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KINESIOLOGY & COACHING

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Kinanthropometric Profile and Maximum Oxygen Consumption in Male Karate Athletes at Different Competitive Levels

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Key words: Performance, VO_{2max}, karate, somatotype, kinanthropometry, body composition

Abstract

Background. Kinanthropometry in karate athletes (KT) can offer advantages over maximum oxygen consumption (VO_{2max}) during consecutive matches in competitions. Problem and Aim. To analyze the association of the kinanthropometric profile with the VO_{2max} of KT of different competitive levels, as well as to compare the kinanthropometric profile and the performance of VO_{2max} between athletes of different competitive levels.

Methods. 36 KT adult males – 12 athletes at state level, 12 at national level (elite level) and 12 members of the control group. Their kinanthropometric profile was analyzed using anthropometry. The resting heart rate was analyzed by a oximeter. The VO_{2max} test was performed according to the standards of Queens College Step Test.

Results. National level athletes showed lower adipose tissue, superior VO_{2max} ($p < 0.05$) and predominant ectomorphic somatotype. The control group showed a predominance of the endomorphic somatotype. There was no relationship between the kinanthropometric profile and VO_{2max} ($p > 0.05$). However, a significant effect size ($f^2 > 0.44$) was reported between the kinanthropometric profile and the VO_{2max} of KT.

Conclusions. The kinanthropometric profile was not related to VO_{2max} in KT. However, national level (elite level) KT point to a higher VO_{2max}, less body fat tissue and greater body straightness when compared to state athletes and non-athletes.

Introduction

Karate is a martial art in which the individual dominates all fundamental movements of the human body in a free and uniform way [Pinto *et al.* 2016]. The modality is divided into Kata and Kumite, the first being a combat simulation that consists of "an imaginary fight", formed by a sequence of highly ritualized and stereotyped movement patterns, full of punches and kicks, while the second concerns the actual fight that takes place against a real opponent [Nickytha *et al.* 2019]. This Japanese art was disseminated among nations following a philosophy of a life of virtues, healthy, disciplined and in balance, through the practitioner's dedication, self-confidence and mental and physical aptitude [Limpo, Tadrist 2020].

As a consequence of dedication to training, karate practitioners tend to have a predominance of lean body mass, for these individuals, having a lower percentage of fat contributes to a more accurate displacement in combat, helping to achieve a positive result in relation to the their sports performance, being able to contribute in general to the health of the body through movement, which makes it important to measure and maintain body composition, which can be analyzed according to the techniques of kinanthropometry (i.e., science that studies the relationship between body structure and human function) [Arazi, Izadi 2017; Rakita *et al.* 2018].

Regarding the physiological aspect, aerobic metabolism is the predominant source of energy during combat karate with anaerobic participation, mainly by high-energy phosphates [Chaabene *et al.* 2019; Hausen *et al.* 2021]. In this context, the analysis of cardiopulmonary conditioning has been used as an index of aerobic capacity for decades [Ross *et al.* 2016]. However, direct measurement of cardiopulmonary fitness using gas analyzers requires expensive equipment, making the analysis not accessible for field tests [Ross *et al.* 2016; Franchini *et al.* 2019]. Therefore, the measurement of maximum oxygen consumption (VO_{2max}) is encouraged through predictive methods such as Queens College Step, an already validated field test that can be performed simplistically in the training environment. [Selland *et al.* 2020]. Cardiorespiratory fitness is directly related to VO_{2max}, which is characterized as the maximum oxygen used during strenuous physical activity [Seulgi-Choi *et al.* 2019] and its measurement is considered the best way to quantify conditioning cardiorespiratory system of an individual [Liguori 2020].

In this sense, karate athletes make several fights in a row in a competitive reality at the state, national or world level and within this context, athletes with better conditioning in relation to VO_{2max} have advantages in relation to their opponents [Chaabene *et al.* 2019]. In this context, among the aspects considered advantageous for a karate athlete, it is desirable to have a straight kinanthropometric profile, with a predominance of lean mass and a low percentage of fat, being identified as a determining factor for the performance of karate practitioners around from the world [Kostovski *et al.* 2017; Arazi, Izadi 2017; Burdukiewicz *et al.* 2018].

