RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Original article

Effects of Krav Maga physical training on body composition, physical fitness, and muscle strength

Efeitos do treinamento físico de Krav Maga na composição corporal, aptidão física e força muscular

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ABSTRACT

Objective: To compare body composition, physical fitness and muscle strength levels between veteran and beginner Krav Maga practitioners during 16-week physical training. **Methods:** Thirty men participated in the study, Krav Maga practitioners divided into veterans (G_V, n = 15) and beginners (G_I, n = 15). Body composition was measured using the Jackson and Pollock method, physical fitness by bending the arm, abdominal and flexibility, isometric handgrip strength using the protocol adapted from Fess, and voluntary muscle strength in the Shoulder Press, Back Squat and Deadlift movements, using the Baseyana statistic. The intervention was carried out with 60-minute sessions, three times a week, for 16 weeks, totaling 48 classes. **Results:** No differences were found between body composition and fat percentage between groups (G_V = 24.14 ± 4.13%; G_I = 26.10 ± 5.18%; BF_{10} = 0.56) in handgrip strength (G_V = 46.66 ± 8.17 kgf; G_I = 41.23 ± 7.77 kgf; BF_{10} = 1,238) and muscle flexibility (G_V = 28.30 ± 7.23 cm; G_I = 24.60 ± 7.61 cm; BF_{10} = 0.691). Statistically significant differences were found in voluntary muscle strength (G_V = 242.13 ± 43.52 kg; G_I = 184.86 ± 43.94 kg; BF_{10} = 25,615). **Conclusion:** It can be concluded that veteran Krav Maga practitioners have higher levels of muscle strength, muscular endurance, physical fitness and upper limb isometric strength when compared to beginners.

Keywords: exercise; muscle strength; physical fitness; body composition.

RESUMO

Objetivo: Comparar a composição corporal, aptidão física e niveis de força muscular, entre praticantes veteranos e iniciantes de Krav Maga durante treinamento físico de 16 semanas. **Métodos:** Participaram do estudo 30 homens, praticantes de Krav Maga divididos em veteranos (G_V, n = 15) e iniciantes (GI, n = 15). Foram mensuradas a composição corporal pelo método Jackson e Pollock, a aptidão física pela flexão de braço, abdominal e flexibilidade, a força de preensão manual isométrica pelo protocolo adaptado de Fess e a força muscular voluntária nos movimentos de Shoulder Press, Back Squat e Deadlift, utilizando-se a estatística Baseyana. A intervenção foi realizada com seções de 60 minutos, três vezes por semana, durante 16 semanas, totalizando 48 aulas. **Resultados:** Não foram encontradas diferenças entre a composição corporal e percentual de gordura entre grupos (G_V = 24,14 ± 4.13%; G_I = 26,10 ± 5,18%; BF_{10} = 0,56), na força de preensão manual (G_V = 46,66 ± 8,17 kgf; G_I = 41,23 ± 7,77 kgf; BF_{10} = 1,238) e na flexibilidade muscular (G_V = 28,30 ± 7,23 cm; G_I = 24,60 ± 7,61 cm; BF_{10} = 0,691). Foram encontradas diferenças estatísticas significantes na força muscular voluntária (G_V = 242,13 ± 43,52 kg; G_I = 184,86 ± 43,94 kg; BF_{10} = 25,615). **Conclusão:** Pode-se concluir que praticantes veteranos de Krav Maga possuem maiores níveis de força muscular, resistência muscular, aptidão física e força isométrica de membros superiores quando comparado aos iniciantes.

Palavras-chave: exercício físico; força muscular; aptidão física; composição corporal.

Received: July 2, 2021; Accepted: November 8, 2021.

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Introduction

In Brazil, the seek for activities related to Fighting, Martial Arts and Combat Sports Modalities (F/MA/CSM), according to data from the last supplementary investigation of the Continuous National Household Sample Survey (PNAD), referring to sports and physical activity, corresponds to 70% of the intentions of the population over 15 years old [1,2].

