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Morphotype and caloric ingestion and its relationship with the physical performance of Mexican boxers

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Key words: anthropometry, somatotype, nutrients, VO_2max, body composition

Abstract
Background. Boxing is a sport that generates important morpho-physiological adaptations in boxers, requiring physical monitoring from the beginning of sports preparation.
Aim. the objective of this study is to correlate physical performance with morphotype and caloric intake in Mexican boxers during physical preparation and compare them by amateur and professional group.
Methods. Quantitative, cross-sectional and comparative study carried out in August 2016 in a sample of 24 male boxers (16 amateurs and 8 professionals) participated, age 18.37±4.60 years, body weight 59.89±10.20kg and height 168.92±8.32cm. During physical preparation, body composition was evaluated with the pentacompartmental model, somatotype, caloric ingestion through 24-hour reminders (R24Hr) and physical performance.
Results. significant differences ($p<0.05$) were found in muscle mass, mesomorphic and ectomorph somatotypes, relative and absolute VO_2max and caloric protein ingestion. A predominance of the ectomorph-mesomorphic somatotype was observed in amateurs and balanced mesomorph in professionals, and a negative correlation of relative VO_2max with adipose mass (r=-0.631; p=0.001) and positive with muscle mass (r =0.503; p=0.012), in addition the absolute VO_2max shows a positive correlation with muscle mass (r=0.470; p=0.020), the mesomorphic somatotype (r=0.533; p=0.007) and negative with the ectomorph (r=-0.415; p=.044), also positive correlation with protein intake in calories (r=0.523; p=0.010).
Conclusion. both groups of boxers presented an adequate morphotype, body composition and caloric ingestion for the sports level, type of preparation and training stage they performed during the intervention, positively influencing physical-sports performance.

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Introduction

The human morphotype constitutes anthropometric characteristics used to determine body composition and somatotype parameters [Alburquerque *et al.* 2005]. It is conditioned by genetic, demographic and environmental factors [Gutnik *et al.* 2015; Singh 2017] although it may undergo modifications with diet and physical exercise [Gutnik *et al.* 2015; Cinarli, Kafkas 2019; Sánchez-Puccini *et al.* 2014]. In athletes, kinanthropometry allows to characterize the body based on basic measurements, lengths, perimeters, diameters and skinfolds [Rodriguez *et al.* 2014; Martínez-Sanz *et al.* 2012; Sánchez-Puccini *et al.* 2014] and its morphological changes that take place through the time of athletic preparation [Nykytenko *et al.* 2013; Sánchez-Puccini *et al.* 2014] or to adapt caloric intake in different periods and stages of training [Smith *et al.* 2001], mainly in adolescents, due to the influence of physical burden on pubertal maturation [Georgopoulos *et al.* 2010] and in professionals, for the benefits granted during the competition [Morton, Robertson, Sutton 2010].

In the case of male boxing, anthropometric characteristics may vary depending on the fight division and competitive level of the boxer. Generally they have long, strong and powerful arms, with agile and thin legs [Noh *et al.* 2014; Lofocco *et al.* 2016], the mesomorphic somatotype predominates [Chaabene *et al.* 2015; Tshibangu 2020], in amateur body fat ranges from 9 to 16% and in professionals from 5 to 12%, both with high development upper body muscle [Giovani *et al.* 2012; Monterrosa *et al.* 2019]. A study carried out by Pons *et al.* [2015] characterized the somatotype to 4069 high-performance athletes, among them boxers in whom the balanced mesomorphic somatotype predominated, likewise, Khanna, Manna [2006] studied the physiological profile in Indian boxers at a national level, observing mesomorphic predominance in adults and ectomorphic in minors.