Thus, previous studies identify that the kinanthropometric profile of karate athletes is related to the performance of muscle strength of the lower limbs and to the aerobic profile of these subjects [Nikookheslat *et al.* 2016; Zagorski 2017; Spigolon *et al.* 2018]. However, data on the relationship between the kinanthropometric profile and the VO_{2max} consumption of karate athletes are scarce in the literature [Najmi *et al.* 2018]. In this sense, the present research hypothesizes that the kinanthropometric profile can have an effect and be significantly related to the VO_{2max} of karate athletes of different competitive levels.

Therefore, the present study aimed to analyze the effect and the relationship of the kinanthropometric profile with the VO_{2max} consumption of karate athletes of different competitive levels, as well as to compare the kinanthropometric profile and the performance of the VO_{2max} test between karatekas of different competitive levels.

Methods

Subjects

The sample consisted of 36 male adults, practicing karate in the shotokan style. 12 athletes at the state level, 12 at national level (elite level) and 12 non-athletes. National athletes were affiliated with the Brazilian Karate Confederation (CBK), while state athletes and the group of non-athletes were affiliated with a federation in the state of Rio Grande do Norte, Natal, Brazil. All participants were recruited after prior explanation of all the benefits and risks of the research. The state and national level athletes were competitors in the “Kumite” modality, while the regional level athletes competed in the “Kumite and kata” modalities, so they were not practitioners of a specific karate discipline. Regarding the sample size, a sample calculation was performed through a pilot study carried out with 10 athletes. Thus, an effect of 0.90 was identified for the relationship between body density and VO_{2max}, considering this result and an $\alpha < 0.05$ and a $\beta = 0.80$, the sample size indicated was 12 subjects for each group. Therefore, a power of 0.99 was identified for the sample size used in the present study.

As inclusion criteria, it was adopted: (i) To be a black belt in karate; (ii) For the non-athletes (control) group, have a weekly training frequency of at least 2 times a week in the last 6 months; (iii) Athletes should be in the state or national ranking, and affiliated to the federative or confederative entity for at least 2 years prior to the research; (iv) Be between 20 and 49 years old. Subjects with articular, cardiac or respiratory problems or who could not complete all the assessments required for the study would be excluded from the sample. The practitioners were divided into three groups (i) Control: 12 non-athlete karate practitioners; (ii) State: 12 karate athletes at the state level; (iii) National: 12 karate athletes at the national level.

Ethics

The research was approved by the Ethics and Research Committee of the Federal University of Rio Grande do Norte - Brazil (CAEE: 29252120.7.0000.5537; Opinion: 3.993.210) according to Resolution 466/12 of the National Health Council, on 12/12/ 2012, strictly respecting the national and international ethical principles contained in the Declaration of Helsinki. In addition, the present study complied with all the international requirements and standards of the STROBE checklist for observational studies [Sharp *et al.* 2019]. All participants signed an informed consent form, stating that they accepted to participate in this research.

Procedures

The data collection of the present study took place in three moments (figure 1): (i) Explanation of the particularities of the research and signature of the terms. (ii) Anthropometric analyzes. (iii) Aerobic capacity test.

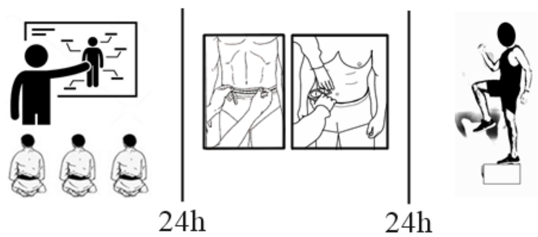

Figure 1. Study design

Body composition assessment
Body composition was analyzed using anthropometry following the International Society of the Advancement of Kinanthropometry (ISAK) standardization [Karupaiah 2018]. It is worth mentioning that all evaluations were performed by a single evaluator, a physical education professional specialized in anthropometric analyzes. Regarding the evaluated, all were wearing bathing suits as clothing. The analyzes were made individually, in a reserved and air-conditioned environment (26 °C). Body weight was analyzed using a digital scale (Sanny®, São Paulo, Brazil) with an accuracy of 0.1 kg. Body height by a stadiometer (Sanny®, São Paulo, Brazil) with an accuracy of (1.0 mm). Bone diameter measurements were obtained using a caliper (Sanny®, São Paulo, Brazil) with an accuracy of (1.0 mm). An anthropometric tape (Sanny®, São Paulo, Brazil) was used to measure the perimeter. Skin folds were measured using a scientific adipometer (Cescorf®, Washington, United States) with an accuracy of (0.1 mm).

