Original Article

RBAFS Revista Brasileira de Atividade Física & Saúde
SOCIEDADE BRASILEIRA DE ATIVIDADE FÍSICA & SAÚDE

rbafs.org.br

Health-related physical fitness of adolescents practicing Krav Maga: proposal for a specific test

Aptidão física relacionada à saúde de adolescentes praticantes de Krav Maga: proposta de um teste específico

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DOI

10.12820/rbafs.30e0383

ABSTRACT

Objetive: To propose a specific test to assess the physical fitness of Krav Maga (KM) practitioners, determine the correlation of this specific test with other physical fitness tests, and assess the sensibility of this specific test to a KM training protocol. Methods: The participants were 24 adolescents of both sexes (17.0 ± 0.5 years old) who were high school students at a Military College and who underwent a 12-week training protocol, 3 times a week. Flexibility, muscular strength/resistance, and cardiorespiratory fitness were measured to assess health-related physical fitness (HRPF), and the Krav Maga Combat Test (KMCT) was proposed to assess the specificity of KM. The t-test was used for dependent samples, while a multiple linear regression model was used to determine how the physical fitness test explains the variance of the KMCT, with all tests adopting a p-value of <0.05. Results: The results showed that 12 weeks of training improved general ($p < 0.05$) and specific HRPF (KMCTpre = 18.37 ± 4.00 reps; KMCTpost = 30.54 ± 11.03 reps, $p < 0.05$), and the KMCT showed moderate-strong correlations (0.42 – 0.72) with HRPF, with these variables explaining 49% of the test. Conclusions: It is concluded that the training program proposed in this study is effective in improving the general and specific physical fitness of KM practitioners, and that the KMCT proposed for the modality presented correlation with physical fitness tests and sensitivity to training.

Keywords: Adolescence; Physical activity; Physical fitness; Health; Krav Maga.

RESUMO

Objetivo: Propor um teste específico para avaliar a aptidão física de praticantes de Krav Maga (KM), determinar a correlação desse teste específico com outros testes de aptidão física e avaliar a sensibilidade desse teste específico a um protocolo de treinamento de KM. Métodos: Os participantes foram 24 adolescentes de ambos os sexos (17,0 ± 0,5 anos) que eram estudantes do ensino médio em um Colégio Militar e que passaram por um protocolo de treinamento de 12 semanas, 3 vezes por semana. A flexibilidade, a força/resistência muscular e a aptidão cardiorrespiratória foram medidas para avaliar a aptidão física relacionada à saúde (AFRS), e o Teste de Combate para Krav Maga (KMCT) foi proposto para avaliar a aptidão física específica para KM. O teste t foi utilizado para amostras dependentes, enquanto um modelo de regressão linear múltipla foi utilizado para determinar como os testes de aptidão física explicam o resultado do KMCT, com todos os testes adotando um valor de $p < 0,05$. Resultados: Os resultados mostraram que 12 semanas de treinamento melhoraram a AFRS geral ($p < 0,05$) e a específica (KMCTpre = 18,37 ± 4,00 repetições; KMCTpost = 30,54 ± 11,03 repetições, $p < ,05$), e o KMCT apresentou correlações moderadas a fortes (0,42 – 0,72) com a AFRS, com essas variáveis explicando 49% do teste. Conclusões: Conclui-se que o programa de treinamento proposto neste estudo é eficaz na melhoria da aptidão física geral e específica de praticantes de KM, e que o KMCT proposto para a modalidade apresenta correlação com a aptidão física e a sensibilidade ao treinamento.

Palavras-chave: *Adolescência; Atividade física; Aptidão física; Saúde; Krav Maga.*

Introduction

The American College of Sports Medicine defines physical fitness as the set of attributes that an individual has or achieves that relate to the ability to perform a physical activity[1]. Health-related physical fitness (HRPF) includes characteristics that, at adequate levels, provide a lower risk of developing diseases or chronic-degenerative conditions associated with low levels of habitual activity, such as: cardiorespiratory fitness, flexibility, strength, muscular endurance, and body composition[2,3].

Anchored in the idea of lifelong physical fitness

and the search for an active lifestyle, HRPF has been shown to be a guideline for promoting and maintaining health in the school environment and reducing the risk of developing chronic degenerative diseases[4].

The international recommendations of the World Health Organization recommend that adolescents do 60 minutes of daily physical activity to maintain proper health[5]. The prevalence of insufficient physical activity in children and adolescents in Brazil was near o 78%[6].

Several studies in children and adolescents have suggested that specific physical exercise programs can lead to important adjustments in the components of HRPF[3,7,8].

