Influence of warm-up, physical activity level, and body fat percentage on the reaction time of punches and kicks in adult kickboxing practitioners[1]

Influência do aquecimento, nível de atividade física e percentual de gordura corporal no tempo de reação de socos e chutes em praticantes adultos de kickboxing

Influencia del calentamiento, nivel de actividad física y porcentaje de grasa corporal en el tiempo de reacción de puñetazos y patadas en practicantes adultos de kickboxing

[Research Article]

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Abstract

The aim of this present study is to investigate the influence of warm-up, physical activity level, and body fat percentages on the reaction time of punches and kicks in adult kickboxing practitioners. The sample consisted of 20 kickboxing practitioners. Physical activity level was

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evaluated by the International Physical Activity Questionnaire-Short Form, body composition by electrical bioimpedance, and reaction time by the mobile application TReaction. The direct punch and the kick with no warm-up had the highest reaction times (p<0.05) when compared with after warm-up and after the two-minute rounds. There were correlations between kick with no warm-up reaction time and fat percentage (r=0.524; p=0.018), and kick with no warm-up and physical activity level (r=-0.560; p=0.010). The physical activity level and the percentage of body fat are variables that interfere with kickboxers' kick reaction time. Furthermore, the warm-up had a positive influence on the reduction of the reaction time of punches.

Keywords: body fat, combat sports, martial arts, physical activity, reaction time, sports.

Resumo

O objetivo do presente estudo foi investigar a influência do aquecimento, nível de atividade física e percentuais de gordura corporal no tempo de reação de praticantes adultos de kickboxing. Vinte praticantes de kickboxing tiveram o nível de atividade física analisado pelo instrumento IPAQ-SF, a composição corporal por bioimpedância e o tempo de reação pelo TReaction. O soco direto e o chute sem aquecimento tiveram os maiores tempos de reação (p <0,05). Houve correlações entre o tempo de reação do chute sem aquecimento e o percentual de gordura (r = 0,524; p = 0,018), e chute sem aquecimento e nível de atividade física (r = -0,560; p = 0,010). O nível de atividade física e o percentual de gordura corporal são variáveis que interferem no tempo de reação do chute dos praticantes de kickboxing. Além disso, o aquecimento teve uma influência positiva na redução do tempo de reação dos socos.

Palavras-chave: artes marciais, atividade física, esportes, esportes de combate, gordura corporal, tempo de reação.

Resumen

El objetivo fue investigar la influencia del calentamiento, el nivel de actividad física y los porcentajes de grasa corporal en el tiempo de reacción de los practicantes de kickboxing adultos. Se analizó el nivel de actividad física de veinte kickboxers mediante el instrumento IPAQ-SF, su composición corporal mediante bioimpedancia y su tiempo de reacción mediante TReaction. El golpe directo y la patada sin calentamiento tuvieron los tiempos de reacción más largos (p<0,05). Hubo correlaciones entre el tiempo de reacción de patada sin calentamiento y el porcentaje de grasa (r = 0,524; p = 0,018), y patadas sin calentamiento y nivel de actividad física (r = -0,560; p = 0,010). El nivel de actividad física y el porcentaje de grasa corporal son variables que afectan el tiempo de reacción de patada de los practicantes de kickboxing. Además, el calentamiento tuvo una influencia positiva en la reducción del tiempo de reacción.

Palabras clave: actividad física, artes marciales, deportes, deportes de combate, grasa corporal, tiempo de reacción.

Introduction

Kickboxing is a combat sport whose purpose is to deliver traumatic blows repeatedly against the body of opponents through punches, kicks, knees, and spurs (Gama et al., 2018). In both training and competition situations, such skills must be performed by combining speed, strength, flexibility, and aerobic endurance (Zadorozhna et al., 2019).

In addition to these characteristics, combat sports such as kickboxing present a significant demand for the development of internal cognitive-motor resources, such as reaction time. Reaction time represents the duration that an individual takes from the moment that a stimulus is perceived

until the moment they respond to that stimulus (i.e., detecting, processing, and responding to a specific stimulus) (Mirifar et al., 2019) and is included like a critical characteristic of optimal performance (Blumenstein & Orbach, 2020)

The preservation and development of these abilities are important not only for sports performance, but also for performing daily activities, such as accelerating or decelerating gait, avoiding unexpected obstacles, lifting and carrying loads, going up and down sloping terrain, and manipulating objects of varying sizes (De Meester et al., 2020). Because of this, many individuals choose to practice kickboxing not only to become high-performance athletes but to increase conditional and coordination skills and improve self-confidence and mental resilience (Piepiora et al., 2022).