Assessment of body density
Body density was verified using the mathematical model by Petroski [Zonatto *et al.* 2017]. The method makes use of the sum of the anthropometric measurements of the tricipital, subscapular, suprailiac and medial leg skinfolds, which consists of:

(1) Body density (g/Cm³) = 1.10726863 – 0.00081201 * (Σ skin folds: tricipital, subscapular, suprailiac and medial leg) + 0.00000212 * (Σ skin folds: tricipital, subscapular, suprailiac and medial leg)² - 0.00041461 * (Chronological age in years)

(g/Cm³): grams per cubic centimeter. Σ: summation.

Analysis of fat percentage
The body fat percentage was analyzed using Siri's mathematical formula [Sinha *et al.* 2018], the mathematical model uses the result of body density to estimate the relative value of adipose tissue.

(2) Body fat (%) = [(4.95 / body density) – 4.50] * 100

(%) Percentage.

Assessment of fat and lean mass
Lean mass (Kg) was calculated by subtracting the result of the percentage of fat from the total body weight (Kg). In this sense, to find the absolute value of fat mass (Kg), the value of lean mass (Kg) was subtracted from the value referring to total body weight.

(3) Lean mass (Kg) = Body weight (Kg) - Body fat (%)

(4) Fat mass (Kg) = Body weight (Kg) - Lean Mass (Kg)

(Kg): kilograms. (%) Percentage.

Bone mass estimation
The total bone mass (Kg) was estimated by the mathematical model proposed by Von Dobeln [1964], the method makes use of the squared body height, the biepicondylial radius ulnar diameter (m) and the diameter of the femur (m).

(5) Bone mass (Kg) = 3.02 * (Biepicondylial diameter of the ulnar radius (m) * Biepicondylial diameter of the femur (m) * 400) $^{0.712}$

(Kg): kilograms. (m): Meters.

Somatotype verification
The somatotype was verified by the protocol proposed by Carter and Heath [1990], the method uses anthropometric measurements of skinfolds (tricipital, subscapular, supraspinatus and medial leg), the circumference of the contracted right arm and calf, the biepicondylial diameter of the humerus (Cm) and femur (Cm), height (Cm) and body weight (Kg). This analysis provides results on different components of body composition (Endomorph: linked to body adiposity; Mesomorph: associated with musculature; Ectomorph: related to body linearity) and classifies individuals according to the predominance of such components. The somatotype coefficient was generated by the sum of all analyzed components. The analyzes were performed using the Somatotype software (Version, 2.2.6; Sweat Technologies, San Diego, USA).

Blood pressure

Resting blood pressure was checked by a single evaluator with prior training. The subject was at rest for 10 minutes, sitting in a comfortable chair, with the knees positioned at 90 °. Subsequently, the evaluator positioned the sphygmomanometer (Premium ®, São Paulo, Brazil) cuff 3 cm above the anterior part of the elbow joint, in sequence the brachial artery was identified. With the stethoscope cuff (3M™Littmann ®, São Paulo, Brazil) positioned over the artery, the evaluator inflated the cuff until the total obstruction of the artery and then inflated an additional 25 mmHg. In sequence, the process was started to deflate the cuff and by auscultation of the artery, the evaluator identified the sound of the first heartbeat, corresponding to the systolic blood pressure (SBP) and the sound of the last heartbeat referring to the diastolic blood pressure (DBP).

Resting heart rate analysis

Resting heart rate (RHR) was analyzed using a portable oximeter (Oled ®, São Paulo, Brazil). In this way, the subject was seated in a chair with the knees bent at 90 ° and hands positioned on the thighs, then the oximeter was placed on the left index finger and the RHR value was acquired.

Estimated aerobic capacity

Aerobic capacity was estimated using the Queens College Step Test [Bennett *et al.* 2016]. The test evaluated the consumption of VO_{2max} and consisted of the subject being evaluated going up and down a 41.3 cm high platform (Crown ®, Buenos Aires, Argentina). The movements up and down the platform were performed at the rhythm (compass) of a mechanical metronome (Crown ®, Buenos Aires, Argentina). The pace corresponded to 24 steps per minute. It is noteworthy that the prediction accuracy of the referred test, in comparison to the ergospirometric analysis, is about 95% of the individual's real VO_{2max} [Mcardle *et al.* 2018]. It is noteworthy that the subjects were instructed not to perform strenuous physical activities in the 24 hours before the test. In this way, before the test started, it was demonstrated in a practical way by the evaluator how to carry out the test, just after the detailed explanation, each individual performed two movements for the first contact with the device.