It is understood that school physical education is fundamental for the promotion of a physically active and healthy lifestyle, representing one of the most important variables to improve the quality-of-life indexes of students, as described by Nahas[9]. The Brazilian Military School System has as one of its main objectives in school physical education the multilateral formation and development of students, by increasing their physical and motor repertoire, their capacity for physical performance, and basic motor and sports skills[10].

To this end, the Military School of Brasília currently offers 16 different sports as part of its curriculum for primary and secondary schools, among which, in the last three years, Krav Maga (KM) has stood out with greater adherence among the combat disciplines offered[11]. Moreover, its practice has been able to stimulate physiological, psychological, and cognitive benefits[12].

Epidemiological studies have highlighted the beneficial role of regular physical exercise for all age groups[10]. In adults, the regular and systematic practice of KM has shown several benefits, including the development of maximal strength, improvement of body composition, and maintenance of metabolic and vascular parameters[12-14]. However, its contribution to improving adolescent health is still unclear.

Several studies have already proposed specific tests to measure parameters related to the physical fitness of practitioners, using specific gestures from their modalities, making it possible to use these results to improve the training regime and verify the athlete's performance for the activity in question. In the case of judo, there are tests to measure anaerobic performance, such as the Special Judo Fitness Test[15], and aerobic capacity and power, such as the Judo Aerobic Test[16]. In addition, the specific anaerobic assessment for mixed martial arts (ASA_{MMA}) was developed and validated to measure the anaerobic capacity of mixed martial arts athletes[17], and the Karate Specific Aerobic Test was developed and validated for karate[18,19].

However, there are no specific tests for KM in the literature or tests that measure HRPF using gestures from martial arts or combat modalities in teenagers, so this test is relevant and important for the KM modality and other combat sports that use similar gestures, such as boxing, Muay Thai, and karate.

In addition, the lack of specific tests for KM makes it difficult to measure the gains from different interventions in KM gestures or techniques. In view of the above, this study aimed to propose a specific test to assess the physical fitness of KM practitioners, determine the correlation of this specific test with other physical fitness tests and assess the sensibility of this specific test to a KM training protocol.

Methods

This study had an experimental-correlational design, consisting of intentional non-probability sampling. Only one group received the pedagogical intervention, which was implemented by the researcher at a single Military School.

This study was previously submitted to and approved by the Ethics and Research Committee of the School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, under CAAE registration no. 40025420.7.0000.5659, opinion nº 4.579.829 - 2021, and by the Military School of Brasília Teaching Directorate Internal Bulletin no 226 of November 30, 2020. All participants and legal guardians were informed about the research procedures, with adults signing the informed agreement form and those under the age of 18 signing the assent form.

Participants

The participants in this study were 24 students of both sexes (14 males and 10 females), aged between 17.0 ± 0.5 years old, all of whom were in high school and voluntarily enrolled in the KM team at the Military School of Brasilia, Brasília, Distrito Federal, Brazil. During the period of this study the participants did not perform any other type of exercise or martial arts parallel to the KM training protocol.

The inclusion criteria for the participants were: a) Did not have previous experience with KM; b) Did not have parallel training during the period of this study.

The exclusion criteria for the participants were: a)

dropped out; b) interrupted the follow-up; c) were prevented from taking all the proposed tests; d) did not complete the two assessment phases (pre- and post-test); e) did not attend 75% of the practical classes; f) did not return the informed agreement form signed by their parents.

The students who were not part of the final sample of this study were not excluded from any of the activities carried out during the research; they were just not included in the sampling.

To characterize the participants in this study, information was collected on gender, socioeconomic status, measured by the Brazilian Economic Classification Criterion[20], physical activity outside of class, using the Project Sport Brazil (*Programa de Apoio à Educação Especial* - PROESP-BR) assessment form[21], and body mass index, determined by weight and height measurements.

The data collection was carried out by two previously trained assessors who were familiar with the study routine, in which anthropometric and motor variables were assessed.

Body composition and anthropometric measurements

The body mass index was calculated to estimate excess weight. To measure body mass, a Welmy model R-110 mechanical scale with 150 kg capacity was used in conjunction with a stadiometer (Caumaq, Brazil) to measure height. To estimate excess visceral fat, the waist-to-height ratio was used, which is determined by calculating the ratio of waist circumference to height in centimeters. Waist circumference was measured using a Sanny Medical model SN-4010 inelastic tape measuring 2 m, positioned at the smallest curvature between the ribs and the iliac crest[22].

To determine body composition, 4 skinfolds were measured with a scientific adipometer: triceps, subscapular, supra iliac, and abdominal. Fat percentage was determined according to Faulkner's[22] protocol.

Health-related physical fitness

To measure the components of physical fitness, the protocols and tests proposed by PROESP-BR, an interdisciplinary and interinstitutional project developed in the field of physical education and school sports, was used to assess children and adolescents between the ages of 7 and 17 in terms of HRPF, physical fitness related to motor development, and perception of motor skills[21].

