied by professionals and technicians in sports nutrition and physical training, who received training prior to the study to unify the criteria established for the protocol.

The first day of data collection began with the Course Navette test (31) to estimate VO₂max expressed in absolute and relative values, i.e. in millilitres per kilogram per day (ml/kg/day) and litres per minute (L/min). On the second day, each subject's body weight was assessed with a Tanita RD-901 Ironman scale graduated in kilograms (kg), with an accuracy of ±100 grams (g) and a maximum capacity of 200 kg, height with a Seca portable and graduated stadiometer, model 213 with a length of 2.2 metres and an accuracy of 1 millimetre (mm), and bicipital plicometry was taken, tricipital, subscapular, supraspinal, abdominal, mid-thigh and calf plicometry were taken to estimate body density using a Harpenden plicometer (BritishIndicators, UK), constant pressure of 10g/mm² on contact and with the density the percentage of fat mass was calculated using the equations of Withers et al. (32) and Siri (33). On the third day, the first of three 24-hour reminders (R24hr) was applied to estimate DQI, the other two were applied during the microcycle (one on training day and one on rest day). The DRI and micronutrients were estimated through the database proposed by the Centro de Investigación en Alimentación y Desarrollo A.C. (Food and Development Research Centre). The estimated average requirement (RPE) of macronutrients was calculated as established by experts in the field of sports nutrition (2,9,14).

The energy requirement was estimated with the equation proposed by De Lorenzo that determines the basal energy expenditure (BEE) and to obtain the total, the physical activity energy expenditure (PAEE), caloric expenditure per EF and food thermogenesis were added (12). For this study, it was decided to add 30% as GEAF due to the type of activities that boxers performed outside training, the energy expenditure per EF was obtained by dividing the relative result of VO₂max by 3.5 corresponding to the minimum oxygen needed by the body to maintain vital functions, the result was expressed as METs and then calculated according to the intensity of training. The equation used was $0.0175 \times \text{training METs} \times \text{weight} \times \text{minutes of activity}$, where 0.0175 = equivalent to resting energy expenditure (12,34). To determine the training METs it was necessary to estimate the maximum heart rate (HR_{max}) expressed in beats per minute (bpm) with the equation $208 - (0.7 \times \text{age})$ for athletes (35) and training HR using the Polar® FT1 pulse monitor including the coded transmitter (Polar® T31).

Nutritional adequacy

The PAN of macro- and micronutrients was assessed by the equation daily intake / recommended daily intake (RDI) x 100 using reference values established by experts in sports nutrition (36). Intake adequacy was defined as acceptable when the intake of a nutrient was between 95 and 105% (37). Results below 95% were categorised as deficient and above 105% as excessive.

Statistical analysis

Data were analysed using Statistica version 8.0 software (StatSoft®, 2008). Before performing the analyses, the normality and homogeneity of the distribution of the variables was examined with the Shapiro-Wilk test. Descriptive statistics of mean and standard deviation ($M \pm SD$) were performed for biological, physiological, anthropometric and energy expenditure characteristics. All comparisons of inter- and intra-group boxer variables were performed using Student's t-test adopting a value of $p \leq 0.05$ to indicate statistical significance.

RESULTS

Table 1 shows the biological, physiological and anthropometric characteristics and daily energy requirements of amateur and professional boxers at the start of physical training.

Table 1. Biological, physiological and anthropometric characteristics and energy expenditure between amateur and professional boxers.

	Amateur (n=15)	Professionals (n=26)
Biological		
Age (years)	16.11 ± 0.78	21.80 ± 2.40
Body weight (kg)	56.91 ± 9.83	69.95 ± 8.98
Height (cm)	168.73 ± 8.08	171.50 ± 6.62
Physiological		
MET (unity)	13.03 ± 1.54	15.92 ± 1.33
HRmax (bpm)	197.2 ± 0.77	192.6 ± 1.86
Intensity (%)	74.0 ± 5.00	74.7 ± 2.95
HRtr. (bpm)	145.8 ± 9.82	143.8 ± 6.00
METtr. (unity)	9.8 ± 1.20	11.9 ± 1.18
Anthropometry (mm)		
Bicipital	3.57 ± 1.24	3.79 ± 0.94
Amateur (n=15) Professionals (n=26)		
Tricipital	6.91 ± 2.34	8.18 ± 2.28
Subscapularis	8.07 ± 1.89	8.53 ± 1.62
Supraspinal	4.26 ± 1.06	10.08 ± 4.07
Abdominal	8.05 ± 2.12	12.84 ± 4.88
Medial thigh	9.16 ± 3.07	9.90 ± 3.33
Calf	8.67 ± 3.13	6.61 ± 2.14
∑7 Skinfold	54.50 ± 19.65	62.16 ± 14.77

Energy expenditure (Kcal)		
Basal	1529.34 ± 173.95	1654.32 ± 139.61
Physical activity	458.80 ± 52.18	496.29 ± 41.88
Physical exercise	1118.3 ± 195.14	1631.3 ± 231.01
Thermogenesis	310.6 ± 39.35	379.5 ± 39.59
Total	3417.1 ± 432.80	4174.8 ± 435.48

kg: kilograms, cm: centimetres, bpm: beats per minute, kcal: kilocalories, %: percentage, VO₂max: maximal oxygen uptake, ml/kg/min: millilitres per kilogram of weight per minute, L/min: litres per minute, MET: metabolic equivalent, METtr: metabolic equivalent per training, HRmax: maximum heart rate, HRtr: training heart rate.