After all the individuals had their first contact with the device, the test itself began. The test was carried out for a period of three minutes, at the end of the test, heart rate (HR) was counted for 15 seconds from 5-20 seconds of recovery. With the aid of a portable cardiac monitor (Polar®, Chicago, USA) (composed of a chest strap positioned at the height of the external and a wrist monitor, the equipment was connected via bluetooth), HR was multiplied by four to obtain the HR that was used to calculate VO_{2max} [Mcardle *et al.* 2018]. In this sense, the mathematical formula for estimating VO_{2max} (ml / kg / min) consists of:

(6) VO_{2max} (ml/kg/min) = 111.33 – (0.42 * Heart rate post test)

(ml/kg/min): milliliters of oxygen per kilogram per minute.

Peak heart rate analysis

Peak heart rate (PHR) was acquired during the aerobic fitness test using a portable cardiac monitor (Polar®, Chicago, USA). The result of the PHR was acquired by consulting the files of the cardiac monitor regarding the behavior of the HR during the aerobic capacity test.

Statistics

The normality of the data was tested using the Shapiro-Wilk and Z-score tests for asymmetry and kurtosis (-1.96 to 1.96). The comparisons between the groups were performed using the ANOVA One-Way statistical test. The partial Eta-square (η^2p) was used to verify the size of the effect of the analysis of variances. The magnitude adopted for η^2p was: Small $\eta^2p \leq 0.10$ to 0.23; Average η^2p from 0.24 to 20.34; Large η^2p from 0.35 to 0.44; Very large $\eta^2p \geq 0.45$ [Norouzian, Plonsky 2018]. Bonferroni's post hoc test was used to find the differences. Pearson's test was used to perform the correlations, the magnitude used was: Insignificant: r <0.10; Weak: r = 0.10-0.39; moderate: r = 0.40-0.69; Strong: r = 0.70-0.89; Very strong: r = 0.90-1.00 [Schober *et al.* 2018]. Through the Cohen's f^2, the of effect size of the variables was verified under the following conditions: (VO_{2max} x RHR); (VO_{2max} x Body Density); (VO_{2max} x Fat (%)); (VO_{2max} x Sum of folds); (VO_{2max} x lean mass); (VO_{2max} x Fat Mass); (VO_{2max} x Bone Mass); (VO_{2max} x somatotype coefficient); (VO_{2max} x SBP); (VO_{2max} x DBP). The adopted magnitude was: small: $f^2 \leq 0.02$ to 0.14; medium: $f^2 \geq 0.15$ to 0.34; large: $f^2 \geq 0.35$ [Norouzian, Plonsky 2018]. The calculation of the technical error of the relative intra-rater measure was performed, the magnitude adopted was: Acceptable <5.0% for skin folds; Acceptable <1.0% for other measures [Norton 2018]. All analyzes were performed using the R software (Version 4.0.1; R Foundation for Statistical Computing®, Vienna, Austria). For all analyzes, p <0.05 was adopted.

Results

The margin of error calculated for the sample size was 4.91%, indicating that the sample had significant statistical strength of 95.09% to answer the research question. Regarding the characterization of the sample (table 1), the control group showed a significant difference in relation to chronological age (younger), the national group (elite level) had a longer experience in the modality in relation to all groups, and the state group showed experience of superior training to the control group. Regarding the components of the somatotype, the control group showed a greater endomorphic component compared to the others. No significant differences were found for the mesomorphic component between the groups. The national group pointed out the superiority of the ectomorph component when compared to the other subjects in the sample.