HRPF was assessed by cardiorespiratory fitness tests (6-minute run/walk test), flexibility (sit and reach test), localized muscular endurance (1-minute sit-up test), upper limb strength (2 kg medicine ball throw test), lower limb strength (horizontal jump test), agility (4x4 meter square test), and speed (20-meter sprint test).

Cardiorespiratory fitness

For cardiorespiratory fitness, a 6-minute run/walk test was performed on an official athletics track, the perimeter of which was recorded. A tape measure, a stopwatch, and an evaluation form were used to facilitate the test. At the end of the test, a signal (whistle) was sounded, and the students stopped the test and remained where they were until the distance covered (in meters) was recorded.

Flexibility

For the flexibility test, the sit-and-reach test was performed using a tape measure and adhesive tape. The tape measure was stretched across the ground and a 30 cm adhesive tape was placed perpendicular to it at the 38 cm mark. The participants were barefoot, with their heels touching the tape at the 38 cm mark, their knees extended, and their hands overlapping, and they were asked to slowly lean forward and extend their hands as far as possible, and to remain in this position for as long as necessary to record the distance. Two attempts were made and the best measurement was used for evaluation.

Muscular endurance

Localized muscular endurance was measured using the abdominal endurance test. During the test, the subject lay supine on a mat with their knees bent at 90º and feet flat on the floor. Their arms were crossed over their chest. The assessor held the subject's ankles on the floor. At the sound of the signal, the subject began flexing their trunk until their elbows touched their thighs, and then returned to the starting position, performing the maximum number of complete repetitions. The result was expressed as the number of complete movements performed in 1 minute.

Upper and lower limb strength

For upper limb strength, a 2 kg medicine ball throw test was performed. The subject sat with their knees straight, legs together, and their back completely against the wall. They held the medicine ball close to their chest with their elbows bent. At the assessor's signal, they had to throw the ball as far as possible, keeping their back against the wall. The distance of the

throw was recorded from point zero to where the ball first touched the ground. Two throws were performed and the best result was recorded for evaluation.

Lower limb strength was measured using the horizontal jump test, which consisted of attaching a tape measure to the ground perpendicular to the starting line. The starting line was marked with masking tape. The zero point of the tape was located at the starting line. The subject stood immediately behind the line, feet parallel and slightly apart, knees semi-flexed, torso slightly forward. At the signal, the student had to jump as far as possible and land with both feet at the same time. Two attempts were made and the best result was used for evaluation.

Agility

For agility, the 4 x 4-meter square test was used, where a square was marked out with four meters on each side and a cone at each angle of the square. The starting line was marked with masking tape. The subject started from a standing position with one foot forward immediately behind the starting line. At the assessor's signal, the subject ran at maximum speed and touched the cone in the diagonal corner of the square with one hand. He/She then ran to touch the cone to his/her left (or right) and subsequently ran to touch the diagonal cone (diagonally across the square). Finally, they run to the last cone, which was the starting point. The timer was started by the evaluator when the subject touched the inside of the square with their foot for the first time and stopped when they touched the fourth cone with one of their hands. Two attempts were made and the shortest time was recorded for evaluation.

Speed

Speed was tested with a 20-meter sprint. Three lines were marked: the first (starting line); the second, 20 meters from the first (timing line); and the third, two meters from the second (finish line). The third line served as a reference point for the runner, preventing them from slowing down before crossing the timing line. At the evaluator's signal, the runner ran as fast as possible toward the finish line.

Krav Maga Combat Test

The Krav Maga Combat Test (KMCT) consisted of a test in which three participants (two stimulators/attackers and one performer) were positioned 2 meters apart, all in a standing position.

After the sound stimulus (whistle), one of the attackers had to push (stimulus) the performer backwards, forwards, or sideways at random. The latter, in turn, with his/her eyes closed, received the surprise attack (stimulus), which threw him/her to the ground and forced him/her to cushion him/herself randomly (in the provoked direction).

He/she then got up as quickly as possible (avoiding a new or continuous stimulus) and performed two hand attacks and one kick (of his/her choice), against the stimulator, as quickly as possible.

The KMCT was divided into four periods: 10 seconds (A), 20 seconds (B), 30 seconds (C), and 40 seconds (D), with 10-second intervals between them, for a total of 130 seconds (estimated time to perform a self-defense technique).

During each of the periods, the performer received a different stimulus (push) and, after cushioning, performed three sequential attacks, always in the same quantity (two hand attacks and one kick of his/her choice), at maximum execution speed, trying to achieve the highest possible number of repetitions of the suggested techniques.

The total number of executions is the main variable of the test, it represents a measure of external work during the test, meanwhile, the heart rate at the end of the test is a parameters of intensity of the test, representing the internal intensity, the recovery of heart rate after 1 minute of the end of the test, represents the ability of aerobic system to recovery after the effort.

