

Changes in body composition and physical performance of professional mixed martial arts athletes between the preparatory and pre-competitive periods

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Resumen

Introducción: El objetivo de este estudio fue investigar los cambios en la composición corporal, la forma corporal, la fuerza isométrica, la flexibilidad y la capacidad cardiorrespiratoria en función de la fase de entrenamiento. Se observaron seis atletas de MMA de alto rendimiento durante la fase preparatoria y competitiva. Se observó una disminución significativa de la masa corporal, masa adiposa, masa residual, grasa corporal, suma de 6 pliegues cutáneos, índice de masa corporal (IMC) y endomorfia. Sin embargo, no se identificaron diferencias significativas en las fortalezas físicas de flexibilidad, resistencia aeróbica, fuerza isométrica absoluta y relativa escapular y lumbar. En cuanto a la fuerza manual, se encontró una diferencia significativa en la fuerza isométrica relativa, pero no en la fuerza absoluta. Por lo tanto, se puede concluir que los principales cambios entre el período preparatorio y competitivo en atletas de alto rendimiento de MMA se observaron en la composición y forma corporal.

Palabras Clave: MMA, Composición corporal, Valencias físicas, Somatotipo.

Abstract

Introduction: Vertical jump performance is an important measure of leg power and explosiveness in sports. Somatotype, referring to body shape and composition. It may relate to vertical jump capacity. This study aimed to compare vertical jump, peak anaerobic power, and relative anaerobic capabilities between ectomorphic-mesomorph and mesomorphic-ectomorph somatotypes among sedentary male students. **Methods:** A total number of 26 students participated in this study. Participants underwent anthropometric assessments to determine Heath-Carter somatotype ratings. Additionally, countermovement jumps were performed to evaluate vertical jump height, estimate peak anaerobic power via the Sayers equation, and calculate a power-to-body mass ratio. **Results:** No statistically significant differences were found between ectomorphic-mesomorphs ($n=15$) and mesomorphic-ectomorphs ($n=11$) for vertical jump (54.47 ± 8.33 cm vs 57.09 ± 6.28 cm, $p = 0.25$), peak anaerobic power (3576 ± 542.01 W vs 3473.47 ± 538.71 W, $p = 0.64$), or power-to-body mass ratio (69.97 ± 10.51 W/kg vs 65.10 ± 7.46 W/kg, $p = 0.18$). **Conclusion:** While this initial study suggested no substantial performance differences based on somatotype, further research with increased statistical power through larger sample sizes is necessary to conclusively determine relationships between physique and anaerobic capacities in the general population. Matching and tracking athletes over sports training may also clarify advantages conferred by morphology alone.

Keywords: Anthropometry, Sedentary, Anaerobic Power, Power-to-body mass ratio

Introduction

A well-organized training plan is essential to maximize athletes' physical improvement potential. In most sports, the annual cycle is divided into preparatory, competitive, and transition phases, whose duration is influenced by the competition schedule, as well as the time needed to enhance specific skills and physical abilities (Bompa and Buzzichelli, 2023).

In MMA, the complexity in training periodization arises from the need to simultaneously develop aerobic and anaerobic capacities, as well as specific skills such as various strikes and attacks involving strength and power (Kirk et al., 2020). Thus, MMA incorporates movements from various martial arts, such as Brazilian jiu-jitsu, boxing, taekwondo, muay thai, wrestling, karate, and judo (James et al., 2016). While judo, jiu-jitsu, and wrestling mainly rely on dynamic and static strength, kung fu, karate, boxing, and muay thai largely depend on explosive strength of the upper and lower limbs (Dantas, 2016). Additionally, differences in physical capacities across weight divisions have been observed, such as in standing combat distance, strike frequency, and clinch (Miarka et al., 2017). These sets of physical demands may vary according to each combat strategy, influencing athletes' physical capacities, and consequently, their body composition.