When comparing macro and micronutrient intake between groups of boxers (Table 2), significant differences were observed in calcium and folate intake ($p < 0.05$), where amateur boxers consumed 648.64 ± 290.17 mg of calcium and 0.48 ± 0.24 mg of folate, in contrast to professionals who ingested 1022.26 ± 436.16 mg of calcium and 0.33 ± 0.11 mg of folate.

Table 2. Comparison of macro- and micronutrient intakes between amateur and professional boxers.

		Amateur (n=15)	Professionals (n=26)	<i>p</i>
Macronutrients				
	%	16.11 ± 4.77	15.21 ± 3.25	0.502
Proteins	kcal	407.93 ± 165.57	524.77 ± 198.22	0.061
	gr/kg/pc	1.77 ± 0.61	1.92 ± 0.65	0.462
	%	32.58 ± 8.27	35.27 ± 6.50	0.254
Fat	kcal	859.70 ± 364.21	1095.05 ± 428.29	0.082
	gr/kg/pc	1.71 ± 0.75	1.71 ± 0.65	0.992
Saturated fats (gr)		14.41 ± 4.57	15.42 ± 7.49	0.647
Polyunsaturated fats (gr)		16.27 ± 6.85	20.92 ± 8.71	0.084
Monounsaturated fats (gr)		35.66 ± 15.85	40.94 ± 19.02	0.370
Cholesterol (mg)		703.93 ± 33.02	774.08 ± 472.80	0.646
	%	51.31 ± 8.96	48.60 ± 9.40	0.458
Carbohydrates	kcal	1260.97 ± 307.93	1511.21 ± 583.98	0.511
	gr/kg/pc	5.68 ± 1.72	5.63 ± 2.18	0.472
		Amateur (n=15)	Professionals (n=26)	<i>p</i>
Fibre (gr)		29.77 ± 9.28	27.28 ± 10.77	0.458
Soluble fibre (gr)		7.93 ± 2.73	7.14 ± 4.07	0.511
Insoluble fibre (gr)		31.77 ± 12.44	35.60 ± 18.05	0.472
Micronutrients				
Minerals (mg)				
Calcium		648.64 ± 290.17	1022.26 ± 436.16	0.014*
Iron		25.91 ± 9.06	24.68 ± 10.03	0.698
Potassium		2657.34 ± 898.80	3038.55 ± 1113.20	0.266
Sodium		3027.28 ± 1145.03	3719.90 ± 1610.85	0.158
Zinc		17.54 ± 7.37	19.25 ± 9.23	0.543

Vitamins (mg)			
Retinol (A)	1400.67 ± 983.66	1420.08 ± 894.10	0.950
Ascorbic acid (C)	147.92 ± 116.42	1089.37 ± 752.25	0.000*
Tocopherol (E)	9.73 ± 5.36	13.13 ± 7.21	0.121
Folate (B9)	0.48 ± 0.24	0.33 ± 0.11	0.023*

Note. kcal: kilocalories, gr: grams, gr/kg/pc: grams per kilogram of body weight, mg: milligrams, G: fat, $p < 0.05$ is statistically significant.

Figure 1 shows the comparison of the percentage of fat mass and VO₂max between the group of amateur and professional boxers. It is observed that the percentage of fat mass was similar in both groups ($p > 0.05$) with averages and standard deviation of $9.63 \pm 3.38\%$ in the amateurs and $10.61 \pm 1.99\%$ in the professionals. On the other hand, with respect to VO₂max, a greater aerobic capacity ($p < 0.05$) was observed in the group of professional boxers who had $55.72 \pm 4.66 \text{ ml/min/kg}$ with respect to the amateurs who had an average of $45.61 \pm 5.38 \text{ ml/min/kg}$.

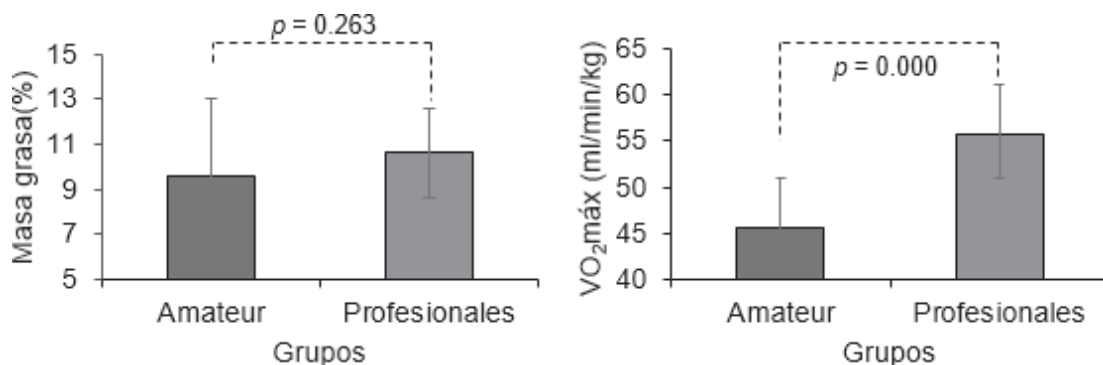


Fig. 1. Comparison of fat mass and VO₂max between amateur and professional boxers.