Using these parameters, the index for the KMCT was calculated according to the following equation[15]:

$$\frac{\text{KMCT} = \text{HRend (bpm)} + \text{HR1min (bpm)}}{\text{A+B+C+D (total number of sets completed)}}$$

Where HRend (bpm) and HR1min (bpm) are the heart rates immediately after the effort and 1 minute after the test, respectively, and A + B + C + D is the total number of sets completed in series A, B, C, and D. The lower the index, the better the result.

Krav Maga class structure

The Military School of Brasília has a dojo for combat sports, a space compatible with the modality. The equipment was satisfactory and included mats, mattresses, balls, cones, and other equipment suitable for the research.

In total, the study lasted 12 weeks, with a total of 36 classes, held three times a week and lasting 45 minutes

each, including tests and re-tests. The classes developed in this study were based on theoretical proposals aimed at promoting HRPF[7,9,21,23]. In practice, the content and methodology developed and approved by the Wingate Academic College were taught, as described in Table 1[23].

The aim of the proposed activities was to develop all the physical skills. As an external motivational element used by the teacher, in addition to the knowledge related to the practices, musical accompaniment was used in each training session. Each activity proposed was always justified with the aim of making the students understand the process they were involved in and its importance for their lives. These aspects allowed the students to be properly involved in the activities, even those that required more physical strength.

Statistical analysis

Normality of the data was determined by the Shapiro-Wilk test, while homogeneity was determined by the Levene test. The presence of outliers was checked using a box plot. In the case of non-parametric data, these were converted to a logarithmic basis (Log 10). To compare two variables before and after, the dependent samples t-test was used and the effect size (ES) was calculated for each of the comparisons and classified as trivial (< 0.35), small (0.35 - 0.80), moderate (0.80 - 1.5), or large (> 1.5). To determine the correlation between the specific test and the physical fitness tests, the variables were correlated using Pearson's correlation, with the correlation coefficients categorized as very weak (0.0 - 0.2), weak (0.2 - 0.4), moderate (0.4 - 0.7), strong (0.7 - 0.9), or very strong (0.9 - 1.0)[24].

The variables that showed significant correlations were entered into a multiple correlation (forward) model, which sought to verify how the dependent variable (KMCT number of reps) is explained by physical fitness. The Durbin Watson test was used to check for correlations between residuals, and only models with values between 1 and 3 were accepted. The regression values were considered like the correlation values. All analyses were performed using JASP software (version 0.17.3, Amsterdam), using a p value <0.05.

Results

Table 2 presents the comparison between the anthropometric characteristics of the participants before and after the KM training period, showing significant changes in fat %.

Table 3 shows the physical fitness of the participants before and after the training period. Abdominal muscle

Table 1 – Description of the activities proposed in the intervention (intervention protocol)

Part of the class	Activities carried out
First part (5 to 10 min)	Exercises for localized effects, neck, shoulders, wrists, elbows, hips, knees, and ankles. General warm-up: trot; 2 sets of 10 reps each of jumping jacks, rowing sit-ups, push-ups on the floor with open palms, squats without weight, jumps over a 40 cm box; 1 minute rest between sets.
Main part (30 to 40 min) Krav Maga techniques	a) Each movement was repeated 10 times, in 3 sets, for 2 minutes each: combat stances, movements, and direct, cross, and upward punches. Open hand attacks, front and side kicks, front, side, and back rolls, elbows, knees, combined attack and defense movements. b) Front and side projections, static and dynamic front, side, and rear choke escapes, baton defenses, knife and improvised weapon drills, wrist, elbow, and shoulder wrench escapes, simulated combat under stress.
Final part	Return to calm, static stretches lasting 20 to 30 seconds each.

Source: Andrade Neto[10].

Table 2 – Anthropometric characteristics and body composition before and after Krav Maga training

Variable	Before	After	p	95% CI	Effect size	Classification
Height (m)	1.68 ± 0.08	1.68 ± 0.08	1.00	-	0.01	Trivial
Weight (kg)	65.55 ± 11.73	64.76 ± 9.77	0.43	-1.27; 2.88	0.16	Trivial
Body mass index (kg/cm)^2	22.85 ± 3.27	22.70 ± 2.91	0.70	-0.62; 0.91	0.08	Trivial
Circumference (cm)	76.04 ± 8.81	75.45 ± 8.79*	0.02	0.07; 1.09	0.48	Small
Tricipital skinfold (mm)	18.37 ± 5.80	18.08 ± 5.32	0.50	-0.59; 1.17	0.13	Trivial
Subscapular skinfold (mm)	19.20 ± 5.30	17.91 ± 4.88*	0.01	0.30; 2.27	0.55	Small
Abdominal skinfold (mm)	22.20 ± 5.52	19.87 ± 6.27*	0.04	0.12; 4.54	0.44	Small
Supra iliac skinfold (mm)	17.91 ± 5.49	17.79 ± 4.51	0.76	-0.71; 0.96	0.06	Trivial
Fat percentage	17.74 ± 2.94	17.15 ± 2.57*	<0.01	0.16; 1.02	0.58	Small