Significant improvements were observed in the physical capacities of VO₂max, power, strength, speed, and body composition after 4 weeks of specific training in experienced MMA athletes, with a training frequency of 3 times per week (Kostikiadis et al., 2018). Changes in biomarkers (myoglobin, tumor necrosis factor, creatine kinase, and interleukin 6) during training periodization in MMA athletes have been reported, contributing to explaining these changes in physical capacity and body composition due to physiological adaptation and supercompensation in response to training (Tota & Wiecha, 2021).

Studies aiming to investigate the effects of training on somatic variables, as well as physical performance in MMA athletes, are scarce (Tota et al., 2019). Therefore, the aim of this study was to compare body composition, body shape, and physical capacities in different phases of training in high-performance MMA athletes.

Material and Methods

The sample was made up of 6 high-performance adult mixed martial arts athletes (1 medium heavyweight; 1 middleweight; 3 lightweight; 1 bantamweight). All participants competed in international MMA events (UFC; Shoto; LFA) and were between 24 and 34 years of age (average 28 years). The assessments were carried out 6 to 8 weeks (preparatory period) and between 7 and 14 days before the fight (competitive period). Muscular strength training occurred 3 times a week, while fight-specific training occurred 6 times a week. The first assessment took place at the end of general physical preparation and the second at the end of the specific training phase. All athletes remained in the same category taking into account the last fight.

Body Composition and Somatotype

All anthropometric measurements (43 measurements) followed the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) carried out in duplicates and when necessary in triplicates (basic measurements: less than 1%; Skinfolds: less than 5%), the value considered was the mean or median (in triplicate measurements). All measurements were carried out by the same anthropometrist (level 2 - ISAK) in an environment with an average temperature of around 23° C, a temperature measured using a Xiaomi Mija 2® digital thermometer. All assessments were carried out at 4 pm with the volunteers measured barefoot and wearing a bathing suit.

Body composition was determined using a body mass fractionation model into 5 components: adipose, muscle, bone, residual and skin mass (Norton et al., 1996; Kerr & Ross, 1988). The model by Martin and collaborators (1994) was used to estimate the percentage of fat for men. Using anthropometric techniques, the somatotype was calculated as suggested by Carter and Heath (1990)

Physical Tests

Sit and Reach Test (Wells): The sit and reach test was used to measure linear flexibility. It consists of measuring the distance between the dactylion and the plantar region, with the individual seated, knees extended, and the sole of the foot resting on the base of the Wells bench.

Also was measured Maximum isometric strength using specific dynamometry devices. Isometric strength of finger flexors, scapular adductors, and trunk and knee extensors were evaluated.

Hand Dynamometry: With the individual standing, arms by their sides, they were instructed to grip the traction bar at the distal phalanx of the last four fingers and the support bar on the last four metacarpals. They were asked to flex their fingers as much as possible. The hand dynamometer from Instrumen® with a maximum capacity of 90kgf was used.

Scapular Dynamometry: With the individual standing, feet parallel, holding the dynamometer with both hands and elbows away from the body. The test was performed with the individual exerting maximum force

possible in scapular adduction. The scapular dynamometer from CROWN® with a maximum capacity of 50kgf was chosen for the test.

Dorsal Dynamometry: Participants were instructed to stand at the base of the device, knees semi-flexed at an angle of approximately 120°, spine erect, arms by their sides, and elbows extended. Participants were instructed to exert maximum force possible. The dorsal dynamometer from CROWN® with a maximum capacity of 200kgf was used for the test.

Astrand Test (cycle ergometer): The test was performed at 50 rpm (revolutions per minute) with a load of 150w. Heart rates were measured at the 5th and 6th minutes to estimate VO_2max using a nomogram, calculated as for men $(195-61/\text{HR}-61) \times \text{VO}_2$ of the load. The VO_2max of the load consists of: VO_2max of the load = $0.014 \times \text{load in Watts} + 0.129$ and the average HR obtained between the 5th and 6th minute. The test was conducted using a Monark pendulum cycle ergometer with mechanical braking. Resistance was given in kiloponds (Kp). Heart rate was measured using a Polar heart rate monitor with chest strap.