Just as the appropriate morphotype in a boxer provides clear advantages in physical performance, caloric intake provides essential nutrients during these morphological changes [Durkalec-Michalski *et al.* 2016]. However, methods that can affect physical performance and health keep currently being used, such as self-induced dehydration [Aloui *et al.* 2016; Reale 2018], extra training [Hall, Lane 2001] and caloric restriction days prior to competition [Dunican *et al.* 2019]. On the contrary, scientific evidence describes benefits that make athletes to adapt caloric intake from the beginning of physical and sports preparation [Holway, Spriet 2011; Smith *et al.* 2001], establishing a decrease in body fat by dietary planning [Shin *et al.* 2012] allowing new protocols or nutritional methods to be established in athletes, such as McSwiney *et al.* [2018] who evaluated effects of diet on performance and body composition in athletes, resulting in progress in aerobic capacity and lean mass with ketogenic diet, and Pons *et al.* [2018] resulting in improvements in mitochondrial biosynthesis by moderately restricting daily caloric intake.

Scientific advances in the areas of physical performance have led those responsible for nutrition in athletes to understand the physiological changes caused by sports training and being more specific when recommending a nutritional plan to athletes [Devlin *et al.* 2017; Silva 2019] before, during, and after a sports preparation. Also, perform evaluations that allow coaches to monitor and control training loads [Monterrosa *et al.* 2019], know the development of conditional physical abilities [Garzon *et al.* 2013; Negrea *et al.* 2019; Martsiv 2015], physiological development [Moskovchenko *et al.* 2018] and genetic aspects [Gutnik *et al.* 2015] in their trained. Based on this approach, the objective of this study is to correlate physical performance with morphotype and caloric ingestion in Mexican boxers during physical preparation and compare them by an amateur and professional group.

Materials and methods

Subjects

Quantitative, cross-sectional and comparative study carried out in August 2016 in a sample of 24 male boxers (16 amateurs; age 15 to 17 years, height 152 to 186 cm and body weight 43.90 to 81.50 kg and 8 professionals; age 18 to 26 years, height 163 to 182.5 cm and body weight 59.90 to 77.60 kilograms) who trained uninterruptedly six days a week in a boxing gym located in Hermosillo, Sonora. The sample was selected for convenience and was stratified by sports expertise (amateur and professional). All amateur boxers had experience in national competitions (state and national Olympics) or international competitions (Central and Panamerican games). Professional boxers had more than five professional fights, in addition, there was a world champion by the World Boxing Council and all had national and international fights when they were amateur.

Procedure and instruments

Boxers were evaluated during the first mesocycle of physical preparation. Prior to conducting the assessments, professional boxers were asked to sign an informed consent according to Helsinky statement and the authorization of parents or guardians to evaluate amateur boxers.

Anthropometric measurements

Anthropometric measurements were performed by a technician certified by the International Society of Advances in Kineanthropometry (ISAK) and sports dieticians supported in recording the values obtained, following the recommendations of Ulijaszek, Kerr [1999]. Each participant was measured barefoot, without a shirt and in shorts. In total, 29 anthropometric variables were measured in each participant (4 basic, 7 diameters, 10 perimeters and 8 cutaneous folds), all on the right side and with duplicate to take the average of each measurement, considering the technical error of measurement (TEM) as indicated by ISAK. Body weight was measured with Tanita® brand scale, Ironman® rd-901 model and height with the Seca® portable stadiometer, model 2013. Skinfolds triceps, subscapular, biceps, iliac crest, supra spinal, abdominal, thigh and leg were evaluated with Harpenden brand plicometer (British Indicators, UK), constant pressure of 10 g/ mm^2 on contact. The diameters of the humerus, femur, biacromial, biiliocristal, transverse thorax and anterior-posterior thorax were measured with the professional Smartmet anthropometer brand. The perimeters of the head, relaxed arm, flexed and contracted arm, forearm, thorax, waist, hip, maximum thigh, middle thigh and leg were measured with 0.5cm inextensible metal tape, Lufkin® WP-606 brand (range 0-150cm).