When comparing the intra- and inter-group requirement and DCI of amateur and professional boxers (Fig. 2), it was observed that both cases consumed less kilocalories than required per day ($p < 0.05$). Amateur boxers required $3417.13 \pm 432.80 \text{ kcal}$ and consumed $2528.59 \pm 703.45 \text{ kcal}$, while professional boxers required $4174.84 \pm 435.48 \text{ kcal}$ and consumed $3079.24 \pm 976.06 \text{ kcal}$. Likewise, when comparing the requirement and ICD between groups, it could be observed that the amateur boxers required less kilocalories compared to the group of professional boxers ($p = 0.000$) and the ICD was similar between both groups ($p = 0.063$).

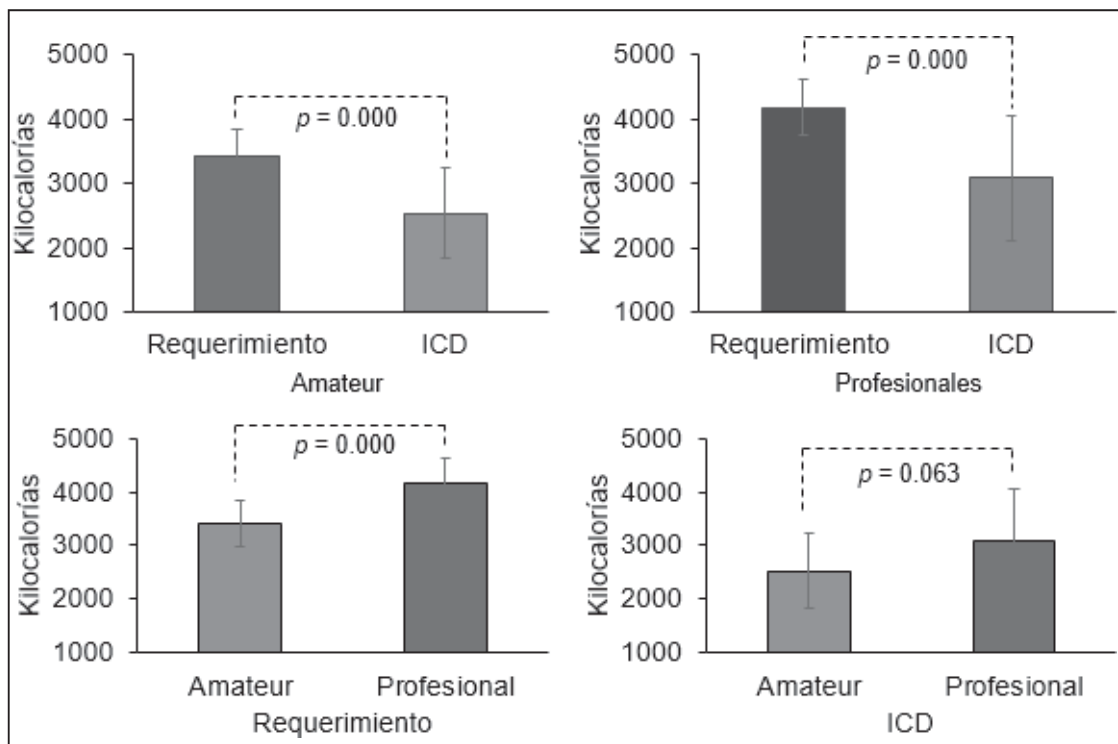


Fig. 2. Comparison of requirement with intra- and inter-group caloric intake of amateur and professional boxers. DCI: daily calorie intake.

Fig. 3 shows the comparison between intake and RPE of macronutrients within groups. Regarding protein intake, a significant difference ($p < 0.05$) was observed in the group of professional boxers, who ingested 1.92g/kg/day and the RPE was 1.54g/kg/day . The fat intake in both groups of boxers was similar to the estimated average requirement and the carbohydrate intake was below the RPE ($p < 0.05$), the group of amateur boxers ingested $5.68 \pm 1.72\text{g/kg/day}$ and the professional boxers $5.63 \pm 2.18\text{g/kg/day}$, however, the RPE for each group was $9.84 \pm 0.69\text{g/kg/day}$ and $9.97 \pm 0.63\text{g/kg/day}$ respectively.