Table 1. Sample characterization

Variable	Control	State	National
N (%)	12 (33.3%)	12 (33.3%)	12 (33.3%)
Age (yrs)	24.5 ± 3.51*	34.0 ± 8.80	27.1 ± 3.95
Practice Time (yrs)	11.0 ± 3.98	17.5 ± 7.32§	20.6 ± 4.03*
Height (Cm)	174.3 ± 5.63	170.9 ± 4.60	172.1 ± 6.71
Weight (Kg)	82.8 ± 20.9	75.3 ± 2.21	72.4 ± 3.06
Body Mass Index (Kg/m^2)	27.1 ± 6.08	25.8 ± 0.88	24.5 ± 2.44
Rest Heart Rate (bpm)	73.3 ± 6.90	66.6 ± 4.07	64.5 ± 6.97
Systolic Blood Pressure (mmHg)	109.1 ± 13.1	105.0 ± 13.8	111.6 ± 10.2
Diastolic Blood Pressure (mmHg)	73.3 ± 7.78	69.1 ± 9.00	73.3 ± 7.17
Endomorph	4.55 ± 1.38*	2.04 ± 0.22	1.81± 0.31
Mesomorph	6.13±2.11	7.20± 1.44	6.43± 1.34
Ectomorph	1.42± 1.07	1.17 ± 0.48	1.80± 1.26*

* Statistically significant difference for all groups. § Statistically significant difference only in the control group, $p < 0.05$. (%): Percentage. (Cm): Centimeters. (Kg): Kilograms. (Kg/m^2): Kilograms per square meter. (bpm): beats per minute. (mmHg): Millimeters of mercury.

Table 2. Comparisons between groups

Variable	Control	State	National	$F_{(2.00)}$	η^2p	p
Body density (g/Cm^3)	1.06 ± 0.01	1.07 ± 0.03	1.07 ± 0.02	22.1	0.333	0.05
Lean mass (Kg)	68.4 ± 13.4	61.9 ± 17.2	66.3 ± 2.43	0.80	0.276	0.7
Fat mass (Kg)	14.4 ± 7.92	13.3 ± 16.99	6.09 ± 1.25 *	2.09	0.261	0.03
Sum folds (mm)	72.2 ± 24.3*	35.8 ± 3.25	30.7 ±2.82	30.3	0.403	0.03
Fat (%)	16.4 ± 4.79	11.1 ± 1.43	8.72 ± 0.99*	21.7	0.332	0.007
Total bone mass (Kg)	10.7 ± 2.01	10.5 ± 1.67	10.4 ± 1.40	0.06	0.281	0.8
Somatotype Coefficient	8.58 ± 1.47	10.4 ± 1.54§	10.0 ± 1.05§	8.25	0.300	0.04
VO_{2max} (ml/Kg/min)	32.2 ± 2.74	47.9 ± 2.71§	55.0 ± 2.45*	12.04	0.226	0.001
PHR (bpm)	189.6 ± 3.44	180.1 ± 8.79	187.0 ± 3.95	8.28	0.342	0.4

VO_{2max} = Aerobic capacity. η2p = effect size by partial Eta-square. PHR = Peak Heart Rate. *Statistically significant difference for all groups. § Statistically significant difference only in the control group. (g/Cm^3): grams per cubic centimeter. (mm): Millimeters. (%) Percentage. (Kg): Kilograms. (ml/kg/min): milliliters of oxygen per kilogram per minute. (bpm): beats per minute.

In the comparisons between the groups, the subjects of the control group pointed out superiority in relation to the sum of skinfolds, while the national athletes (elite level) stood out in relation to the smaller amount of fat mass and higher VO_{2max} in relation to the other evaluated groups. The group of state athletes presented VO_{2max} higher than the control group. The state and national groups showed superiority in relation to the somatotype coefficient when compared to the control group.

Table 3. Correlation of variables with VO_{2max}.

Variable	Control		State		National	
	VO_{2max} (ml/Kg/min)					
	r	p	r	p	r	p
Body density (g / Cm^3)	-44	0.1	-0.27	0.3	-0.17	0.5
Lean mass (Kg)	0.08	0.7	0.32	0.2	-0.26	0.41
Fat mass (Kg)	0.25	0.4	-0.35	0.2	0.23	0.4
Sum folds (mm)	0.35	0.2	-0.31	0.3	0.04	0.88
Fat (%)	0.44	0.1	-0.27	0.3	0.17	0.5
Total bone mass (Kg)	0.14	0.6	-0.56	0.05	-0.00	0.9
Somatotype Coefficient	0.34	0.26	-0.05	0.8	0.24	0.4
RHR (bpm)	-0.05	0.8	-0.12	0.6	0.64*	0.02
PHR (bpm)	-0.17	0.5	0.18	0.5	0.13	0.6
SBP (mmHg)	-0.58*	0.04	-0.03	0.9	0.36	0.2
DBP (mmHg)	-0.51*	0.008	0.10	0.7	-0.30	0.3