Statistical Analysis

To investigate the differences between the preparatory and competitive periods regarding body composition, somatotype, and physical capabilities, we conducted a paired t-test, adopting a significance level of $p < 0.05$ to identify significant differences. The Shapiro-Wilk test was used to assess the normality of the data. GraphPad Prism 8.0® software was employed to conduct the aforementioned statistical tests.

Results

After the preparatory period, significant changes were observed in the body composition of professional MMA athletes.

Table 1. Comparison between body composition between the preparatory and pre-competitive period of Fighters.

Body Composition	Preparatory		Competitive		p
	Mean	SD	Mean	SD	
Body mass (kg)	90,47	9,20	84,74	9,58	0,0015
Muscle mass (%)	52,55	1,89	54,58	2,29	0,0006
Muscle mass (kg)	47,80	6,05	46,37	6,6	0,0631
Adipose mass (%)	20,65	1,91	17,82	1,57	0,0001
Adipose mass (kg)	18,48	1,96	15,07	1,79	0,0001
Residual mass (%)	11,00	0,43	11,04	0,38	0,7186
Residual mass (kg)	10,01	1,29	9,39	1,18	0,0173
Bone mass (%)	10,93	0,95	11,58	1,33	0,0237
Bone mass (kg)	9,81	1,13	9,75	1,02	0,3834
Skin mass (%)	4,88	0,21	4,97	0,29	0,4933
Skin mass (kg)	4,34	0,39	4,22	0,34	0,0732
Body fat (%)	12,07	1,64	9,8	1,24	0,0001
Body fat (kg)	10,80	1,50	8,41	1,32	0,0002
$\sum 6$ Skinfolds (mm)	59,05	5,19	41,11	4,02	0,0001
Bone-muscle index (kg)	4,86	0,52	4,78	0,71	0,4862
BMI (kg/m^2)	27,36	1,34	25,53	1,53	0,0011
Endomorphy	2,61	0,37	1,78	0,26	0,0007
Mesomorphy	6,26	1,01	6,06	0,98	0,1875
Ectomorphy	1,28	0,55	1,88	0,7	0,0028

$\sum$ = sum; n = athletes; p = statistical significance between categories; SD= Standard deviation.

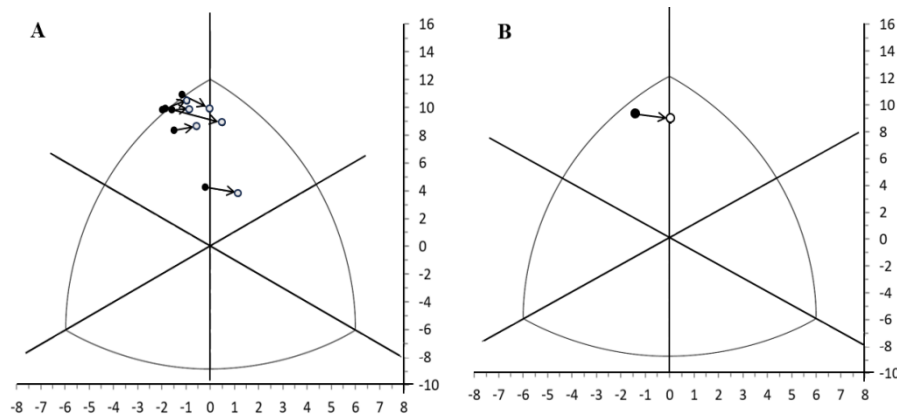


Figura 1. A = Disposition of volunteers under somatocarta during the preparatory and pre-competitive period. B = Somatopoint of the average value of the athletes in each period. The black circle represents the preparatory period, while the white circle indicates the pre-competitive period.