*represents statistical difference between measurements (p < 0.05)

strength, jumping, and medicine ball throwing showed significant improvements, as did the results for muscle flexibility, aerobic endurance, and speed were improved with intervention. The 20-meter sprint speed was not altered by the training.

The Table 4 presents the comparison between the KMCT before and after the training protocols, the results evidencing that improved KMCT a KM training, indicating that KMCT was sensitive to training process.

The correlations between KMCT and physical fitness variables were present in Table 5, the variables sit ups, long jumps, Medicine ball throw, 6' test, 20m sprint and rafting of perceived exertion presented moderate to strong correlations with the KMCT.

The variables that presented correlation with KMCT were added to a multiple linear regression model. The combinations of the variables that better explained the variation of the tests were presented in Table 6, the variables that presented autocorrelation, or violated the linear regression's assumptions were not considered as valid models.

Table 5 – Correlations between Krav Maga Combat Test and physical fitness

Variable	KMCT (n. reps)	Classification
Abdominal strength	-0.04	Very weak
Sit-up	0.44*	Moderate
Long Jump	0.61*	Moderate
MBT	0.72*	Strong
Flexibility	-0.03	Very weak
6' test	0.52*	Moderate
Square	-0.21	Weak
20m test	-0.51*	Moderate
[La]mean	-0.05	Very weak
[La]peak	0.16	Very weak
RPE	0.42*	Moderate
HRmean	0.21	Weak

MBT = medicine ball throw; [La]mean = mean blood lactate concentration; [La]peak = peak of blood lactate concentration; RPE = rafting of perceived exertion; HRmean = mean heart rate. * Represents statistical correlation ($p < 0.05$).

Discussion

This study aimed to propose a specific test to assess the physical fitness of KM practitioners, determine the

Table 3 – Comparison between the physical fitness of practitioners before and after Krav Maga training in teenagers.

Variable	Before	After	p	95% CI	Effect size	Classification
Abdominal strength (rep)	15.35 ± 3.98	18.48 ± 4.06*	<0.01	-3.94; -2.30	1.61	Large
Sit-ups (rep)	25.95 ± 7.65	37.08 ± 7.34*	<0.01	-14.00; -8.00	1.59	Large
Long Jump (m)	1.72 ± 0.41	1.90 ± 0.46*	<0.01	-0.24; -0.11	1.16	Moderate
Medicine ball throw (m)	3.74 ± 0.97	4.42 ± 1.04*	<0.01	-2.34; -1.68	1.03	Moderate
Flexibility (cm)	34.58 ± 8.42	41.5 ± 10.45*	<0.01	-38.00; -30.0	1.81	Large
6' test (m)	1045.25 ± 445.53	1242.60 ± 216.57*	0.01	-1296; -1107	0.48	Small
Square (s)	6.89 ± 0.74	6.55 ± 0.72*	0.04	0.01; 0.59	0.43	Small
20m test (s)	3.25 ± 0.44	3.15 ± 0.5	0.18	-0.03; 017	0.18	Trivial

* represents statistical difference between measurements ($p < 0.05$)

Table 4 – Comparison of Krav Maga Combat Test before and after training in teenagers.

Variable	Before	After	p	95% CI	Effect size	Classification
Time (m)	2.94 ± 0.38	2.87 ± 0.72	0.66	-0.24; 0.37	0.09	Trivial
Reps	18.37 ± 4.00	30.54 ± 11.03*	<0.01	-16; -8	1.24	Moderate
[La]rep (mmol/L)	1.43 ± 0.75	1.12 ± 0.62	0.14	-0.11; 0.74	0.30	Trivial
[La]mean (mmol/L)	8.54 ± 4.04	7.17 ± 2.66	0.09	-0.25; 3.00	0.35	Small
[La]3' (mmol/L)	10.43 ± 2.38	8.90 ± 2.69*	0.01	0.37; 2.70	0.55	Small
[La]5'(mmol/L)	11.05 ± 6.12	8.09 ± 3.79*	0.02	0.48; 5.53	0.50	Small
RPE (a.u.)	9.29 ± 0.55	8.95 ± 0.55*	0.02	0.03; 0.63	0.47	Small
HRmean (bpm)	185.29 ± 9.22	184.37 ± 8.04	0.60	-2.65; 4.48	0.10	Trivial
HR3'(bpm)	126.04 ± 13.29	126.87 ± 18.38	0.81	-7.99; 6.32	0.04	Trivial
HR5'(bpm)	118.62 ± 9.90	118.50 ± 13.68	0.96	-5.07; 5.32	0.01	Trivial

[La]rep = rest blood lactate concentrations; [La]mean = mean blood lactate concentration; [La]3'= blood lactate concentration after 3 minutes of the end of the test; [La]5'= blood lactate concentration after 5 minutes of the end of the test; RPE = rating of perceived exertion; HRmean = mean heart rate; HR3' = heart rate after 3 minutes of the end of the test; HR5' = heart rate after 5 minutes of the end of the test.