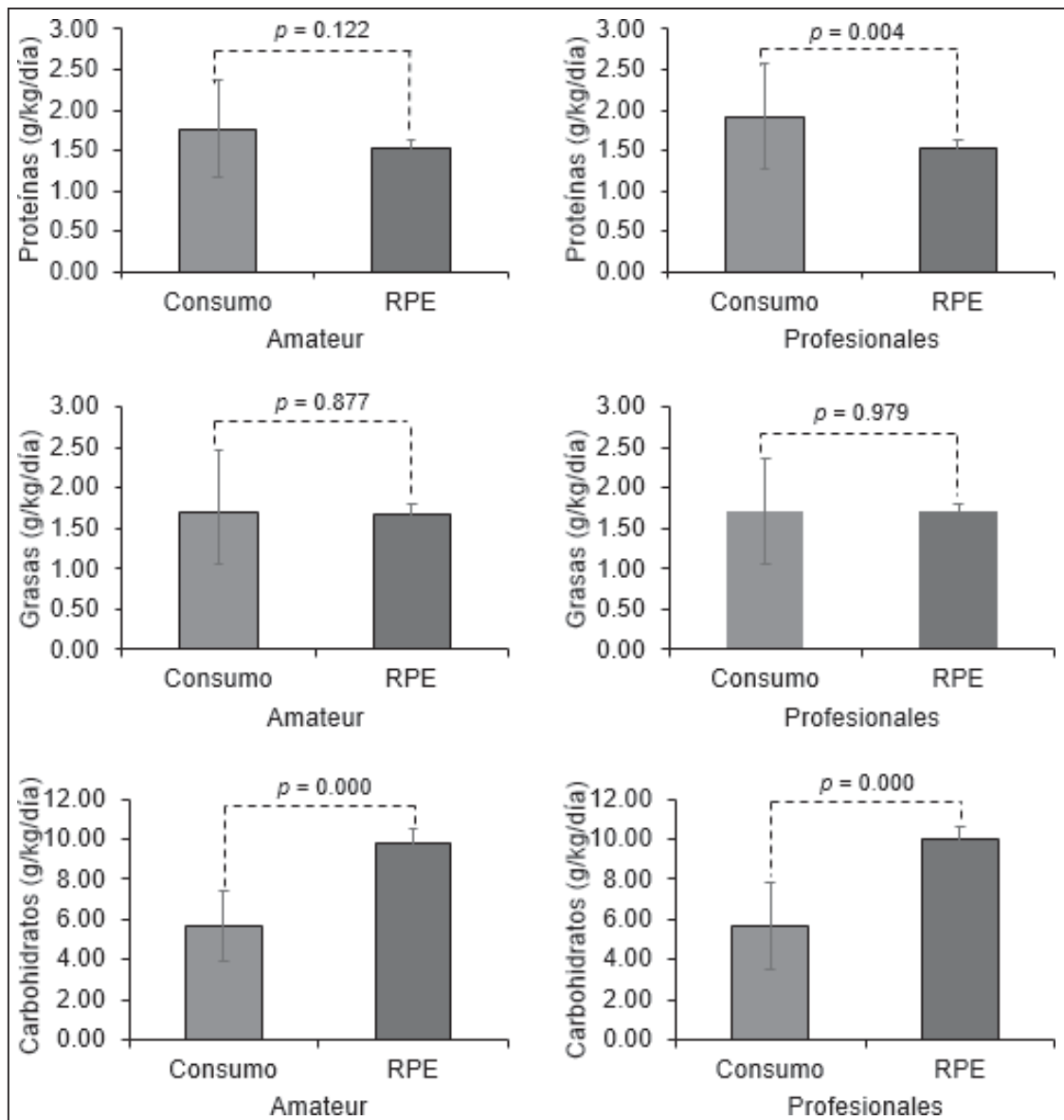


Fig. 3 Comparison between intake and macronutrient requirement within groups. RPE: estimated average requirement.

When comparing PAN between amateur and professional boxers (Table 3) according to the estimated average requirement, no significant differences ($p > 0.05$) were observed in macronutrients, although excessive protein intake was observed in both groups and deficient in carbohydrates. Also, fibre intake was deficient in both groups. Within micronutrients, in minerals, significant differences ($p < 0.05$) were observed in calcium intake, although it was deficient in both groups, similar to potassium intake. The consumption of iron, sodium and zinc was excessive in both groups ($p > 0.05$) and in vitamins, the group of professional boxers consumed more retinol and ascorbic acid than the amateurs ($p > 0.05$), although both groups had an excessive consumption. groups had an excessive intake. On the other hand, there were no significant

differences in tocopherol and folate ($p>0.05$), although in the amateur group an excessive consumption of folate was observed.

Table 3. Comparison of the percentage of nutritional adequacy between amateur and professional boxers.

		Amateur (n=15)	Professionals (n=26)	<i>p</i>	DCI
Macronutrients					
Proteins		118.93±45.17	125.08±0.10	0.661	1.2-2 ¹⁴
Fat		102.89±46.49	105.39±0.10	0.858	1-2 ⁹
Carbohydrates		57.83±16.98	56.46±0.10	0.836	5-12 ²
Fibre	Average	79.39±24.75	72.74±28.72	0.458	25-50 ^{14,17}
	Maximum	59.54±18.56	54.56±21.54	0.458	
Micronutrients					
Minerals					
Calcium		43.24±19.34	64.77±24.43	0.015	1500 ⁵
Iron		323.90±113.29	308.45±125.33	0.698	8 ⁸
Potassium		75.92±25.68	86.81±31.81	0.407	3500 ¹⁸
Sodium		201.82±76.33	206.12±76.88	0.864	1500 ¹⁷
Zinc	Average	140.30±58.96	158.83±74.68	0.416	10-15 ¹⁷
	Maximum	116.92±49.13	132.36±62.23	0.416	
Vitamins					
Retinol	Average	175.09±122.96	467.43±199.54	0.000	0.7-0.9 ³
	Maximum	155.63±109.29	415.49±177.37	0.000	
Ascorbic acid		164.36±129.35	1155.42±852.73	0.000	90 ³
Tocopherol		64.90±35.72	84.22±35.67	0.108	15 ¹⁰
Folate		119.27±60.43	86.74±36.57	0.066	0.4 ³