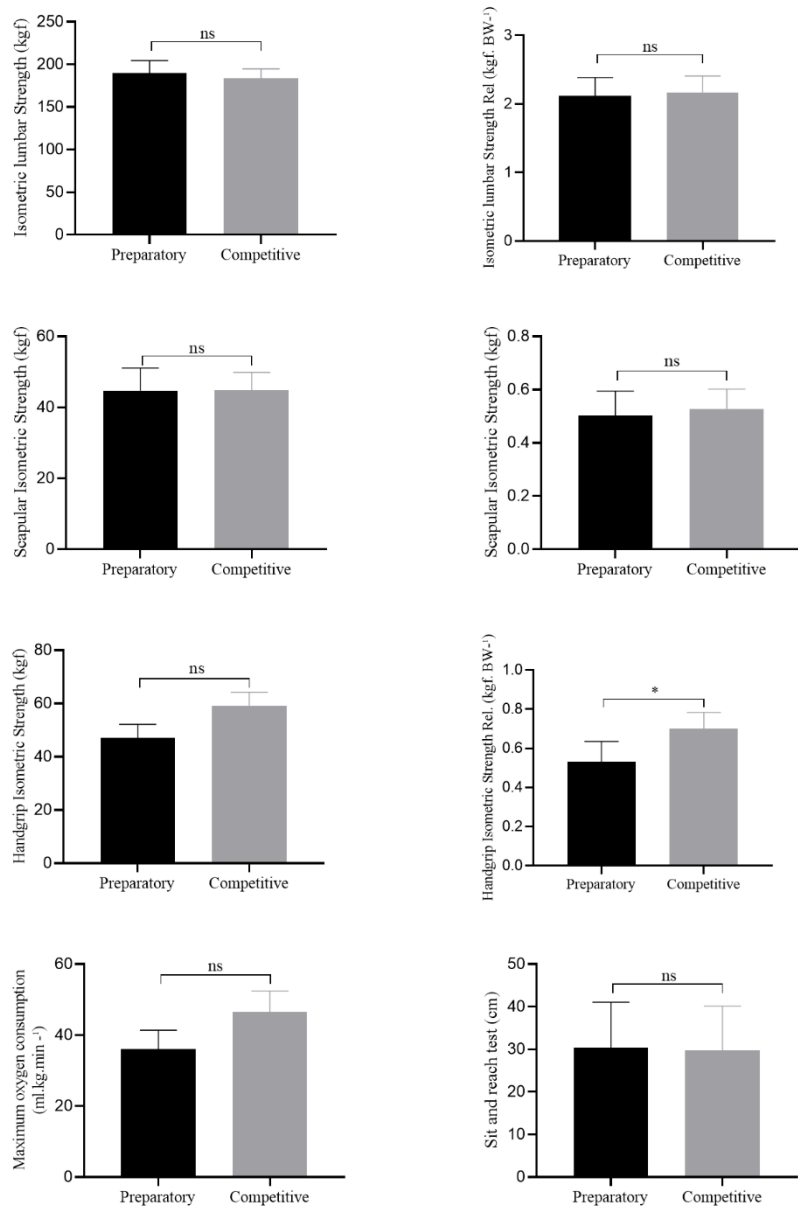


Figura 2. Comparison between physical values the preparatory and pre-competitive period.

However, no significant differences were observed in aerobic fitness, flexibility, and isometric strength of the scapular and lumbar muscles. The percentage of muscle mass in athletes increased by an average of 2%; however, there were no significant differences in absolute muscle mass. The percentage of adipose tissue decreased by approximately 2.8%, which, in absolute terms, represented an average of 3.4 kg less in the competitive period. The percentage of body fat decreased by an average of 2.27% (2.4 kg), and the sum of skinfold thickness decreased by 17.9 mm in the competitive period compared to the preparatory period.

In relation to somatotype, significant differences were observed in the degree of endomorphy and ectomorphy, but not in mesomorphy. Regarding somatotype classification, during the preparatory period, five volunteers were classified as mesomorph-endomorphs and one as mesomorph-balanced. In the competitive period, two volunteers remained classified as mesomorph-endomorphs, while the other three volunteers shifted from this classification to mesomorph-balanced. The only volunteer classified as mesomorph-balanced in the preparatory period transitioned to mesomorph-ectomorph classification in the pre-competitive period.

