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Original article

INFLUENCE OF ANTHROPOMETRIC FACTORS AND BODY COMPOSITION ON POSTURAL STABILITY IN MARTIAL ARTS ATHLETES

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Abstract

Aim. This study aims to analyze the relationship between anthropometric indices, body composition and static balance parameters in martial arts athletes, in order to identify the key factors that influence postural stability.

Methods. The methodology of this study involved the participation of 16 senior athletes practicing Pankration martial arts, aged between 20 and 40 years. Anthropometric and body composition measurements were conducted using the Tanita scale. Static balance was assessed using the Sensamove platform. Statistical analysis included calculating descriptive indices and applying Pearson's correlation coefficient to examine the relationships between static balance and anthropometric and body composition factors, with a significance level set at $p<0.05$.

Results. The analysis of anthropometric indices and body composition revealed significant variations among athletes, with average values aligning with martial arts standards but showing high heterogeneity in fat mass and body fat percentage. This shows the need for optimizing body mass to enhance performance. The overall static balance performance was relatively homogeneous (74.69%), but directional deviation analysis highlighted substantial variability and significant asymmetries, indicating individual postural stability issues, particularly forward and to the left. Correlation analysis showed a negative influence of height ($R = -0.388$) and fat mass ($R = -0.441$ and $R = -0.471$) on static balance performance, as well as moderate correlations between weight ($R = -0.381$) and postural deviations, emphasizing the impact of body composition on stability.

Conclusions. This study highlights the importance of optimizing body composition and adjusting postural technique to improve performance in martial arts. The variability in postural stability and the negative influence of anthropometric indices, such as height and body fat, suggest the need for personalized training and nutrition programs. These specific interventions can significantly contribute to enhancing static balance and, consequently, the performance of athletes in disciplines requiring stability, such as Pankration.

Keywords: Body mass, static balance, performance, deviations, correlation analysis.

Introduction

Static balance is an essential skill in martial arts which contributes to maintaining a stable position during fights, executing techniques correctly and preventing injuries (Zemková, 2014). It plays a crucial role in postural control and stability during competitions, directly impacting the performance of athletes in various combat sports (Litwiniuk et al., 2023). Studies suggest that external martial arts training can improve both static and dynamic balance measurements (Kemerly, 2001). Good stability is considered a tactical advantage in contact sports (Bourantanis, Nomikos & Wang, 2024). Comparing static and dynamic balance performance in combat sports such as wrestling and judo has shown significant differences in the ability to maintain balance (Gencay et al., 2020). Additionally, biomechanical analysis of static balance in Taekwondo highlighted the importance of correct training technique for optimizing performance (Gonzalez Mejia, 2019). Furthermore, Olympic combat sports can be effective in improving balance and reducing the risk of falls, especially for older adults, emphasizing their benefits for overall stability (Valdés-Badilla et al., 2022).

Balance achievement is influenced by a range of physiological and biomechanical factors, including anthropometric indices and body composition. Studies have shown that the body mass index (BMI) is significantly related to postural control, and individuals with a higher BMI may face difficulties maintaining balance (Ku et al., 2012). Moreover, body composition, including body fat percentage, is highly important in postural stability, negatively impacting balance performance in athletes with a high percentage of body fat (Del Porto et al., 2012). Şimşek and Arslan (2019) underlined that different sports disciplines distinctly influence balance performance and specific anthropometric

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characteristics may cause variations in the ability to maintain postural stability. Besides, Lukaski and Raymond-Pope (2021) emphasize the importance of body composition assessment for optimizing physical performance. Other specialists, like Stewart and Ackland (2017) state that accurate measurement of anthropometric indices is essential for understanding the relationship between body structure and physical performance, including balance. These studies support the idea that optimizing body composition is vital for improving postural stability and performance in sports that require balance.

Indices such as height, weight, limb length and the waist-to-hip ratio are closely related to the center of gravity and postural stability in athletes. These kinanthropometric traits play a significant role in determining balance and general performance in martial arts (Pankration). Research by Nichas (2017) and Starosta (2019) supports the idea that these anthropometric measurements influence the biomechanical aspects of performance. Additionally, studies such as those conducted by Sterkowicz et al. (2016) and Fukuda (2019) have explored the relationship between acute physical effort, strength, and balance, emphasizing the impact of body composition on postural control and stability in athletic performance.