Note DCI: daily calorie intake. Macronutrients and fibre in grams per day, micronutrients in milligrams per day.



DISCUSSION

The aim of this study was to compare the BDI and energy requirements between amateur and professional boxers at the start of physical training. The results showed that the daily energy requirement was higher in professional boxers compared to amateurs, a situation that may be related to the difference in body weight that influences GEB (38), in addition to the physiological difference in VO₂max required to calculate METs and GEEF in athletes (12,39). Authors such as Debnath et al. (40) describe the existence of a strong positive correlation between caloric intake and VO₂max, supporting that, as the intensity of physical exertion increases, muscle requires more oxygen to produce energy and movement. In this case, professional boxers required more than 700kcal compared to amateurs, however, the ICD was similar in both groups who had a negative balance of approximately 1000kcal, which

could have a negative impact on the physical performance of the boxers by decreasing muscle strength, reflexes and glycogen reserves as argued by Peos et al. (20), mainly due to the low consumption of CHO associated with post-exercise physical recovery, making it clear that athletes should be encouraged to adjust their intake of this nutrient in order to recover muscle tissue (41).

Although the consumption of CHO in the amateur and professional boxers evaluated in this study coincides with that observed by Pettersson and Berg (1) when 68 combat athletes were involved in analysing dietary intake between the weigh-in and the first bout, in both cases, the consumption was deficient according to Lambert (2), consumption was deficient according to Lambert and Jones (42) and Vitale and Getzin (2) who recommend between 8 and 12g/kg of body weight in order to replenish glycogen after intense training or when daily sessions are between 4 and 5 hours. Likewise, dietary fibre should be adjusted among the CHOs for its benefits to health and physical performance (40), which, in the present study, both groups of boxers met the daily recommendations (14). However, in nutrition being a complex area, there may be discrepancy in the type of strategy implemented in athletic preparation, such is the case of Morton et al. (27) who reported a decrease of 9.4kg (5.1% fat) without affecting performance in a boxer during 12 weeks of nutritional intervention. The strategy consisted of consuming between 2 and 2.5g/kg/bw of CHO with low or medium glycaemic index together with 2g/kg/bw of protein during this period until before the official weigh-in and after this, 12g/kg/bw of low glycaemic index CHO were provided together with a hydric strategy achieving a rebound of 4.3kg equivalent to two divisions during the competition. This nutritional strategy contributed to lipid oxidation and induced gluconeogenesis (27) with muscle glycogen resynthesis (4,43) which could delay fatigue during training sessions or competition.

The protein intake observed in the present study was excessive according to the NAP, although it was within the normal range for athletes (3,2) and deficiencies of this macronutrient are unlikely to be found (11) when a normal diet is consumed. The excess of proteins could be associated to the intensity of the training during the microcycle, in this sense, it can be inferred that to adequate the consumption of amateur boxers they should ingest 1.51 ± 0.11 gr/ kg/bw and the professionals 1.54 ± 0.10 gr/kg/bw (10% of the ICD) being able to benefit positively in the construction of hormones, enzymes and synthesis of muscular proteins, besides preventing the loss of lean muscular mass and facilitating adaptations to the training (3,13). Likewise, consuming 0.25g/kg/day of protein combined with 1g/kg/day of CHO within the first hour after intense or eccentric training minimises muscle damage and increases muscle

glycogen resynthesis (2), probably as a result of glycogen synthase enzyme activation when stimulated by insulin to uptake glucose into muscles (44).

Fat consumption was within the normal range (45) with an acceptable PAN, favouring nerve function (27), absorption of fat-soluble vitamins and carotenoids and indispensable for the growth and development of adolescent athletes (46). Furthermore, as there was a low consumption of CHO (amateur: 5.68 ± 1.72 g/kg/weight and professional: 5.63 ± 2.18 g/kg/weight), fats were possibly used as an energy source during aerobic training sessions and the consumption of polyunsaturated fatty acids (ω -3 and ω -6) could have had benefits in reducing inflammation and muscle damage derived from the physical load, as described by Lee et al (13).