In addition, kickboxing, if exercised with high volume and training intensity, produces high caloric expenditure (Duarte et al., 2021; Necip et al., 2021). This can influence the body composition of practitioners through a decrease in fat mass percentages and an increment in lean mass (Rapkiewicz et al., 2018). Hence, low-fat mass ratios and high lean mass ratios are associated with greater body displacement speed, better dynamic balance, and shorter reaction time to motor stimuli (Gürsoy & Canli, 2021; Witkowski et al., 2021).

Another variable to be considered concerns the warm-up performed at the beginning of kickboxing training sessions, that is, the set of bodily acts to prepare the locomotor system for the subsequent execution of fighting skills, both in training and in actual sports combats. It is estimated that the warm-up positively influences the generation of muscle strength and speed if performed with adequate accuracy, specificity, and duration (Altavilla et al., 2018; Özcan et al., 2018).

Therefore, the information listed allows the formal hypothesis that kickboxing training programs, depending on the volume and intensity prescribed, tend to amplify the levels of strength and speed of the blows delivered (kicks, punches, knees, elbows, among others), and to reduce the reaction time. On the other hand, body composition indices and pre-workout warm-ups are also variables that influence strength, speed, and reaction time. Thus, the aim of this present study was to investigate the influence of warm-up, physical activity level, and body fat percentages on the reaction time of punches and kicks in adult kickboxing practitioners.

Methods

Participants

The present study is characterized as descriptive, correlational, and cross-sectional research (Thomas, Nelson & Silverman, 2012; Siedlecki, 2020). The sample consisted of kickboxing practitioners of all graduation levels, effectively training in academies accredited by the

Kickboxing Federation of the State of Rio de Janeiro, Brazil. For the composition of the participants, the administrative managers of the kickboxing academies in the city of Rio de Janeiro were initially contacted through e-mail messages made available on their websites. In these messages, the purposes of the investigation and the request for an appointment with the athletes were explained. Because of this, sample was composed for convenience.

Sample size was estimated using G*Power software version 3.1.9.4, with the information inputted: Anova with effect size = 0.3, alpha = 0.05, power = 0.8, number of measures = 3, and correlation between measures = 0.5. The result of this calculation was of 20 participants. All data necessary was collected with 20 kickboxers, without sample loss (100% of estimated).

As inclusion criteria, it was established that the study participants would be those aged between eighteen and sixty years, including men and women, practicing kickboxing for at least 3 months in two or three weekly sessions of at least sixty minutes, without any type of muscular or skeletal injury. Additionally, the subjects should exhibit negative scores on the International Physical Activity Questionnaire-Short Form (IPAQ-SF) (Warburton et al., 2021). Women in the premenstrual period were excluded, as were individuals who did not attend data collection. All participants signed an informed consent formed with agreement to participate in the study, as described in Resolution 466/12 of the Brazilian National Health Council.

Data collection procedures

Data collection was carried out in three visits with two days of interval. On the first visit, assessments of the usual physical activity level of the research participants were performed using the IPAQ-SF and body composition by bioimpedance was evaluated. Reaction time was assessed using the TReaction application on the second visit for condition without previous warm-up and after five minutes warm-up and on the third visit for condition after two-minutes round. The entrance order of the conditions was random by use of Excel software.

International Physical Activity Questionnaire – Short Form (IPAQ-SF)

The assessment of the usual physical activity level of kickboxers was carried out by completing the IPAQ-SF, made available via email (Kurth & Klenosky, 2021). This questionnaire includes seven questions related to time spent with physical activity by the individual in the last week. Questions include activities undertaken at work, to get from one place to other, for leisure, for sport, for exercise, or as part of activities at home or in the garden. The filtering of the answers was done in the software Automatic Report of the International Physical Activity Questionnaire.

This program sets the level of weekly physical activity as low, moderate, and high, multiples of metabolic equivalents per week and kcal per week.

The category of the high level of physical activity includes people who meet any of the following two criteria: 1) in the last week, they performed vigorous physical activities on at least three days, accumulating 1500 MET-minutes/week; 2) combined, for seven days, walking and physical activities of moderate or vigorous intensity, reaching a minimum of 3000 MET-minutes/week.

The moderate level of physical activity category encompasses individuals who meet any of these three criteria: 1) three or more days of vigorous physical activity for at least 20 minutes; 2) five days or more of moderate physical activity or walking lasting at least 30 minutes; 3) five or more days of any combination of walking, moderate, or vigorous physical activity, reaching a minimum threshold of 600 MET-minutes/week. The low level of physical activity category encompasses individuals who did not meet the criteria for the high and moderate level of physical activity categories.