At the same time, body composition, especially the ratio of muscle mass to fat mass, is highly important for the ability to maintain balance in martial arts. Studies by Chyu et al. (2013) and Durkalec-Michalski et al. (2016) show the impact of body composition on physical performance and balance in combat sports. Moreover, research by Podstawski et al. (2017) and Tota et al. (2014) explores how specific training programs can influence body composition, strength and motor skills, thus improving balance and performance. Also, Niewczas et al. (2023) and Stachoń et al. (2014) have highlighted the relationship between body composition and technical-tactical performance in martial arts. They pointed out the importance of optimizing the muscle mass/fat mass ratio for improved stability and overall athletic performance.

Studying these relationships can provide valuable insights for the optimization of training in martial arts, adapting physical preparation programs and improving athletic performance. In addition, a better understanding of these correlations can contribute to preventing muscle imbalances and postural issues.

In this study, we aim to investigate the correlation between anthropometric indices, body composition and static balance parameters in martial arts athletes to identify key factors that influence postural stability. These results can offer useful perspectives for coaches and athletes in the process of improving performance and musculoskeletal health.

Methods

The research was organized with the participation of 16 senior athletes, aged 20 to 40 years, practicing Pankration martial arts. The study was conducted in December 2022 at the Shin Daito Sports Club in Bucharest, in collaboration with the Romanian Pankration Athlima Federation. The research was consistent with the Helsinki Declaration and was approved by the local ethics committee (ID: 24/16.12.2024) of the Doctoral School of Sports Sciences and Physical Education, National University of Science and Technology *Politehnica* Bucharest, University Center Pitesti.

Tests and Instruments Used:

Anthropometric and Body Composition Measurement: The Tanita scale was used to record the following indices: Height (cm), Weight (kg), Percentage of Body Fat (PBF, %), Body Fat Mass (kg), and Body Mass Index (BMI, kg/m²).

Static Balance Measurement Test: The Sensamove platform (mini board) was used to measure the following indices: Performance (%), Front average deviation (degrees), Back average deviation (degrees), Left average deviation (degrees), and Right average deviation (degrees).

Statistical Analysis. The statistical analysis was performed using KyPlot software, calculating basic descriptive indices: central tendency (mean and median), data dispersion (standard deviation - SD, variance, range and coefficient of variation - CV%), and data distribution asymmetry (skewness). The Pearson linear correlation coefficient was applied to examine the relationships between static balance indices and the influence of body composition and anthropometric factors. Significant results were compared at a significance level of $p<0.05$.

Results

Table 1 presents the descriptive values of the main anthropometric indices (height, weight) and body composition (body fat percentage, fat mass and body mass index) for martial arts athletes, highlighting central tendency, data dispersion and distribution characteristics.

The results of the anthropometric indices show the following:

Height (cm): The average height for the athletes analyzed is 172 cm, with moderate variation in height within the group and a slight negative skewness (-0.54), indicating values slightly shifted towards the taller individuals.

Weight (kg): The mean and median values are close, suggesting a balanced distribution, with a large variation in weight, reflected by a coefficient of variation (Cv%) = 22.44%, indicating a less homogeneous group in terms of weight and a slight positive skewness (0.41), indicating some values higher than the average.

Table 1. Results of anthropometric indices and body composition indices in martial arts athletes

Variables	*Mean*	*Median*	*SD*	*Variance*	*Range*	*Cv(%)*	*Skewness*
Height (cm)	172.00	174.5	7.68	59.06	23	4.47	-0.54
Weight (kg)	75.12	76.8	16.86	284.29	62.8	22.44	0.41
PBF (%)	20.85	17.55	10.68	114.05	33.7	51.2	0.33
Body Fat mass (kg)	16.62	13.2	10.72	114.99	31.3	64.5	0.59
BMI (kg/m^2)	25.29	24.75	4.93	24.29	16.7	19.49	0.13

Notes. PBF - Percentage of body fat, BMI – body of mass indices

Body Composition Indices

Body Fat Percentage (%): The body fat percentage is 20.85%, which represents a moderate level of body fat typical for a martial arts athlete, but relatively higher compared to elite athletes in sports where body fat is generally lower. There is high variation in body fat percentage, with a coefficient of variation (Cv%) = 51.2%, indicating considerable heterogeneity within the group and a slight positive skewness (0.33), suggesting a few higher values.

Fat Mass (kg): The average fat mass is 16.62 kg, with a very large variation among athletes. The Cv(%) = 64.5% reflects the highest heterogeneity among all the analyzed indices and moderate positive skewness (0.59), denoting the presence of athletes with significantly higher fat mass.