In contrast, both groups of boxers had an imbalance in micronutrient intake and, although there are no clear criteria for the daily requirement in athletes (47), it is known that excessive intake can have adverse effects on performance and long-term health (13,26,47,48). In this case, excessive intakes of iron, sodium and zinc may counteract athletic performance in later stages of training because they are related to proper organ function (7). In contrast, micronutrient deficiencies are commonly found in athletes as highlighted by Papadopoulou et al. (6) following dietary assessment in 60 Tae Kwon Do athletes. Dietary food restriction is usually the main reason for nutritional deficiencies, coupled with the amount of sweat and urine generated during training sessions (15,28,29,49) which can affect nerve, circulatory and physiological functions such as decreased bone mineral density, the onset of physical weakness and muscle ailments (5). Therefore, deficient intakes of tocopherol in both groups of boxers and folate in professionals may be related to increased free radical formation resulting from intense physical loads (26) and gastrointestinal problems due to excessive consumption of ascorbic acid, although supplementation with mega doses (500mg/day) after intense training may prevent upper respiratory tract infections (3). In addition, the excessive intake of retinol during physical training may have caused toxicity and thus symptoms such as nausea, vomiting, diarrhoea, headaches and joint pain (3). headaches and joint pain (3,47).

In conclusion, the DQI was deficient in both groups, mainly due to the low consumption of CHO which are important for energy intake during sport. Protein intake was slightly high and fat intake was normal for the stage of training, allowing the percentage of fat mass and VO₂max to be adequate for the sport, training period and sporting level of the boxers, although it was observed that the consumption of minerals and vitamins within and between groups, which are essential for the body's functions and key to the

physical performance of the athletes throughout the macrocycle of training, was inadequate.



LIMITATIONS AND FUTURE PATHS

The main strength of this research is the intervention in amateur boxers with experience in the sport and professional boxers, including world champions, which can be taken as a reference in future studies. Among the limitations, we only analysed some vitamins and minerals due to the characteristics of the software used, and it was impossible to evaluate micronutrient concentrations in blood that would allow us to relate intake to serum concentrations and infer whether they met the daily requirements according to an objective parameter. However, prior counselling was always included and food replicates were shown to subjects to reduce bias when answering each R24Hr, and VO₂max was considered to estimate caloric expenditure per training session. Finally, it is recommended that in future research, in addition to self-reporting, blood micronutrient status should be considered and the results correlated with those obtained through R24Hr.



BIBLIOGRAPHIC REFERENCES

1. Pettersson S, Berg CM. Dietary intake at competition in elite Olympic combat sports. *International Journal of Sport Nutrition and Exercise Metabolism*. 2014; 24(1):98-109. doi.org/10.1123/ijsnem.2013-0041
2. Vitale K, Getzin A. Nutrition and supplement update for the endurance athlete: review and recommendations. *Nutrients*. 2019; 11(6):1289. doi.org/10.3390/nu11061289
3. Kerksick CM, Wilborn CD, Roberts MD, Smith-Ryan A, Kleiner SM, Jäger R, et al. ISSN exercise & sports nutrition review update: research & recommendations. *Journal of the International Society of Sports Nutrition*. 2018; 15(1):1-57. doi.org/10.1186/s12970-018-0242-y
4. Naderi A, Samanipour MH, Sarshin A, Forbes SC, Koozehchian MS, Franchini E, et al. Effects of two different doses of carbohydrate ingestion on taekwondo-related performance during a simulated tournament. *Journal of the International Society of Sports Nutrition*. 2021; 18(1):1-8. doi.org/10.1186/s12970-021-00434-4

5. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: nutrition and athletic performance. *Journal of the Academy of Nutrition and Dietetics*. 2016; 116(3):501-528. doi.org/10.1016/j.jand.2015.12.006
6. Papadopoulou SK, Dalatsi VA, Methenitis SK, Feidantsis KG, Pagkalos IG, Hassapidou M. Nutritional routine of tae kwon do athletes prior to competition: what is the impact of weight control practices?. *Journal of the American College of Nutrition*. 2017; 36(6):448-454. doi.org/10.1080/07315724.2017.1319305
7. Opoka W, Kryczyk-Poprawa A, Studzińska M, Piotrowska J, Muszyńska B. The comparison of trace elements content with labels on dietary supplements used by athletes. *Acta Poloniae Pharmaceutica. Drug Research*. 2020; 77(4). doi: 10.32383/appdr/126547
8. Rubeor A, Goojha C, Manning J, White J. Does iron supplementation improve performance in iron-deficient nonanemic athletes?. *Sports Health*. 2018; 10(5):400-405. doi.org/10.1177/1941738118777488
9. Stellingwerff T, Maughan RJ, Burke LM. Nutrition for power sports: middle-distance running, track cycling, rowing, canoeing/kayaking, and swimming. *Journal of Sports Sciences*. 2011; 29(sup1):79-89. doi.org/10.1080/02640414.2011.589469
10. Gogojewicz A, Śliwicka E, Durkalec-Michalski K. Assessment of dietary intake and nutritional status in CrossFit-trained individuals: A descriptive study. *International Journal of Environmental Research and Public Health*. 2020; 17(13):4772. doi.org/10.3390/ijerph17134772
11. Kårlund A, Gómez-Gallego C, Turpeinen AM, Palo-Oja OM, El-Nezami H, Kolehmainen M. Protein supplements and their relation with nutrition, microbiota composition and health: is more protein always better for sportspeople?. *Nutrients*. 2019; 11(4):829. doi.org/10.3390/nu11040829
12. Tumnark P, Cardoso P, Cabral J, Conceição F. An Ontology to Integrate Multiple Knowledge Domains of Training-Dietary-Competition in Weightlifting: A Nutritional Approach. *ECTI Transactions on Computer and Information Technology (ECTI-CIT)*. 2018; 12(2):140-152. doi.org/10.37936/ecti-cit.2018122.135896
13. Lee EC, Fragala MS, Kavouras SA, Queen RM, Pryor JL, Casa DJ. Biomarkers in sports and exercise: tracking health, performance, and recovery in athletes. *Journal*

of Strength and Conditioning Research. 2017; 31(10):2920. doi: 10.1519/JSC.0000000000002122