Body composition assessment

Body composition was estimated using a bioimpedance scale, model Omron HBF-515C. It is an instrument for measuring body composition, indicating the approximate amount of muscle, bone, and adipose tissue through an electric current that passes through the body via metal plates. All participants were instructed to follow the preparation protocol, which consisted of: not ingesting caffeinated food or drinks in the four hours prior to the test; not ingesting alcoholic beverages in the 24 hours before the exam; drinking two to four glasses of water before the exam; do not smear hands or feet with any type of cream; urinating up to thirty minutes before the procedure; wear light clothing items when weighing; not practicing physical exercises in the 24 hours before weighing; not going to saunas in the 12 hours before the exam (Ward, 2019).

For the measurement of body composition, a previous entry was made in the device of information about the age, sex, and height of the individual. Then, the participant was asked to get on the scale barefoot and without socks, wearing as little clothing as possible and without metallic parts on the body; put feet in the delimited space; hold a metal plate with the shoulder flexed at 90° and wait for the device to be read. After processing, the results were recorded in notebooks with data relating to age, sex, height, body mass, lean mass and body fat percentage, body mass index (BMI), basal metabolism, body age, and visceral fat. The BMI qualifying categories are underweight (less than 18.5 kg/m²), normal weight (between 18.5 and 24.9 kg/m²), overweight (between 25.0 and 29.9 kg/m²), and obesity (higher than 30.0 kg/m²) (Heslehurst et al., 2019).

Reaction time test

The reaction time test was performed with the TReaction app. This estimates the time interval resulting from the perception of an external stimulus, emitted by a mobile phone device with a light flash positioned in a straight line, one meter away and at shoulder height from the participant. The motor response to the stimulus was expressed in the form of noise produced by a blow applied to the punching bag. This application has been reviewed and validated by Coswig et al. (2019), being an accurate reaction time test measure and used in a variety of sports. In each test, the cell phone fires five flashes, with the lowest reaction time being counted, which corresponds to the best performance. In the present study, we recorded the reaction time of the direct punch delivered by the back hand in the high guard posture, as well as the back leg circle kick in the same position. These strikes were chosen because they are considered low-motor complexity fighting skills.

The measurements of the punch and kick reaction time described above took place in three different situations, namely: 1) without a previous warm-up (no warm-up – NW); 2) after a 5-minute warm-up (with warm-up – WW); 3) after a two-minute round (Post2min) in the context of kicklight, which is a modality of kickboxing. The 5-minute warm-up was divided into 3 minutes of stretching and joint mobility exercises for the lower and upper limbs (ankle, knee, hip, trunk, elbow, wrist, and neck) and 2 minutes of running at submaximal intensity. The simulated two-minute round was in kicklight mode, which reproduced the combat mode of amateur competitions.

Statistical analysis

All collected data were processed by the IBM SPSS Statistics 25 program and presented as mean, standard deviation, and minimum and maximum values. The normality and homogeneity of variance of the data were verified by the use of Shapiro-Wilk and Levene tests, respectively. The One Way ANOVA, followed by the adjusted Bonferroni post hoc, was applied to identify possible differences in reaction time between punching and kicking conditions in the study participants. The independent t-test was used to analyze the difference between the sexes. Pearson's correlation test was used to analyze the associations between the variables body fat percentage, level of physical activity, and reaction time, with the degree of correlation classified as follows: ≤ 0.19 very weak; 0.20 to 0.39 weak; 0.40 to 0.69 moderate; 0.70 to 0.89 strong; and 0.90 to 1.00 very strong (Devore, 2006). A level of $p < 0.05$ was considered statistically significant.

Results

The sample consisted of 20 kickboxing practitioners, 11 men (55%) and 9 women (45%). Table 1 shows the descriptive results of the anthropometric characteristics, body composition, and age of the participants.

Table 1.
Anthropometric characteristics, body composition, and age of the sample.

Variables	Mean	SD	Minimum	Maximum
Age (years)	31.60	9.25	20.00	46.00
Height (cm)	169.90	12.00	151.00	187.00
Total body mass (kg)	78.82	17.24	55.90	134.20
Body fat (%)	31.99	10.46	12.40	49.30
Muscle mass (%)	30.95	6.69	22.00	43.80
BMI (kg/m²)	27.38	5.64	19.10	43.80
Visceral fat (%)	8.35	4.86	2.00	23.00

SD: standard deviation; BMI: body mass index

Table 2 shows the comparison of study variables between the sexes (male vs. female). A higher percentage of fat was observed for women ($p < 0.05$) and a higher basal metabolism for men ($p < 0.05$). The other variables did not show significant differences.