Body Mass Index (BMI) (kg/m^2): The BMI is 25.29 kg/m^2, which is at the threshold between normal weight and overweight, revealing that some athletes might benefit from optimizing their body mass. There is moderate variation, with Cv(%) = 19.49%, indicating relatively good homogeneity and the distribution is nearly symmetric (0.13).

Table 2 presents the descriptive results of the static balance indices for the martial arts athletes, including overall performance (%) and average deviations in four directions (front, back, left and right).

Table 2. Results of static balance indices in martial arts athletes

Variables	*Mean*	*Median*	*SD*	*Variance*	*Range*	*Cv(%)*	*Skewness*
Performance (%)	74.69	77.5	8.81	77.56	28	11.79	-0.47
Front, avg deviation (grade)	1.75	1.58	0.77	0.59	3.13	44.18	1.45
Back, avg deviation (grade)	-1.36	-1.22	0.71	0.50	2.67	52.19	-1.07
Left, avg deviation (grade)	-1.51	-1.37	0.68	0.46	2.41	45.02	-1.51
Right, avg deviation (grade)	1.27	1.27	0.48	0.23	1.47	37.41	0.23

The overall performance (%) was 74.69%, with a slightly higher median value (77.5%), indicating a distribution close to symmetrical. The variability of performance is moderate, with a coefficient of variation (Cv%) of 11.79%, suggesting relative homogeneity in the group. The skewness value of -0.47 indicates a slight negative skew, reflecting a small tendency of the data toward higher performance values.

The deviation toward the front (Front) had a mean of 1.75 degrees and a median close to it (1.58), suggesting a slight forward inclination. The variability is high, with a Cv (%) of 44.18%, and the positive skewness (1.45) indicates higher values towards the extreme, meaning that some athletes had significant deviations.

The deviation toward the back (Back) had a mean of -1.36 degrees and a median of -1.22, indicating a slight tendency to lean backward. The coefficient of variation (Cv%) is high at 52.19%, reflecting a large variability in backward stability. The negative skewness (-1.07) denotes a tendency of the data toward smaller deviations.

The deviation toward the left (Left) had a mean of -1.51 degrees and a median of -1.37, showing a slight tendency to lean left. The variability is high (Cv% = 45.02%) and the negative skewness (-1.51) indicates a predominance of smaller deviations to the left.

The deviation toward the right (Right) had a mean of 1.27 degrees, which is identical to the median value, suggesting a symmetrical distribution. The coefficient of variation (Cv%) of 37.41% indicates moderate variability. The slight positive skewness (0.23) reflects an almost symmetrical distribution.

Figure 1 presents the correlational analysis between anthropometric indices and static balance performance in martial arts athletes, highlighting the relationships between body characteristics (height, weight, body fat percentage) and postural stability in different directions.

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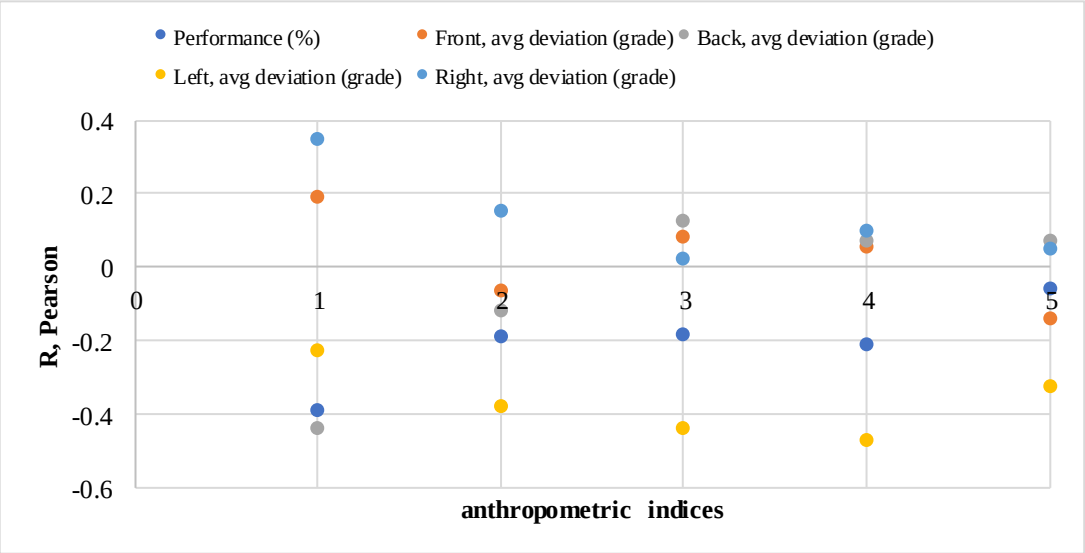