Body composition or body masses

Body composition was determined using the penta-compartmental model established by Kerr [1988] that evaluates fat, muscle, residual, bone and skin mass. The bicompartmental method was used to estimate the percentage of body fat, with equations *D = 1.0988 - 0.0004 x (Σ7 skinfolds)*, proposed by Withers *et al.* [1987], where D = density, Σ7=sum of tricipital, bicipital, subscapular, abdominal, supraespinal, frontal thigh and middle calf and Siri [1956] which sets *%body fat = [(4.95/ D) – 4.50] x 100*. The fat-free mass (FFM) was obtained by subtracting the body fat in kilograms from the total body weight *FFM = total weight (kg) – body fat (kg)*.

Somatotype

The somatotype was calculated using the equations of Carter, Heath [1990], to identify the endomorphic, mesomorphic and ectomorphic components in each participant, where the equations were as follows [Singh, 2017]:

Endomorphic = -0.7182 + 0.1451 x (tricipital fold + subscapular fold + suprailiac fold) x (170.18/Height in cm).

Mesomorphic = (0.858 x humerus diameter + 0.601 x femur diameter + 0.188 x corrected arm perimeter + 0.161 x corrected calf perimeter) - (height in cm x 0.131) + 4.5 corrected arm perimeter (cm) = arm perimeter – tricipital fold (cm).

To know the ectomorphic parameter, the weight index (WI) was calculated with the equation "(height (cm)/cubic root of body weight (kg)". With the result obtained from the WI, it was categorized with the criterion (If WI > 40.75, then it was ectomorphic = (WI x 0.732) - 28.58), (If WI < 40.75 y > 38.28, then it was ectomorphic = (WI x 0.463) – 17.63) and (If WI ≤ 38.28, then it was ectomorphic = 0.1.

From the result of the three components, the somatotype was represented in a graph using axes and coordinates X and Y, where:

X axis = ectomorphic – endomorphic; Y axis = (2 x mesomorphic – (endomorphic – ectomorphic))

Caloric intake

Caloric intake was estimated using direct interview to apply R24Hr. Each participant was interviewed by a sports dietitian with previous training and standardized in application of the instrument, which were applied on three occasions (2 days of training and 1 day after the rest day). In each interview, participants had access to replicas of kitchen utensils and food (Ferrari 2013) so that they would approximate the amount and type of food consumed 24 hours prior to the interview [Suliburska *et al.* 2016].

Physical Performance

Physical performance was evaluated by determining aerobic power (VO_2max relative and absolute) through the Course Navette test, which establishes a round-trip race at a distance of 20 meters, starts at a speed of 8.5 km/h and increases 0.5 km/h every minute until the exhaustion of the participant or reaching the last period. In professional boxers (>18 years), VO_2max was determined with the equation "*VO_2max = 5.87 x maximum speed (km/h) — 19.458*" [Monterrosa *et al.* 2019] and in amateur (< 18 years), VO_2max = 31, 025 + (3, 238 × VA) – (3, 248 × E) + (0, 1536 × VA × E) E: age in years; VA: speed achieved in km/h [García, Secchi 2014]. The result was relative (ml/min/kg), to obtain the absolute value (l/min) the equation VO_2max relative * body weight/1000 was used.

Statistical analysis

Descriptive with mean more standard deviation (M±SD) and inferential analyses were performed using the t-student test to compare anthropometric characteristics, body composition, caloric intake and VO_2max (relative and absolute) and analysis of variance (ANOVA) for compared weight category, applying a significance in $p < 0.05$. The distribution of somatotype by subject was plotted in Microsoft Excel® spreadsheet. Relative and absolute VO_2max were correlated with the somatotype (endomorphic, mesomorphic and ectomorphic), body composition (adipose mass, muscle mass and fat mass) and caloric intake (total, protein and carbohydrates) with Pearson´s correlation coefficient. All statistical analyzes were carried out with the Statistica 8.0 software (StatSoft®, 2008).

Results

Table 1 presents the results of basic anthropometric measurements, age and body weight showed significant differences. It can be observed that in the different measurements (basic, diameters and perimeters) significant differences were obtained, where professional boxers presented larger morphological characteristics compared to amateurs. Regarding skinfolds, no significant differences were observed between both groups.

Table 1. Comparison of basic anthropometric measurements, perimeters, diameters and skinfolds in amateur and professional boxers.