Table 6 – Multiple linear regression relating combat-specific test and physical fitness

Dependent variable	Independent variable	r	R^2	Adjusted R^2	DW	F	P
KMCT (reps)	MBT, 6' test, abdominal strength	0.69	0.49	0.41	1.183	6.05	0.01

KMCT = Krav Maga Combat Test; MBT = medicine ball throw; DW = Durbin Watson test.

correlation of this specific test with other physical fitness tests and assess the sensibility of this specific test to a KM training protocol. The main findings showed that the KMCT was correlated with the different components of physical fitness, and these components explain 49% of the variance of the specific test, furthermore, the KMCT shows sensibility to the training process, once the KM training protocol results in improvements of physical fitness, and the specific test detected these improvements.

A secondary result, the regular training of KM (3 times per week, for 12 weeks) presents benefits to health aspects of the adolescents, such as reduction in fat mass, lower waist circumference, better aerobic capacity, flexibility, lower and upper limps power and abdominal strength.

Regarding the anthropometric characteristics of the participants analyzed before and after the KM training period, there were significant changes in fat percentage and in the measurement of subscapular and abdominal skinfolds. It should be noted that the participants did not change their diet during the study period or did other exercises or physical activities during the period of this study.

Although there are studies relating fat loss in young people to different physical activities[3,7,25], the literature is limited in relation to KM. The study by Andrade Neto et al.[13], which used the same protocol in adults, found a reduction in fat in the groups examined, like the results of the present study.

The reduction in fat mass and improvement in body composition were associated with better health parameters in children and adolescents[26]. The KM training protocol from this study could be used as an effective strategy to maintain adequate body composition.

Regarding the participants' physical fitness before and after the training, it was clear that the parameters related to abdominal muscle strength (ES = 1.61), vertical jumping (ES = 1.15), medicine ball throwing (ES = 1.03), flexibility (ES = 1.81), aerobic endurance (ES = 0.48), and agility (ES = 0.43) showed significant improvements, while the 20-meter sprint speed (ES = 0.18) was not altered by the training. In their study of adult beginners and veterans who practiced KM with a protocol like the one used here, Andrade Neto et al.[11] found statistically significant differences in flexibility, physical fitness, and muscle strength, confirming the results found here.

These results are also like those of Gehre et al.[27], who found significant differences in upper limb strength and abdominal strength in jiu-jitsu practitioners compared to the control group. In the present study, the mean values for the medicine ball throw test for males were 32%, 44%, and 23% for the classifications "bad," "normal," and "excellent," respectively (Table 2), like the findings of Luguetti et al.[28] for public school students aged between 7 and 16.

In the study by Silva et al.[29], the results obtained showed that practicing taekwondo improved the variables flexibility, agility, and lower limb strength in a statistically significant way when comparing the pre- and post-practice phases, like KM practitioners.

No significant changes in 20-meter sprint speed (ES = 0.18) were observed in this study. Gehre et al.[27] also presented similar results when analyzing jiu-jitsu students, in which 25 male students with an average age of 16.04 ± 0.62 years obtained results considered "very weak" for this variable, and the non-practitioners obtained results considered "excellent."

The data found in the study conducted by Verardi et al.[30] on 105 children and adolescents of both sexes aged between 10 and 15 from public or private schools who practiced martial arts show that the boys (94.1%) and girls (84.6%) had their performance classified as "reasonable," "weak," and "very weak." These data are similar, probably since the speed achieved during the 20-meter sprint was not the main objective to obtain good performance in the modality, making it a skill that is seldom worked on or neglected.

The KM protocol from this study was effective in improving general physical fitness; higher physical fitness was associated with better health in adulthood and lower disease prevalence[31].

Table 3 shows improvements in the specific test with KM training when comparing the pre- and post-tests. There was statistical significance in the number of repe-

titions performed in the post-test (ES = 1.24), in the lactate measurements at 3 min (ES = 0.55) and 5 min (ES = 0.50) after the activity, and in the rating perceived exertion (ES = 0.47). These data show that the KMCT is sensitive to the stimuli used during the training process.