Figure 1. Correlation analysis between anthropometric, body composition and static balance indices in martial arts athletes

The correlation analysis identified 25 correlations, of which 44% were positive and 56% were negative. Static balance performance is slightly negatively influenced by anthropometric indices, particularly height and body fat mass, though the correlations are weak. A moderate negative correlation exists between height and performance (R = -0.388). The average forward-backward deviations show a moderate impact on the backward deviation in relation to height (R = -0.439) and the rightward deviation (R = 0.349). The average lateral deviations (left/right) are moderately negatively correlated with weight (R = -0.381), body composition (body fat mass expressed in % and kg, R = -0.441 and R = -0.471) and body mass index (R = -0.326), highlighting the negative influence of body fat on stability.

Discussions

The results of this study reveal significant correlations between anthropometric indices, body composition and static balance parameters. They confirm that factors such as height, waist-to-hip ratio and muscle mass directly influence the postural stability of martial arts athletes. These findings support the conclusions of previous research (Zemková, 2014; Gonzalez Mejia, 2019) and emphasize the importance of personalizing training programs to optimize athletic performance and prevent postural imbalances. Furthermore, the differences observed between expert and non-expert athletes, as reported by Litwiniuk et al. (2023), highlight the impact of experience and specific training on postural stability. Other studies, such as those conducted by Gencay et al. (2020) and Bourantanis et al. (2024), have demonstrated the relevance of biomechanics in optimizing balance and performance in combat sports.

The results reveal significant variability in body composition and weight within the group of athletes, underlining the need for personalized interventions to optimize body mass and body fat percentage. The literature supports these observations, emphasizing that optimal body composition has a direct impact on athletic performance, particularly in terms of strength, speed and mobility (Durkalec-Michalski et al., 2016; Lukaski & Raymond-Pope, 2021; Stachoń et al., 2014).

The static balance performance was generally good; however, the high variability in the coefficients for the average deviations toward the front, back and left indicates asymmetries and stability issues in some athletes. These findings are supported by the research of Şimşek and Arslan (2019), who identified relationships between anthropometric characteristics and balance performance. Other specialists, such as Ku et al. (2012) highlighted the influence of body mass index on postural control. Smaller deviations to the right suggest better stability in this direction, but individual differences in body composition and postural technique contribute to variations (Stewart & Ackland, 2017; Sterkowicz et al., 2016).

The correlational analysis revealed a predominance of negative correlations (56%), indicating a moderate influence of anthropometric indices on static balance performance. Height and body fat mass had a negative impact on stability, confirming the observations of Del Porto et al. (2012), who demonstrated the negative impact of increased body mass on balance. Additionally, the significant relationships between weight, body composition and the average forward-backward or lateral deviations are in line with the research of Gonzalez Mejia (2019) and Valdés-Badilla et al. (2022), who emphasized the importance of reducing body fat to improve stability and performance.

These results denote that personalized interventions in training to optimize body composition and improve postural control are essential for maximizing performance in martial arts. In particular, programs that include specific exercises for balance and body fat reduction could significantly enhance stability and performance capacity in athletes.

Conclusions

In conclusion, the descriptive statistical analysis indicates a relative homogeneity in height and body mass index (BMI), in contrast with significant heterogeneity in weight, body fat percentage and fat mass, highlighting differences in the structure and body composition of athletes. High levels of body fat can negatively affect performance in martial arts, suggesting the need for monitoring and adjusting body composition. These findings may support the development of personalized training and nutrition programs aimed at improving athletic performance.

Static balance performance is generally good, but there is significant variability in the average deviations, particularly in the front, back and left directions, revealing deficiencies in postural stability among some athletes. The asymmetry in lateral and front-back deviations emphasizes the need to adjust training to enhance postural control. Furthermore, individual differences in body composition and postural technique highlight the importance of specific interventions to optimize balance and performance in sports requiring stability, such as martial arts.

The correlation analysis identifies a moderate negative influence of anthropometric indices, particularly height and body fat, on static balance. It highlights the need to optimize body composition in order to improve performance in these disciplines.

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