	Amateur (n=16)	Professionals (n=8)	*p* value
Basic			
Age (years)	15.50 ± 0.63	24.13±3.48	0.000*
Body mass (kg)	56.23 ± 9.88	67.21±6.41	0.010*
Height (cm)	167.70 ± 8.83	171.36±7.07	0.320
Sitting height (cm)	86.64 ± 3.94	87.80±4.45	0.521
Diameters (cm)			
Biacromial	37.79 ± 2.46	40.83 ± 2.70	0.011*
Transverse thorax	26.74 ± 1.51	29.94 ± 1.74	0.000*
Anterior-posterior thorax	19.06 ± 4.43	27.15 ± 9.61	0.009*
Biiliocristal	29.01 ± 1.53	29.35 ± 1.07	0.576
Humerus	6.38 ± 0.49	6.81 ± 0.69	0.086
Wrist	5.24 ± 0.36	5.54 ± 0.66	0.166
Femur	8.71 ± 0.56	9.39 ± 0.87	0.029*
Perimeters (cm)			
Head	54.31 ± 1.41	55.63 ± 1.19	0.035*
Relaxed arm	26.16 ± 2.50	28.40 ± 1.06	0.025*
Flexed and contracted arm	28.34 ± 2.70	31.39 ± 1.85	0.009*
Forearm	24.31 ± 1.66	25.90 ± 1.14	0.024*
Thorax	83.74 ± 5.37	92.58 ± 4.85	0.001*
Waistline	69.50 ± 5.93	75.08 ± 9.45	0.089
Hip	85.06 ± 4.99	90.06 ± 4.72	0.028*
Maximum thigh	49.69 ± 4.32	54.06 ± 4.22	0.028*
Middle thigh	47.28 ± 5.02	50.40 ± 2.83	0.119
Leg	32.50 ± 2.74	34.68 ± 2.12	0.063
Skinfolds (mm)			
Biceps	3.73 ± 1.36	3.69 ± 0.94	0.936
Triceps	7.34 ± 2.84	7.98 ± 2.01	0.578
Subscapular	8.04 ± 1.83	9.14 ± 3.33	0.303
Supra spinal	7.29 ± 5.61	9.75 ± 4.76	0.300
Iliac crest	8.51 ± 5.22	9.01 ± 3.25	0.808
Abdominal	10.34 ± 5.41	12.20 ± 5.36	0.436
Thigh	10.72 ± 5.16	8.99 ± 3.08	0.395
Leg	8.83 ± 3.09	7.35 ± 2.33	0.246
∑6 folds	53.78 ± 19.73	54.66 ± 11.56	0.909
∑7 folds	56.29 ± 20.29	59.09 ± 13.39	0.728

kg = kilograms; cm = centimeters; mm = millimeters; * = significant difference ($p < 0.05$).

The distribution of somatotype by subject and average of amateur and professional boxers is shown in Figure 1. A varied somatotype distribution can be observed among this group of boxers, where one is a central biotype, three endomorphic-mesomorphic, three balanced mesomorphic, three meso-ectomorphic, two ecto-mesomorphic and four balanced ectomorphic. On average, amateur boxers present an ectomorphic-mesomorphic biotype. The distribution of the somatotype in professional boxers can be observed two endomorphic-mesomorphic biotypes, one meso-endomorphic, three balanced mesomorphic, one meso-ectomorphic and one ectomorph-mesomorphic, predominating the balanced mesomorphic biotype.

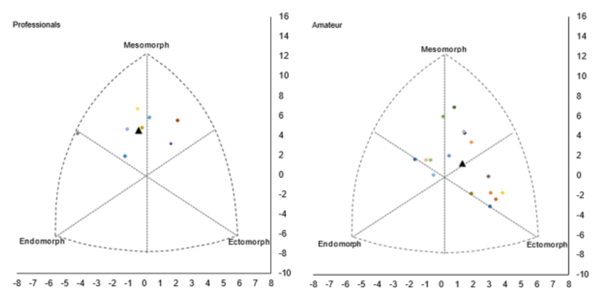

Figure 1. Distribution of somatotype and average in amateur and professional boxers. ▲ = average somatotype.