Although we did not observe a significant difference in VO₂ max between the preparatory and pre-competitive periods, there was a trend toward a significant difference in the mean value of VO₂ max ($P=0.53$), reflecting an increase of 10.5 ml.kg.min⁻¹ in VO₂ max in the pre-competition period compared to the preparatory period. There was no significant difference in absolute handgrip isometric strength. However, there was an average increase of 24% in relative isometric strength in the pre-competitive period compared to the preparatory period. No significant differences were observed in lumbar and scapular isometric strength between the training periods.

Discussion

The body composition of MMA athletes in the present study, regardless of the training period, is consistent with findings from other studies investigating the body composition of MMA athletes. In regional-level MMA athletes, Dell Vecchio and Ferreira (2013) and Shick et al. (2010), using the skinfold method, found average body fat percentages of 9.5 and 11.7, respectively. Meanwhile, in high-level professional athletes, Alm and Yu (2013) found an average body fat percentage of 12.25, estimated by DEXA.

Muñoz, Franco & Martínez (2024), like our current study, characterized the body composition of Colombian MMA athletes using the body mass fractionation method into 5 components during the competitive phase. They observed an average of 50.2% (36.1 kg) muscle mass, 21.2% (15.3 kg) adipose mass, 12.5% (8.92 kg) residual mass, 10.9% (7.8 kg) and 5.1% (3.65 kg) epithelial mass. Compared to our findings, the values reported by Muñoz, Franco & Martínez are slightly lower, particularly in terms of absolute values. These differences can be attributed to the prevalence of weight categories in both studies; while our study primarily included athletes in the welterweight categories or higher, the previously cited study mainly involved athletes classified as lightweights. However, the values of the muscular bone muscle index were lower than our results when compared at both moments of periodization (~1.49 kg in the preparatory period and 1.41 kg in the competitive period.).

In a short training period (4 weeks), Kostikiadis et al. (2018) observed no significant changes in the body composition of MMA athletes subjected to specific or traditional training. However, interestingly, after 4 weeks of training, the group that underwent specific training gained more lean body mass compared to the group that followed traditional training. In another study, experienced MMA athletes underwent 2 months of medium or high-intensity training. Both training programs had significant impacts on body composition in the first month after training, with the only positive result for the high-intensity training group (on average - 2% body fat and + 1.9 kg lean body mass). Additionally, changes in steroid hormones cortisol and testosterone in the serum of MMA athletes after the first month were observed only in the high-intensity training group (Chernozub et al., 2022).

Regarding the longer training period, Tota et al. (2019), comparing body composition before and after the preparatory phase (14 weeks), found a significant decrease in body mass (3%), body fat percentage (2.6%), and fat mass (22.4%), but no significant changes in lean body mass. Our results are in line with those of Tota et al., as we also found a significant decrease in body mass (3%), body fat percentage (2.3%), and fat mass (22.1%) between the preparatory phase and the beginning of the competitive phase. Additionally, we did not observe significant differences in absolute muscle mass. Changes in these body composition indicators indicate a pronounced process of organic adaptation in response to training (Chernozub et al., 2022).

Regarding somatotype, Marinho et al. (2016) found in national-level MMA athletes average values of 2.9 for endomorphy, 6.4 for mesomorphy, and 1.9 for ectomorphy. Recently, it was observed in a group of 19 MMA athletes during the competitive period that the average values were 2.5 for endomorphy, 5.1 for mesomorphy, and 1.9 for ectomorphy (Muñoz, Franco & Martínez, 2024). Compared to the present study, these values were very similar to those found in the preparatory phase in athletes, but different from those found in the competitive phase. The main difference found was mainly in the degree of endomorph and ectomorph. Endomorphy refers to relative

adiposity while ectomorph refers to relative linearity, and therefore, the decrease in body adiposity, body mass, and especially skinfold thickness clearly influenced the somatotype. Overall, if endomorphs and mesomorphs are high, ectomorphs will be relatively low, which is a common characteristic in combat sports (Esparza-Ros & Vaquero-Cristóbal, 2023).