(ml/kg/min): milliliters of oxygen per kilogram per minute. VO_{2max} = Aerobic capacity. RHR = Resting Heart Rate. PHR = Peak Heart Rate. SBP = Systolic Blood Pressure. DBP = Diastolic Blood Pressure. * Statistically significant. (g/Cm^3): grams per cubic centimeter. (mm): Millimeters. (%) Percentage. (Kg): Kilograms. (ml/kg/min): milliliters of oxygen per kilogram per minute. (bpm): beats per minute. (mmHg): Millimeters of mercury.

The correlation analyzes indicated that the resting heart rate showed a significant relationship with the VO_{2max} of athletes of national level (elite level), while the diastolic and systolic blood pressures correlated with the VO_{2max} of the control group.

The percentage of fat indicated a broader effect size for the VO_{2max} of the control group. For the state group, body density, lean mass, fat mass, sum of folds, bone mass, somatotype coefficient and diastolic blood pressure showed higher effects size in relation to the other groups analyzed. For the national group, systolic blood pressure and peak and resting heart rate showed magnitudes of effect size (f^2) higher than the other groups.

The control group showed a predominance of the endomorphic and mesomorphic components in relation to the somatotype. For the subjects of the state group, the predominance of the mesomorphic component of the somatotype was verified. While for the members of the national group (elite level), the predominance of the somatotype varied between the mesomorph and ectomorph components.

Table 4. Effect size of study variables in relation to VO_{2max} consumption.

Variable	Control	State	National
	VO_{2max} (ml/kg/min)		
	f^2	f^2	f^2
Body density (g / Cm³)	0.69	0.94*	0.21
Lean mass (Kg)	0.65	1.23*	0.37
Fat mass (Kg)	0.28	0.90*	0.34
Sum folds (mm)	0.07	0.39*	0.18
Fat (%)	0.45*	0.09	0.40
Total bone mass (Kg)	0.44	2.56*	0.01
Somatotype Coefficient	0.06	0.09*	0.04
RHR (bpm)	0.07	0.15	1.15*
PHR (bpm)	0.31	0.30	0.36*
SBP (mmHg)	0.76	0.37	0.81*
DBP (mmHg)	0.31	0.44*	0.35‖

(ml/kg/min): milliliters of oxygen per kilogram per minute. f^2 = Cohen’s coefficient for the magnitude of the effect size of the dependent variable in relation to the independent variable. * = Magnitude of f^2 greater in relation to all groups. VO_{2max} = Aerobic capacity. RHR = Resting Heart Rate. PHR = Peak Heart Rate. SBP = Systolic Blood Pressure. DBP = Diastolic Blood Pressure. (g/Cm³): grams per cubic centimeter. (mm): Millimeters. (%) Percentage. (Kg): Kilograms. (ml/kg/min): milliliters of oxygen per kilogram per minute. (bpm): beats per minute. (mmHg): Millimeters of mercury.

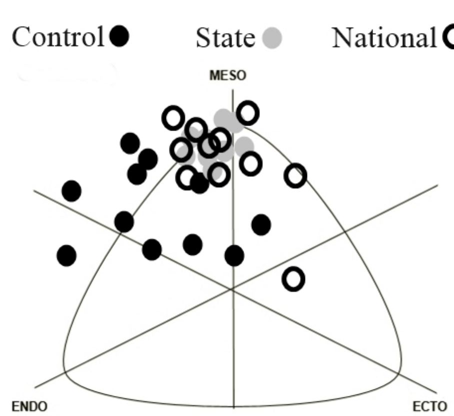

Figure 2. Somatochart.
Endo = Endomorphic component of the somatotype. Meso = Mesomorphic component of the somatotype. Ecto = ectomorphic component of the somatotype.

It is noteworthy that in relation to all anthropometric analyzes, the technical error of relative intra-rater measurement (TERIRM) indicated measures below 4.39% for all skin folds and in relation to the other measures TERIRM below 0.95%. The values indicate an acceptable TERIRM for the analyzes performed by the present study.