When comparing body composition, somatotype distribution by group and average (Table, 2), significant differences were observed ($p < 0.05$), in muscle mass and skin, although when fractioning fat mass to percentage of body fat and bone mass and residue, no significant differences were observed ($p > 0.05$) between both groups. In endomorphic and ectomorphic somatic components there were no significant differences between both groups, although it was different ($p < 0.05$) in the mesomorphic component, where professional boxers tend to be more mesomorphic compared to the amateur group.

Table 2. Comparison of body composition and somatotype in amateur and professional boxers.

	Amateur (n=16)	Professionals (n=8)	*p* value
Body composition (%)			
Adipose mass	25.79 ± 4.20	22.62 ± 1.88	0.055
Muscle mass	43.03 ± 3.49	45.90 ± 2.46	0.051*
Residue	11.84 ± 1.06	13.30 ± 3.10	0.099
Bone mass	13.20 ± 1.16	12.78 ± 1.36	0.438
Skin	6.14 ± 0.58	5.40 ± 0.38	0.004*
Fat mass	9.94±3.49	10.40±2.29	0.737
Somatotype			
Endomorphic	2.24 ± 0.83	2.66 ± 1.03	0.289
Mesomorph	3.51 ± 1.13	4.75 ± 0.64	0.009*
Ectomorphic	3.59 ± 1.09	2.35 ± 0.98	0.013*
Physical performance			
VO_2max (ml/min/kg)	45.61 ± 4.97	54.32 ± 5.45	0.001*
VO_2max (l/min)	2.56 ± 0.97	3.64 ± 0.45	0.000*

% = percentage; * = significant difference ($p < 0.05$).

Table 3 presents the comparisons of total caloric intake distributed in proteins, fats and carbohydrates among amateur and professional boxers. Higher protein consumption ($p < 0.05$) was observed in the professional boxers group (593.54 ± 230.26kcal.) compared to the amateur group (407.93 ± 165.57kcal.). On the other hand, the intake of macronutrients in grams per kilogram, total caloric intake, fat calories and carbohydrate calories was similar among amateur and professional boxers ($p > 0.05$).

Table 3. Comparison of total and distributed caloric intake in proteins, fats and carbohydrates in amateur and professional boxers.

	Amateur (n=16)	Professionals (n=8)	p value
Caloric intake	2528.59 ± 703.45	2898.38 ± 667.81	0.236
Proteins	407.93 ± 165.57	593.54 ± 230.26	0.036*
Fats	859.70 ± 364.21	957.69 ± 301.52	0.523
Carbohydrates	1260.97 ± 307.93	1340.03 ± 368.34	0.589
Ingestion of macronutrients (g/kg/day)			
Proteins	1.77 ± 0.61	2.17 ± 0.66	0.159
Fats	1.71 ± 0.75	1.57 ± 0.42	0.637
Carbohydrates	5.67 ± 1.72	4.99 ± 1.34	0.343

* = significant difference ($p < 0.05$); g/kg/day = grams per kilogram of body weight per day.

When comparing the caloric intake by weight category in amateur and professional boxers (Table 4), no significant differences were observed in amateurs. On the other hand, within professional boxers, a higher caloric intake of protein and fat was observed ($p < 0.05$) in those who made up the heavy weights.