Table 2.
Comparative analysis of study variables between sexes.

Variables	Sex	Mean	SD	Mean difference	p-value
Age	♂	31.09	9.67	-1.13	0.794
	♀	32.22	9.24		
Body fat percentage	♂	26.08	8.59	-13.12	0.002
	♀	39.20	7.80		
Basal metabolism	♂	1854.18	212.06	503.40	<0.001
	♀	1350.78	51.99		
Punch NW	♂	502.64	126.94	-10.70	0.855
	♀	513.33	130.48		
Punch WW	♂	486.45	119.95	14.34	0.795
	♀	472.11	122.06		
Punch Post2min	♂	472.00	113.39	-30.22	0.488
	♀	502.22	65.21		

Kick NW	♂	683.09	114.37	-26.46	0.542
	♀	709.56	62.12		
Kick WW	♂	680.55	73.75	-26.01	0.483
	♀	706.56	88.76		
Kick Post2min	♂	654.45	126.01	-46.77	0.308
	♀	701.22	48.22		
MET	♂	5415.55	5210.83	2611.55	0.175
	♀	2804.00	2033.59		
Kcal	♂	7909.06	6814.76	4676.48	0.065
	♀	3232.58	2274.63		
PA level	♂	2.45	0.93	0.12	0.769
	♀	2.33	0.87		

♀: woman; ♂: man; NW: no warm-up; WW: with warm-up; Post2min: after a two-minute round; MET: metabolic equivalent; PA: physical activity.

Table 3 shows the reaction times values for punch NW, kick NW, punch WW, kick WW, punch after two-minute round (punch-post2min), and kick after two-minute round (kick-post2min) in relation to the body fat percentages and levels of physical activity, explicit as MET/week and kcal/week of the sample. It was observed that the direct punch NW and the kick NW presented the longest reaction times ($p<0.05$) when compared with those performed after warm-up (punch WW: p=0.012; kick WW: p=0.027) and after the two-minute rounds (punch-post2min: p=0.038; kick-post2min: p=0.022). This shows that athletes without warm-up were slower to deliver the blows. Moreover, the sample had an average MET/week of 4240.35 and 5804.64 kcal/week, both by IPAQ-SF. Therefore, the level of weekly physical activity is high.

Table 3.
Sample reaction time results.

Variables	Mean	SD	Minimum	Maximum
Punch NW (ms)	539.30*	77.59	419.00	694.00
Punch WW (ms)	448.90	89.76	229.00	616.00
Punch Post2min (ms)	485.60	93.79	305.00	733.00
Kick NW (ms)	720.60*	58.69	620.00	880.00
Kick WW (ms)	680.15	58.59	575.00	807.00
Kick Post2min (ms)	675.50	99.53	332.00	824.00
MET/week-IPAQ	4240.35	4220.07	488.00	18216.00

| kcal/week-IPAQ | 5804.64 | 5684.95 | 581.83 | 23494.09 |

SD: standard deviation; NW: no warm-up; WW: with warm-up; Post2min: after a two-minute kicklight round; MET/week: multiples of the metabolic equivalents per week; IPAQ: International Physical Activity Questionnaire; *: $p<0.05$ NW vs. WW and Post2min.

In table 4, a moderate positive correlation was detected between the reaction time of the kick NW and the body fat percentage, as well as a moderate negative correlation between the reaction time of the kick NW and the level of physical activity expressed in MET/week. These results show that a higher body fat percentage is related to a longer reaction time, that is, slower motor response to the stimulus. Moreover, higher levels of physical activity are related to a shorter reaction time.

Table 4.
Analysis of the correlation between the study variables.

		BF%	Punch NW	Punch WW	Punch Post2min	Kick NW	Kick WW	Kick Post2min	MET/ week
Punch NW	r	0.218							
	p-value	0.355							
Punch WW	r	0.114	0.411						
	p-value	0.631	0.072						
Punch Post2min	r	0.457	0.495	0.344					
	p-value	0.043*	0.027	0.138					
Kick NW	r	0.524	0.495	0.454	0.567				
	p-value	0.018*	0.027*	0.044*	0.009*				
Kick WW	r	0.462	0.369	0.541	0.620	0.765			
	p-value	0.040*	0.110	0.014*	0.004*	0.000			
Kick Post2min	r	0.278	0.359	0.378	0.464	0.653	0.676		
	p-value	0.236	0.120	0.100	0.039*	0.002	0.001		
MET/week-IPAQ	r	-0.447	-0.320	-0.094	-0.133	-0.560	-0.280	-0.232	
	p-value	0.048*	0.169	0.694	0.576	0.010*	0.232	0.325	
kcal/week-IPAQ	r	-0.446	-0.284	-0.042	-0.098	-0.476	-0.234	-0.208	0.984
	p-value	0.049*	0.225	0.861	0.682	0.034*	0.321	0.378	<0.001 *