Table 4 shows the correlation values between the KMCT and variables related to physical fitness. The test showed moderate-strong correlations with parameters related to physical fitness, particularly medicine ball throwing (r = 0.72), jumping (r = 0.61), cardiorespiratory assessment (r = 0.52), speed (r = 0.51), number of sit-up repetitions (r = 0.44), and rating perceived exertion (r = 0.42).

While the multiple linear regression (Table 5) shows that the medicine ball throw, 6-minute test, and abdominal strength variables (number of repetitions) explain 49% of the variation in the test, it can be said that almost half of the test is explained by the individual's physical fitness. The other variables were not included in the model due to autocorrelation between them, resulting in Durbin Watson values higher than those acceptable to consider the model valid. Thus, the data confirm the ability of the test for measuring physical fitness in a specific way to KM.

It is important to note that this study has some limitations, such as the fact that the participants were not randomized and that it was not double-blind. Therefore, the effect found cannot be attributed to the pedagogical intervention alone, but to the sum of these factors. Important variables related to health indexes such as maximum oxygen uptake using breath by breath gas analyzer, or anaerobic threshold were not determined. Nevertheless, a study of this type is important because its design respects the common dynamics of classes in the school context and its results help to develop hypotheses about the aspects studied[30].

Conclusions

The training program proposed was this study is effective in improving the general and specific physical fitness of KM practitioners, and that the specific test proposed for the modality, the KMCT, measures the physical fitness and presented sensitivity to training process.

The study evaluated the levels and physical fitness of adolescents practicing KM after a specific training protocol and proposed a specific test to measure KM physical fitness.

The results have great practical implications for KM instructors. This study presents a test that is easy to use in practice and highly important for detecting improvements in the conditioning of KM practitioners. It is useful for teachers of the modality to better evaluate and prescribe training based on the response to the tests.

Conflict of interest

The authors declare no conflict of interest.

Author's contributions

Andrade-Neto JB: Conceptualization: Methodology; Software, validation, formal analysis, investigation, resources, data curation, supervision, project administration, visualization, funding acquisition, writing – original draft, writing – review & editing, approval of the final version. Silva MS: Methodology, validation, resources, data curation, supervision, visualization, writing – original draft, writing – review & editing, approval of the final version. Foresti YF: Methodology, software, validation, investigation, resources, data curation, supervision, visualization, writing – original draft, writing – review & editing, approval of the final version. Papoti M: Methodology, validation, visualization, funding acquisition, writing – original draft, writing – review & editing, Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools for preparation of the manuscript.

Availability of research data and other materials

The contents are already available

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Received: 08/01/2024
Reviewed: 12/09/2024
Approved: 01/08/2025

Cite this article as:
Andrade Neto JB, Silva MS, Foresti YF, Papoti M. Health-related physical fitness of adolescents practicing Krav Maga: proposal for a specific test. Rev. Bras. Ativ. Fis. Saúde. 2025;30:e0383. doi: 10.12820/rbafs.30e0383

Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Anonymous

- This study investigated the health-related physical fitness (HRPF) of Krav Maga (KM) practitioners following a typical training protocol and proposed a specific test to assess the modality. The research included 24 adolescents of both sexes, with an average age of 17 years, who were high school students at a Military School. They participated in a 12-week training protocol with three weekly sessions.

Methods

- To assess HRPF, three main components were measured: flexibility, muscular strength/endurance, and cardiorespiratory fitness. For the specific evaluation of Krav Maga, the Krav Maga Combat Test (KMCT) was proposed. A paired t-test was used to compare pre- and post-training results. Additionally, a multiple linear regression model was employed to determine the validity of the KMCT, using a p-value < 0.05 as the criterion for statistical significance.

Results

- The 12-week training led to significant improvements in both general and specific HRPF ($p < 0.05$). Specifically, performance in the KMCT increased from 18.37 ± 4.00 repetitions before training to 30.54 ± 11.03 repetitions after training, indicating a significant improvement ($p < 0.05$). The KMCT showed moderate to strong correlations (0.42–0.72) with HRPF measures, and these variables explained 49% of the variability in test performance.

Conclusions

- The proposed training program is effective in improving both general and specific physical fitness in Krav Maga practitioners. Additionally, the KMCT proved to be a valid tool for measuring physical fitness and training responsiveness in this modality. This suggests that the KMCT can be a useful tool for assessing Krav Maga practitioners' progress in terms of specific physical fitness and responsiveness to training.
- Overall, the article is well-written, and studies on Krav Maga are scarce in the literature. The author cites their own work three times in the references. Care should be taken to avoid excessive self-citation.
- Table 1: The height data needs to be adjusted.
- Table 2: Abbreviations should not be used in the description. The authors should create a column to include the p-value for pre- and post-training comparisons.
- Table 3 & Table 4: Abbreviations should not be used in the descriptions.
- The description of each table should be comprehensive, indicating the population to whom the test was applied.