When comparing the maximum relative and absolute VO_2max, significant differences were observed, the relative result in amateur boxers was 45.61 ± 4.97 ml/min/kg and in professionals 54.32 ± 5.45 ml/min/kg ($p < 0.001$) and absolute had 2.56 ± 0.47 l/min/kg in amateur boxers and 3.64 ± 0.45 l/min/kg in professionals ($p < 0.000$). Table 5 shows the correlations of the relative and absolute maximum VO_2max with body composition, somatotype, caloric intake and macronutrients ingestion per kilogram of body weight per day. When correlating the relative max VO_2max with the variables body composition, somatotype and caloric intake, it was possible to observe a negative correlation between the relative max VO_2max with the adipose mass (r = -0.631; $p < 0.001$) and positive with muscle mass (r = 0.503; $p < 0.012$), without correlating with somatotype, caloric intake and ingestion of macronutrients per kilogram of body weight per day. On the other hand, it was observed that the absolute maximum VO_2max had positive correlation with muscle mass (r = 0.470; $p < 0.020$), mesomorphic somatotype (r = 0.533; $p < 0.007$) and negative correlation with ectomorphic (r = -0.415; $p < 0.044$). Also, positive correlation was obtained with protein intake in calories (r = 0.523; $p < 0.010$). No correlation was observed with body composition, endomorphic somatotype, total caloric intake, lipids and carbohydrates, as well as caloric ingestion and ingestion of macronutrients in grams per kilogram of body weight per day.

Discussion

This study aimed to correlate physical performance with morphotype and caloric intake in Mexican boxers during physical preparation and compare them between an

Table 4. Comparison of the total caloric intake and distributed in proteins, fats and carbohydrates by category of low weights, medium weights and heavy weights in amateur and professional boxers.

	Low weights	**Medium weights**	**heavy weights**	**p value**
Amateur				
Caloric intake	2343.54±712.02	2705.07±669.86	◖◖	0.372
Proteins	333.28±145.70	486.37±117.13	◖◖	0.068
Fats	804.52±366.55	869.31±371.83	◖◖	0.758
Carbohydrates	1205.74±332.43	1349.39±305.72	◖◖	0.442
Ingestion of macronutrients (g/kg/day)				
Proteins	1.63±0.66	1.94±0.55	◖◖	0.387
Fats	1.78±0.82	1.57±0.76	◖◖	0.646
Carbohydrates	6.02±1.97	5.38±1.25	◖◖	0.527
Professionals				
Caloric intake	◖◖	2460.19±603.59	3336.57±405.29	0.053
Proteins	◖◖	433.55±117.16	753.54±204.25	0.035*
Fats	◖◖	752.63±133.08	1162.75±286.86	0.041*
Carbohydrates	◖◖	1274.01±436.40	1406.06±338.38	0.649
Ingestion of macronutrients (g/kg/day)				
Proteins	◖◖	1.76±0.51	2.57±0.57	0.080
Fats	◖◖	1.35±0.19	1.80±0.50	0.147
Carbohydrates	◖◖	5.13±1.58	4.86±1.28	0.801

* = significant difference ($p < 0.05$); ◖◖ = No enough data available; g/kg/day = grams per kilogram of body weight per day.

amateur and professional group. The results allowed to observe some larger diameters and perimeters in professional boxers, mainly upper body and thighs, which are most commonly used in boxing. The differences could be due to morphological maturity, training loads and competitive level among groups of boxers, generating various specific morphological adaptations derived from the intensity, frequency and muscle planes used to exercise the movements during training sessions [Gucluover *et al.* 2019], such as in the case of changes in the upper extremities, a result of constant hitting [Guidetti, Muslim, Baldari, 2002] or changes in the thickness of the Achilles and patellar tendon in elite athletes, product of specific adaptation to the sport [Cassel *et al.* 2017].

Table 5. Correlation of the maximum relative and absolute VO_2 with body composition, somatotype, total caloric intake and per macronutrients in grams per kilogram of body weight per day.