14. Jenner SL, Trakman G, Coutts A, Kempton T, Ryan S, Forsyth A, Belski R. Dietary intake of professional Australian football athletes surrounding body composition assessment. *Journal of the International Society of Sports Nutrition*. 2018; 15(1):1-8. doi.org/10.1186/s12970-018-0248-5

15. Salomon A, Mandecka A, Rózańska D, Konikowska K, Kosendiak A, Regulska-Illow B. Dietary Intake of Minerals in Diets of Adults Preparing for Marathon. *Central European Journal of Sport Sciences and Medicine*. 2017; 18(2):23-32

16. Mielgo-Ayuso J, Maroto-Sánchez B, Luzardo-Socorro R, Palacios G, Palacios N, González-Gross M. Valoración del estado nutricional y del gasto energético en deportistas. *Revista Española de Nutrición Comunitaria*. 2015; 21(1):225-234. doi:10.14642/RENC.2015.21.sup1.5069

17. Yerzhanova E, Sabyrbek Z, Milašius K. Comparative evaluation of actual nutrition and micronutrients provision of judo wrestlers of various sport performance levels. *Sporto mokslas / Sport Science*. 2017; 3(89):47-53. doi.org/10.15823/sm.2017.28

18. Chapman S, Roberts J, Smith L, Rawcliffe A, Izzard R. Sex differences in dietary intake in British Army recruits undergoing phase one training. *Journal of the International Society of Sports Nutrition*. 2019; 16(1):1-9. doi.org/10.1186/s12970-019-0327-2

19. Sagayama H, Hamaguchi G, Toguchi M, Ichikawa M, Yamada Y, Ebine N, et al. Energy requirement assessment in Japanese table tennis players using the doubly labeled water method. *International Journal of Sport Nutrition and Exercise Metabolism*. 2017; 27(5):421-428. <https://doi.org/10.1123/ijsnem.2017-0022>

20. Peos JJ, Norton LE, Helms ER, Galpin AJ, Fournier P. Intermittent dieting: theoretical considerations for the athlete. *Sports*. 2019; 7(1):22. doi:10.3390/sports7010022

21. Mata-Ordoñez F, Sánchez-Oliver A, Domínguez-Herrera R. Importancia de la nutrición en las estrategias de pérdida de peso en deportes de combate. *Journal of Sport and Health Research*. 2018; 10(1):1-12.

22. Franchini E, Brito CJ, Artioli GG. Weight loss in combat sports: physiological, psychological and performance effects. *Journal of the International Society of Sports Nutrition*. (2012; 9(1): 1-6. doi.org/10.1186/1550-2783-9-52

23. Durkalec-Michalski K, Goscianska I, Jeszka J. Does conventional body weight reduction decreasing anaerobic capacity of boxers in the competition period?. *Archives of Budo*. 2015; 11:251-258.
24. Martínez-Abellán A, Ros EC, Morán-Navarro R, López-Gullón JM, Pallarés JG, De la Cruz-Sánchez E, Montero FO. Efecto de la bajada de peso y la competición sobre el perfil de estado de ánimo en deportes de combate. *Cuadernos de Psicología del Deporte*. 2015; 15(3):99-104.
25. Reljic D, Jost J, Dickau K, Kinscherf R, Bonaterra G, Friedmann-Bette B. Effects of pre-competitive rapid weight loss on nutrition, vitamin status and oxidative stress in elite boxers. *Journal of Sports Sciences*. 2015; 33(5):437-448. doi.org/10.1080/02640414.2014.949825
26. Mazzeo F, Santamaria S, Monda V, Tafuri D, Dalia C, Varriale L, et al. Dietary supplements use in competitive and non-competitive boxer: An exploratory study. *Biology and Medicine*. 2016; 8(4):1-8. doi.org/10.4172/0974-8369.1000294
27. Morton JP, Robertson C, Sutton L, MacLaren DP. (2010). Making the Weight: A Case Study From Professional Boxing. *International Journal of Sport Nutrition and Exercise Metabolism*. 2010; 20:80-85. doi.org/10.1123/ijsnem.20.1.80
28. Anyżewska A, Dzierżanowski I, Woźniak A, Leonkiewicz M, Wawrzyniak A. Rapid weight loss and dietary inadequacies among martial arts practitioners from Poland. *International Journal of Environmental Research and Public Health*. 2018; 15(11):2476. doi.org/10.3390/ijerph15112476
29. Książek A, Karpała J, Słowińska-Lisowska M. An evaluation of diets in the Polish national judo team during the pre-competition weight loss period. *Archives of Budo Science of Martial Arts and Extreme Sports*. 2017; 13:101-106
30. de la Salud, P. (1987). Reglamento de la ley general de salud en materia de investigación para la salud. http://www.diputados.gob.mx/LeyesBiblio/regley/Reg_LGS_MIS.pdf
31. Leger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences*, 1988; 6(2):93-101. doi.org/10.1080/02640418808729800
32. Withers RT, Craig NP, Bourdon PC, Norton KI. Relative body fat and anthropometric prediction of body density of male athletes. *European Journal of Applied*