Final Decision

- Revisions required

Reviewer B

Anonymous

- The manuscript aimed to assess the health-related physical fitness levels of Krav Maga (KM) practitioners following a typical training protocol and to propose a specific test for KM evaluation. The sample consisted of high school students from a Military School who participated in a 12-week KM training protocol, three times per week for 90 minutes. Although the proposal of a martial arts-based training program for adolescents is highly relevant for promoting physical activity in this age group, the study does not effectively address its stated objective. The following considerations are listed:
- It is unclear whether the study aims to examine the effect of the KM intervention on adolescents' overall physical fitness or to propose a methodology for assessing KM performance.
- The authors describe the exclusion criteria for the sample but do not mention whether the participants practiced other sports or had prior experience in other martial arts.
- The criteria used to develop the specific KM test are not clearly defined.
- The authors propose multiple linear regression as a

statistical method to validate the KM performance test, which is incorrect. The statistical description does not clarify whether the study aims to validate the instrument or to investigate whether overall physical fitness (assessed by the PROEXP battery) explains performance on the specific KM test.

Final Decision

- Reject

Reviewer C

Igor Massari Correia
Universidade de São Paulo, São Paulo, Brasil

- The article proves to be important, but it has a series of issues that need to be worked on and are in the document I sent:

Abstract

- The summary in Portuguese or Spanish is missing.

Introduction

- 2nd paragraph: Since the issue is adolescent health, it is necessary to provide an epidemiology of the number of sedentary adolescents with health problems in percentage terms. And to provide information on the adherence to Krav Maga and that it is an interesting alternative for practicing physical activity and improving health indicators.
- 7nd paragraph: In this case, the validity of this test would be for teenagers, I believe that this is missing in the gap and in the objective.
- 8nd paragraph: If there is already a test for karate, why use this one? Explain below what makes this test different and what it will bring to practical application, both in sports, health, research and public policy. Highlighting the importance of your work shows the magazine and the reader that it has practical applicability.

Methods

- **Participants**:
- Here does not mention the inclusion criteria
- Body composition assessment and anthropometric measurements:
- It doesn't say here what method or equipment you used to measure height.
- **Krav Maga Combat Test (KMCT)**
- Since women's physiology is different from men's and puberty can change fitness, why didn't they use a gender- and age-specific equation (or some puberty marker)?
- HR is a variable more related to aerobic training, why did you use it to compare with other physical capacities, such as flexibility or power of the upper limbs, for example? How was this equation generated? How did you arrive at the conclusion that this equation could be related to these variables? It is necessary to explain this in the article.
- **Krav Maga Class Structure**
- This part is not clear. Are the two classes only for elementary school students? And the other only for high school students? If there are 3 classes per week, how does this work? If the classes are both for high school and elementary school, could this affect the development of the most trained or physically fit students?
- Why Chart and not Table? You should put the title and description here, as well as in the results.

Results

- You need to describe the results better in this section; the discussion is used to discuss the results that were described in this section.
- Tables: You need to describe all the captions better, there are tables that lack explanations of the acronyms and there are tables that do not have captions

Discussion

- 3nd paragraph: Since the adolescents were not athletes, what is the point of this paragraph? I believe that it is not necessary to discuss this in your article.
- 6nd paragraph: The discussion lacks a series of important issues. You only bring up comparisons with other studies. Try to think about the story told by the work.
- First, the focus was on relating the test to physical fitness/health variables in adolescents. Why not discuss the benefits of physical exercise and related health improvements in adolescents. In addition to the physical issue, the practice can lead to a healthy lifestyle in adulthood. Bring up a discussion demonstrating how your data can help prevent disease, reduce sedentary behavior, etc., especially at this age when screen time is increasing.
- 7nd and 8nd paragraph: Many things here should be described in the results, try to modify the discussion and the results according to what each party requests.

- 9nd paragraph: It is possible to observe that this test is a field test that does not use reference methods for each type of physical fitness, such as the use of incremental testing using ergospirometry. What was the explanation for using field tests for correlation? I believe that this should be explained in the study limitation, and should be considered a limitation of the study, in addition to the lack of differentiation by sex in the equation.
- Another issue is to draw attention to the strengths of the study and its importance in science and practice, since it is the first study that specifically tests Krav Maga for adolescents. Therefore, you need to explain why someone should use your test and demonstrate its importance and the context in which it should be applied.

Reference

- You need to standardize the references in the journal's standard and, if possible, update the references. Most of them were published more than 5 years ago.

Comments to the authors:

- Congratulations on your work, I hope to be contributing to the article for publication in the journal.

Decision

- Revisions required