	Relative (ml/kg/min)		Absolute (l/kg/min)	
	r	*p* value	r	*p* value
Body composition				
Adipose mass	-0.631	0.001*	-0.373	0.073
Muscle mass	0.503	0.012*	0.470	0.020*
Fat mass	-0.403	0.051	0.114	0.596
Somatotype				
Endomorphic	-0.232	0.275	.235	0.269
Mesomorphic	0.403	0.051	.533	0.007*
Ectomorphic	-0.082	0.703	-.415	0.044*
Caloric intake				
Total	-0.138	0.530	.224	0.305
Proteins	-0.001	0.997	.523	0.010*
Lipids	-0.249	0.252	.049	0.824
Carbohydrates	-0.053	0.810	.081	0.714
Ingestion of macronutrients (g/kg/day)				
Proteins	-0.088	0.689	0.279	0.198
Lipids	-0.342	0.110	-0.327	0.128
Carbohydrates	-0.165	0.451	-0.403	0.056

VO_2max = maximum oxygen consumption; r = correlation coefficient; * = significant difference ($p < 0.05$); ml/min/kg = milliliter per minute per kilogram of body weight; l/min/kg = liters per minute per kilogram of body weight; g/kg/day = grams per kilogram of body weight per day.

The results obtained with respect to the comparison of body composition and somatotype showed professional boxers to be more muscular, with less fat mass and greater mesomorphy compared to the amateur group. When comparing fat mass, it was observed that both groups maintain similar values ($p > 0.05$), although there are few studies that characterize these variables in boxers, the results coincide with those reported by Chaabene *et al.* [2015], Khanna, Manna [2006] when experienced boxers are involved in national competitions. On the other hand, when plotting the somatotype by groups, balanced mesomorphic was obtained in professionals and ectomorphic-mesomorphic in amateurs. Results in previous studies, such as Pons *et al.* [2015] and Chaabene *et al.* [2015] confirm that somatotype in boxers varies between categories, although most have a tendency to develop high muscle percentage and low body fat levels predominating mesomorphic somatotype, however, Khanna, Manna [2006] report that somatotype in amateur boxers is more oriented to ectomorphy. It should be noted that these somatotypic variations may be due to the degree of biological maturity [Chaabene *et al.* 2015], genetic [Gutnik *et al.* 2015; Singh 2017], experience in the practiced sport [Cinarli, Kafkas 2019; Sanchez-Puccini *et al.* 2014) and diet [Mazzeo *et al.* 2016].

In the case of a diet, both groups ingested a similar amount of calories ($p > 0.05$), although protein ingestion was higher ($p < 0.05$) in professional boxers (593.54 ± 230.26kcal) compared to amateurs (407.93 ± 165.57kcal) and between them, who were of heavy weight (753.54±204.25kcal), respect to medium weight (433.55±117.16kcal) being able to make the difference in adipose mass, muscle mass and mesomorphy between the two groups. However, after comparing the protein intake in grams per kilogram, it was observed that it was similar in both groups (1.77 ± 0.61g/kg/day; amateur and 2.17 ± 0.66g/kg/day; professionals) and similar between low, medium and heavy weight categories could allow boxers better body composition, decreased body fat and tissue regeneration affected by muscle microcracks caused by daily training load [Bermon *et al.* 2017; Doering *et al.* 2016], because the daily ingested amount meets the recommendation (1.6-2.4g/kg/day) as described by Hector, Phillips [2018] in adequate body weight reduction in elite athletes or Garthe, Raastad, Sundgot-Borgen [2011] to avoid unhealthy diets days before a competition, they highlight consuming between 1.2 to 1.8g/kg/day of protein when athletes are gradually decreasing body weight.

Among the limitations of the study is the intervention in a single training period to avoid interrupting boxers during their daily sessions, in addition, there was a lack to analyze and compare the consumption of micronutrients among groups of boxers, due to the action they exert in the regulation in various processes ranging from energy production to the generation of new cells and proteins [Molina-Lopez *et al.* 2020], which is necessary for adolescent athletes because they are in growth and development and professionals who have more specific and intense training, leading to cell inflammation and oxidative stress [Marin *et al.* 2013]. However, it is important to emphasize that both groups complied with the recommended daily intake of macronutrients (1.6-2.4g/kg/day; proteins, 5-8g/kg/day; carbohydrates and 20-35%; lipids) according to Garthe, Raastad, Sundgot-Borgen [2011]; Sanz, Otegui, Ayuso [2013] and Smith *et al.* [2001] for the kind of physical preparation they were in and the metabolic needs of boxers. Also, in the future studies the sample can be increased to compare by fight division.