BF%: body fat percentage; NW: no warm-up; WW: with warm-up; Post2min: after a two-minute kicklight round; MET/week: multiples of the metabolic equivalents per week; IPAQ: International Physical Activity Questionnaire; * $p<0.05$.

Discussion

The aim of this present study was to investigate the reaction time of adult kickboxers, considering warm-up, physical activity level, and body fat percentages. No differences were found in reaction time between men and women. This allowed performing the comparative and associative analyzes as a single group. In the present study, warmed-up fighters were found to kick and punch faster than non-warm-up fighters. This result corroborates both the observations of Altavilla et al. (2018) and the findings of Eken et al. (2020). Kicks and punches are motor skills that require the removal of limbs from inertia in an accelerated and vigorous way. Therefore, to deliver them, the fighter must be efficient in the immediate generation of muscular force through the alactic energy pathway of creatine phosphate. This is most easily achieved when body temperature rises (Altavilla et al., 2018). Similar results to those of the present study were found by González-Fernández et al. in 2022. They evaluated the reaction time of 14 soccer players using a psychomotor vigilance task under conditions with no warm-up, immediately after warm-up, and with 15 minutes of passive rest after warm-up. The best result for reaction time analysis was found immediately after the warm-up (González-Fernández et al., 2022). Warm-up is used to prepare an individual's body for subsequent exercises, with the aim of improving performance and reducing the risk of injury. Warm-up is associated with both thermo-dependent and thermo-independent mechanisms related to the neuromuscular and cardiovascular systems, and it has a connection with cognitive changes that can impact the subsequent physical performance of the practitioner (Rumeau, Grospretre, & Babault, 2023).

The present study also recorded a moderate and positive correlation between the reaction time of the kick NW and the body fat percentage. That is, the higher the percentage of body fat, the longer the kick reaction time. In this study, the authors found that kickboxers with body fat percentages between 9 and 16% reacted more slowly to stimuli for kicks than those with values between 6.1 and 11.4%. Dominski et al. (2018) assessed reaction time in 22 police officers belonging to a special operations unit and found results similar to the findings of the present study. In their study, individuals with a lower percentage of body fat demonstrated better performance in the reaction time assessment conducted using a task applied with a simple visual stimulus of the Vienna Test System (VTS), version S9 (Dominski et al., 2018).

A moderate negative association between the reaction time of the kick NW and the level of physical activity expressed in MET/week was also observed in the present study. That is, the

greater the degree of weekly physical exercise, the shorter the reaction time. The study by Ambrozy et al. (2022) confirms this finding. In experimental research carried out in Poland, the authors divided 60 elite kickboxers into an experimental group (EG) and a control group (CG). The EG performed technical kickboxing exercises plus CrossFit sessions, and the CG performed only the usual technical training. The duration period was ten days. At the end of the intervention, they found that the reaction time of the EG was reduced when compared to that of the CG ($p < 0.05$). Pavelka et al. (2020) reached a similar conclusion but investigated the performance of mixed martial arts (MMA) fighters. The authors concluded that increases in physical fitness are reflected in reductions in the reaction time of lower limb blows.

The present study verified limitations as the cross-sectional design. This did not allow us to investigate possible variations in the reaction times of punches and kicks from a longitudinal perspective. The convenience sampling process and the inability to control nutrition can be considered as additional limitations. Therefore, the results should be analyzed with caution.

Conclusion

The present study observed that the warm-up, the level of physical activity, and the percentage of body fat constitute variables that are related with the reaction time of kickboxers regarding the kick. Moreover, the warm-up influenced the reaction time of punches. In terms of practical applications for the elaboration of training programs, this means that warm-ups must be performed accurately at the beginning of the sessions for better prepare athletes body for training and competitions stimulus. Furthermore, it is critical to observe whether the athletes body composition changes with the training regime, given the relationship observed with the execution of kicks. It is recommended that future studies investigate the variables analyzed from a longitudinal context.

Conflicts of interest – There is no conflict of interest, confirmed by all authors.

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