Physiology and Occupational Physiology. 1987; 56(2):191-200. doi.org/10.1007/BF00640643

33. Siri WE. Body composition from fluid spaces and density: analysis of methods. University of California. "Lawrence Berkeley National Laboratory". 1956; no. 3349.

34. Elder SJ, Roberts SB. The effects of exercise on food intake and body fat- ness: a summary of published studies. Nutrition Reviews. 2007; 65(1):1-19. doi. org/10.1111/j.1753-4887.2007.tb00263.x

35. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revis- ited. Journal of the American College of Cardiology. 2001; 37(1):153-156.

36. Córdoba-Caro LG, Luego LM, García V. Adecuación nutricional de la inges- ta de los estudiantes de secundaria de Badajoz. Nutrición Hospitalaria. 2012; 27(4):1065-1071. doi.org/10.3305/nh.2012.27.4.5800

37. Trindade CDZ, Montenegro KR, Schneider CD, de Souza FA, Baroni BM. Ade- quacy of dietary intake in swimmers during the general preparation phase. Sport Sciences for Health. 2017; 13(2):373-380.

38. De Lorenzo A, Bertini I, Candeloro N, Piccinelli R. A new predictive equation to calculate resting metabolic rate in athletes. Journal of Sports Medicine and Physical Fitness. 1999; 39(3):213-219.

39. Nabli MA, Abdelkrim NB, Castagna C, Jabri I, Batikh T, Chamari K. Energy demands and metabolic equivalents (METS) in U-19 basketball refereeing during official games. Journal Sports Medicine Doping Studies. 2017; 7(190):2161-0673. doi:10.4172/2161-0673.1000190

40. Debnath M, Chatterjee S, Bandyopadhyay A, Datta G, Dey SK. Prediction of athletic performance through nutrition knowledge and practice: a cross-sectional study among young team athletes. Sport Mont. 2019; 17(3):13-20. doi: 10.26773/ smj.191012

41. Alva LM, Pautaso VC, Genuario A, Schenone A, Ravelli S. Evaluación nutricion- al e ingesta de macronutrientes de taekwondistas. Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte. 2021; 10(3): 99-115. doi: 10.24310/ riccafd.2021.v10i3.12775

42. Lambert C, Jones B. Alternatives to rapid weight loss in US wrestling. Inter- national Journal of Sports Medicine. 2010; 31(08):523-528. doi.org/ 10.1055/s- 0030-1254177

43. Van Proeyen K, Szlufcik K, Nielens H, Ramaekers M, Hespel P. Beneficial metabolic adaptations due to endurance exercise training in the fasted state. *Journal of Applied Physiology*. 2011; 110(1):236-245. doi.org/10.1152/jappphysiol.00907.2010
44. Jeukendrup AE, Jentjens RL, Moseley L. Nutritional considerations in triathlon. *Sports Medicine*. 2005; 35(2):163-181. doi.org/10.2165/00007256-200535020-00005
45. Nunes CL, Matias CN, Santos DA, Morgado JP, Monteiro CP, Sousa M. Characterization and Comparison of Nutritional Intake between Preparatory and Competitive Phase of Highly Trained Athletes. *Medicina*. 2018; 54(3):1-14. doi: 10.3390 / medicina54030041
46. Tyagi P, Bhushanam GV. A comparative study on the macronutrient intake of elite Indian female weightlifters and boxers. *International Journal of Physiology, Nutrition and Physical Education*. 2021; 6(1):79-84. doi.org/10.22271/journalof-sport.2021.v6.i1b.2175
47. Wardenaar F, Brinkmans N, Ceelen I, Van Rooij B, Mensink M, Witkamp R, De Vries J. Micronutrient intakes in 553 Dutch elite and sub-elite athletes: prevalence of low and high intakes in users and non-users of nutritional supplements. *Nutrients*. 2017; 9(2):142. doi.org/10.3390/nu9020142
48. Baart AM, Balvers MGJ, de Vries JHM., Ten Haaf DSM, Hopman MTE, Klein Gunnewiek JMT. Relationship between intake and plasma concentrations of vitamin B12 and folate in 873 adults with a physically active lifestyle: a cross-sectional study. *Journal of Human Nutrition and Dietetics*. 2021; 34(2):324-333. doi.org/10.1111/jhn.12814
49. Fleming S, Costarelli V. Nutrient intake and body composition in relation to making weight in young male Taekwondo players. *Nutrition & Food Science*. 2007; 37(5):358-366. doi.org/10.1108/00346650710828389