However, differences in somatotype have been reported when comparing combat modalities. For example, judo, wrestling, and kickboxing athletes showed higher degrees of mesomorph and endomorph compared to taekwondo and karate athletes (Burdukiewicz et al., 2017). In our results, in the preparatory phase, athletes presented a mesomorphic-endomorphic classification (considering the average values of the components), while in the competitive phase, possibly due to dietary restriction aiming at the official weigh-in, athletes presented a balanced mesomorphic classification. These data highlight the importance of carefully defining the timing of physical assessment in future investigations aiming to perform somatotypic characterization in MMA athletes.

Furthermore, we did not observe significant differences in absolute and relative isometric strength (except for relative handgrip strength), relative VO₂max, and flexibility. Although we did not identify a statistically significant increase, there was a trend of difference in VO₂max, observed through an average increase of 29% in the competitive period. Kostikiadis et al. (2018) observed a significant improvement (11% improvement) in VO₂max only in the group that underwent specific training. Additionally, this and other studies using the cycle ergometer reported very similar values to the present study, despite using different methods (Kostikiadis et al., 2018; Alm & Yu, 2013). Moreover, in an exploratory systematic review, studies evaluating maximum oxygen consumption reported an average value of 45.5 ml/min/kg-1 (Bueno et al., 2022). Aerobic and anaerobic qualities are indispensable in high-level MMA, however, their contribution may not be as important as maximal neuromuscular capabilities (James et al., 2018; James et al., 2017).

Franchini et al. (2000) observed in young judokas a significant increase in hand and lumbar isometric strength, both considering absolute and relative values, between the preparatory and competitive phases. However, they also did not observe significant differences in scapular isometric strength. The absence of a significant difference in absolute handgrip strength in the present study between periods, compared to the findings of the aforementioned study, may be justified by the possible increase in specific judo motor gestures, which utilize the gi and are consequently more dependent on handgrip isometric strength when compared to MMA. Folhes et al. (2022) did not observe significant differences in hand and lumbar isometric strength among MMA athletes across weight categories and competition levels. However, they found a significant difference in one-repetition maximum bench press between elite Heavyweight and elite and professional Lightweight athletes.

Regarding flexibility, in the present study, there were no significant changes in the sit and reach test between the preparatory and competitive periods. In contrast, Peacock et al. (2018) observed that after 6 weeks of resistance training (30 min twice a week at 67-85% 1-RM) concomitant with metabolic conditioning training (10 min twice a week, with >9 Mets) and Tai Chi (10 min twice a week), there was a significant improvement in the sit and reach test. However, the values reported by the previous study were lower compared to ours (average 17.4 and 18.8 cm vs 30.4 and 29.7 cm, respectively). Flexibility may vary according to the combat modality; MMA athletes showed in the sit and reach test a reach of about 30 cm (Gochioco et al., 2010; Oliveira et al., 2015; Schick et al., 2010), very similar to wrestlers but lower than Kung Fu (Schick et al., 2010) and Kickboxing athletes (Senduran, Mutlu & Kasap, 2019).

Conclusions

Our results demonstrate that between the preparatory and competitive periods, high-performance MMA athletes experienced a significant decrease in body mass, body fat, and endomorphy, accompanied by an increase in ectomorph. As a result of these changes, athletes exhibited a mesomorphic-endomorphic somatotype during the preparatory period, while in the competitive phase, the somatotype was mesomorphic-balanced. Additionally, we did not observe significant differences in scapular and lumbar isometric strength, flexibility, and aerobic conditioning. However, there was a significant increase in relative handgrip strength and a tendency for improved aerobic conditioning. Nevertheless, the main changes between the preparatory and competitive phases were in body composition and shape.

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Data availability

Full access to data on request.

Conflicts of Interest

The Authors have no conflict of interest to declare.

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Informed Consent Statement

All the athletes included in the study provided written informed consent.

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