Discussion

The aim of the present study was to analyze the effect and the relationship of the kinanthropometric profile with the VO_{2max} consumption of karate athletes of different competitive levels, as well as to compare the kinanthropometric profile and the performance of the VO_{2max} test between Karate athletes of different competitive levels. Thus, the results showed: (i) National-level athletes stand out in relation to the lower accumulation of body fat tissue and in relation to the superiority of VO_{2max} when compared to state-level athletes and non-athletes of the same modality. (ii) Body composition, resting and peak heart rate and blood pressure exert effects size (f^2) of relevant magnitudes on the VO_{2max} of karate athletes at state and national levels and of non-athletes practicing the sport. (iii) The kinanthropometric profile shows a greater tendency towards the accumulation of lean mass for athletes at state and national levels, as well as a trend of narrow and linear body for athletes at a national level.

We emphasize that the sample of state and national-level athletes in the present study was composed of competitors of the Kumite modality, although the objective of the present study was not to differentiate karate athletes from the Kumite and kata modalities, for a better interpretation of the data, it is necessary to highlight that there are particularities between the metabolic profiles of karate athletes from the Kumite and kata modalities; however, according to Doria *et al.* [2009], no differences were found between the VO_{2max} levels of athletes from the Kumite and kata modalities of Italian elite karate. In this sense, there may be differences between the kinanthropometric profiles of karate athletes in the Kumite and kata modalities. Thus, when generalizing the present discussion and the results of this study to the practical field, the modality in which the karate athlete is specialized (i.e., Kumite or kata) must be taken into account.

According to the findings of this study, the national group presented, in relation to the state and control groups, lower values of body mass index, body fat percentage, thus, consequently, lower components for endomorphy and predominance of the mesomorphic somatotype. The control group showed a predominance of the endomorphic somatotype, resulting from the higher percentage of body fat possibly as a result of the lower level of training, corroborating the study by Arazi, Izadi [2017], in which they analyzed the anthropometric components, body composition, somatotype and biomotor characteristics in elite Iranian karate athletes, finding a predominance for the mesomorph component and low percentages of body fat (8.66 ± 3.65). In addition, for the body composition of karate athletes, Chaabene *et al.* [2012] found values between 7.50 ± 1.60 and 16.80 ± 2.51 in relation to the fat percentages of Japanese and Polish elite athletes.

It is noteworthy that in the present study the national level athletes also pointed out superiority in relation to

VO_{2max}, when compared to state level athletes and non-athletes in the control group (η2p = 0.226; p = 0.001). These findings corroborate the research by Arazi, Izadi [2017], the authors also found values similar to those found in the present study for athletes of national competitive level with regard to the percentage of body fat (8.72 ± 0.99), as well as similar values VO_{2max} (51.58 ± 3.39) in the face of the results of the present research (55.0 ± 2.45). In the same sense, Chaabene *et al.* [2012], reported values between 48.5 ± 6.00 ml/Kg/min (Italian elite karate athletes) and 59.5 ± 6.60 ml/Kg/min (Japanese elite karate athletes) for VO_{2max}. It is worth noting that in relation to the present study, different methods were used to obtain the values of VO_{2max} and the different age range of the samples may have influenced the values obtained in each study.

The present research brings among the findings that in addition to the age group, anthropometric characteristics and body composition can also influence the VO_{2max} of karate athletes (table 4). This fact was evident when comparing the groups, where the subjects with the narrower and linear kinanthropometric profile and with a lower percentage of fat were superior in relation to the performance in the VO_{2max} test (table 1). Thus, in the study conducted by Kostovski et al. [2017], the anthropometric and physical fitness characteristics of male elite karate athletes were evaluated, obtaining a fat percentage of 15.8 ± 1.9 and the value of 43.4 ± 5.4 for VO_{2max}, showing significant differences in relation to the results of the present study (see table 2).

In the present study, all karate athletes showed high values in relation to the mesomorphic component of the somatotype and a low percentage of fat (Figure 2, table 1). In addition, athletes in the national group showed superiority in the ectomorphic component of the somatotype when compared to athletes at the state level and non-athletes in the control group (table 1). These findings corroborate those of Zagorski [2017], the author points out that competing karate athletes of both sexes point, in fact, to a kinanthropometric profile with a predominance of lean mass and with straight stature, the referred author does not indicate the competitive levels from the analyzed sample, however, it is known that the anthropometric characteristics of elite karate competitors present singularities in relation to other combat modalities [Burdukiewicz *et al.* 2018].