On the other hand, a positive correlation was observed between VO_2max with the ingestion of proteins in grams per kilogram of body weight, it can be noted that protein ingestion in addition to influencing the loss of body fat [Garthe *et al.* 2011] and regeneration of muscle tissue [Bermon *et al.* 2017] influences the improvement of VO_2max and this at the same time in generating structural adaptations with which hypertrophy will improve hypertrophy, strength and muscle power [Dominguez, Garnacho-Castano, Mate-Munoz 2016], in addition to supporting the metabolic demands generated during the training or competition sessions [Chaabene *et al.* 2015]. These findings expand and reinforce the importance of the multidisciplinary team in sports to control and supervise athletes in various stages of performance and preparation, prioritizing enhancing physical and motor qualities [Nykytenko *et al.* 2013], reducing the likelihood of generating injuries caused by physical overload [Bolach *et al.* 2016] and allow for better aerobic capacity to enable improvements in physical performance and health care.

Conclusions

The body composition of boxers can influence physical performance during physical preparation, so that, the lower percentage of adipose tissue and fat mass, muscle mass is increased by generating better physical performance.

The somatotype varies according to the competitive level, where professional boxers tend towards balanced mesomorphy and amateurs towards ectomorphy-mesomorphy.

Caloric intake allows the improvement of physical performance in boxers during physical preparation, also influencing body composition and somatotype during physical preparation.

The amateur and professional boxers presented an adequate morphotype, body composition and caloric intake for the sporting level, type of preparation and training stage in which they were during the intervention.

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Morfotyp i spożycie kalorii oraz ich związek z wydolnością fizyczną meksykańskich bokserów

Słowa kluczowe: antropometria, somatotyp, składniki odżywcze, VO_2max, skład ciała

Streszczenie

Tło. Boks jest sportem, który generuje ważne adaptacje morfofizjologiczne u bokserów, wymagające fizycznego monitorowania od początku przygotowań sportowych. Celem niniejszego badania było skorelowanie wydolności fizycznej z morfotypem i spożyciem kalorii u meksykańskich bokserów podczas przygotowania fizycznego i porównanie ich w grupie amatorskiej i zawodowej.

Metody. Ilościowe, przekrojowe i porównawcze badanie przeprowadzone zostało w sierpniu 2016 r. na próbie 24 bokserów płci męskiej (16 amatorów i 8 zawodowców), w wieku 18,37±4,60 lat, o masie ciała 59,89±10,20 kg i wzroście 168,92±8,32 cm. Podczas przygotowania fizycznego oceniano: skład ciała (za pomocą modelu pięciokomorowego), somatotyp, spożycie kalorii za pomocą 24-godzinnych przypomnień (R24Hr) oraz wydolność fizyczną.

Wyniki. Stwierdzono istotne różnice ($p<0,05$) w masie mięśniowej, somatotypach mezomorficznym i ektomorficznym, względnym i bezwzględnym VO_2max oraz spożyciu kalorycznego białka. Zaobserwowano przewagę somatotypu ektomorficzno-mezomorficznego u sportowców amatorów i zrównoważonego mezomorficznego u profesjonalnych sportowców oraz ujemną korelację względnego VO_2max z masą tłuszczową ($r=-0,631$; $p=0,001$) i dodatnią z masą mięśniową ($r=0,503$; $p=0.012$), ponadto bezwzględne VO_2max wyka-

zuje dodatnią korelację z masą mięśniową (r=0,470; p=0,020), somatotypem mezomorficznym (r=0,533; p=0,007) i ujemną z ektomorficznym (r=-0,415; p=,044), a także dodatnią korelację ze spożyciem białka w kaloriach (r=0,523; p=0,010).
Wnioski. Obie grupy bokserów prezentowały odpowiedni morfotyp, skład ciała i spożycie kalorii dla poziomu sportowego, rodzaju przygotowania i etapu treningu, który wykonywali podczas interwencji, pozytywnie wpływając na wyniki fizyczno-sportowe.