Although the kinanthropometric profile is important for the performance of karate athletes, the results of the present research did not indicate significant correlations between anthropometric parameters and VO_{2max} in the analyzed athletes (table 3). However, Spigolon *et al.* [2018] found that the anthropometric profile of karate athletes correlates significantly (p <0.05) with the strength performance of these athletes. Nikookheslat *et al.* [2016], highlight that anthropometric characteristics point to significant correlations with strength performance in male Iranian karate athletes. It is known that muscle strength can also influence cardiorespiratory capacity and that the kinanthropometric profile changes due to chronic muscle strength stimuli exercised during sports training [Vikmoen *et al.* 2016; Suchomel *et al.* 2016; Murlasits *et al.* 2018; Suchomel *et al.* 2018].

The prospects of the present study are that the results can assist sports professionals in relation to the prescription of training aimed at the development and improvement of the VO_{2max} of karate athletes and expose the kinanthropometric profile of Brazilian athletes of different competitive levels, which can be useful for the selection process for sports talents in the sport in question. However, the research has the following limitations: (i) The research design is an observational approach, which does not allow us to establish a cause-and-effect relationship, (ii) Despite the reliability, predictive methods were used, which expresses results approximate to the real results in relation to the kinanthropometric profile and the athletes' performance during the VO_{2max} test. (iii) The sample was limited only to Brazilian athletes of the shotokan karate style. Thus, in athletes of other nationalities and or of other styles, the results may be different from those shown in this research.

Conclusions

It is concluded that the kinanthropometric profile does not point to significant correlations for maximum VO2 (VO_{2max}) in *karate* athletes. However, it has a effect size (f^2) of relevant magnitudes on the VO_{2max} of karate athletes of different competitive levels. In addition, national-level (elite level) karate athletes point to a higher VO_{2max}, less body fat tissue and greater body straightness when compared to state-athletes and non-athletes practicing the sport.

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Profil kinantropometryczny i maksymalne zużycie tlenu u zawodników karate będących na różnych poziomach rywalizacji

Słowa kluczowe: wydolność, VO_{2max}, karate, somatotyp, kinantropometria, skład ciała

Streszczenie

Tło. Kinantropometria u zawodników karate (KT) może oferować korzyści w stosunku do maksymalnego zużycia tlenu (VO_{2max}) podczas kolejnych spotkań na zawodach.

Problem i cel. Analiza związku profilu kinantropometrycznego z VO_{2max} zawodników karate o różnych poziomach wyczynowych, a także porównanie profilu kinantropometrycznego i wyników VO_{2max} między zawodnikami będących na różnych poziomach rywalizacji.

Metody. W badaniu wzieło udział 36 dorosłych karateków płci męskiej, w tym 12 będących sportowcami na poziomie stanowym/regionalnym, 12 na poziomie ogólnokrajowym (poziom elitarny) i 12 członków grupy kontrolnej. Profil kinantropometryczny analizowano za pomocą antropometrii. Spoczynkowe tętno analizowano za pomocą oksymetru. Test VO_{2max} przeprowadzono według standardów *Queens College Step Test*.

Wyniki. U sportowców na poziomie ogólnokrajowym stwierdzono niższą wartość tkanki tłuszczowej, lepsze VO_{2max} ($p < 0{,}05$) oraz przewagę somatotypu ektomorficznego. W grupie kontrolnej stwierdzono przewagę somatotypu endomorficznego. Nie stwierdzono zależności pomiędzy profilem kinantropometrycznym a VO_{2max} ($p > 0{,}05$). Natomiast odnotowano istotną wielkość rezultatu ($f^2 > 0{,}44$) pomiędzy profilem kinantropometrycznym a VO_{2max} KT.

Wnioski. Profil kinantropometryczny nie był związany z VO_{2max} u karateków. Jednak na poziomie ogólnokrajowym (elitarnym) karatecy mieli wyższe VO_{2max}, mniejszą ilość tkanki tłuszczowej i bardziej wyprostowaną postawę ciała w porównaniu z innymi zawodnikami na stanowym poziomie rywalizacji a także zawodnikami nie będącymi sportowcami.