Physical Training (PT) is characterized in the literature as an organized and systematic process of physical improvement, in its morphological and functional aspects, directly impacting the ability to perform activities involving psychomotor tasks, whether sports or not [3,4].

The regular practice of PT applied to F/MA/CSM is reflected in beneficial physiological adaptations for individuals, such as improvement in body composition, changes in fat percentage (%F) and lean mass weight (LMW) [5], development of handgrip strength (HGS), general muscle strength (GMS) being indicated as a predictor of performance in fights and combat sports [6]. In studies with judo athletes, higher values of general muscle strength (GMS) and improvement in muscle flexibility (Flex) were observed when compared to non-practicing active individuals [7-9].

In this bias, Krav Maga (KM) is one of the fighting modalities with the greatest adherence and practice currently. This melee combat method is based on techniques from other F/MA/CSM such as Jiu-Jitsu, Kapap, Boxing, Wrestling, Judo [10,11]. It was developed in the 19th century by Jewish immigrants, in the then Palestinian territory of what is now the State of Israel, and is practiced in more than 120 countries, considered the highest-rising Israeli hand-to-hand combat method in the world [11,12].

Although its practice is currently growing, scientific knowledge about the physical effects produced by this bodily practice is still limited, not following its rise. With a view to finding publications on physical training methods and the physiological effects produced by their practice, Andrade Neto et al. [12] carried out a literature review on the production related to the topic between the years 1998 and 2018, finding only 7 scientific articles on this topic [12,13].

Therefore, the lack of scientific information on the practice of physical exercises involving Krav Maga makes it difficult to apply a specific physical training protocol for the modality, especially if based on scientific evidence, since the possible benefits of its regular practice, in the general physical fitness of its practitioners, are not clear.

In this sense, this study aimed to compare body composition, fitness, and muscle strength levels, between veteran and beginner Krav Maga practitioners during training for 16 weeks. Thus, it was adopted as a study hypothesis that the practice of physical training in the Krav Maga fighting modality can induce significant physiological changes in these biomarkers when comparing beginners and veterans submitted to the same physical training protocol.

Methods

Study design and sample characteristics

The present study had a prospective cross-sectional longitudinal design [15]. It is when individuals with and without exposure to the risk factor being investigated are selected at the beginning of the study and followed for a specified period, that is, when there is a cause or determining factor and the result is sought [16].

Voluntarily participated in this research with an intentional sample, 30 young adult men, practitioners of Krav Maga belonging to Pro Krav Maga Brasil - Personal Security Advisory in the city of Teresina/PI, Brazil.

The volunteers were divided into two groups: veterans (n = 15), who had been practicing Krav Maga for at least 12 weeks, and beginners (n = 15) who were starting to practice the modality.

The characteristics of the sample such as age (years), height (cm), total body mass (Kg) and Body Mass Index (BMI - Kg/m²) are shown in chart 1.

Chart 1 - Sample characteristics

Groups	Age (years)				Height (cm)			
	Average	SD	Min	Max	Average	SD	Min	Max
General (n = 30)	32.27	11.58	14	56	173.10	6.82	163	187
Veterans (n = 15)	33.60	12.23	19	52	172.67	6.03	165	183
Beginners (n = 15)	30.93	11.16	14	56	173.53	7.73	163	187
	Body mass (kg)				BMI (kg/m²)			
General (n = 30)	78.81	11.74	52.80	107.70	26.29	3.87	18.10	33.50
Veterans (n = 15)	79.62	8.73	64.80	97.00	26.63	2.36	23.00	31.30
Beginners (n = 15)	77.99	14.41	52.80	107.70	25.95	5.03	18.10	33.50

Inclusion and exclusion criteria

The inclusion criteria adopted for the participants were: a) the volunteers do not have medical restrictions for the application of protocols and practice of physical exercises; b) do not have any disease, being asymptomatic; c) be physically active, with a minimum weekly physical activity of 150 minutes; d) The GV group has more than 12 weeks of continuous training in the modality.

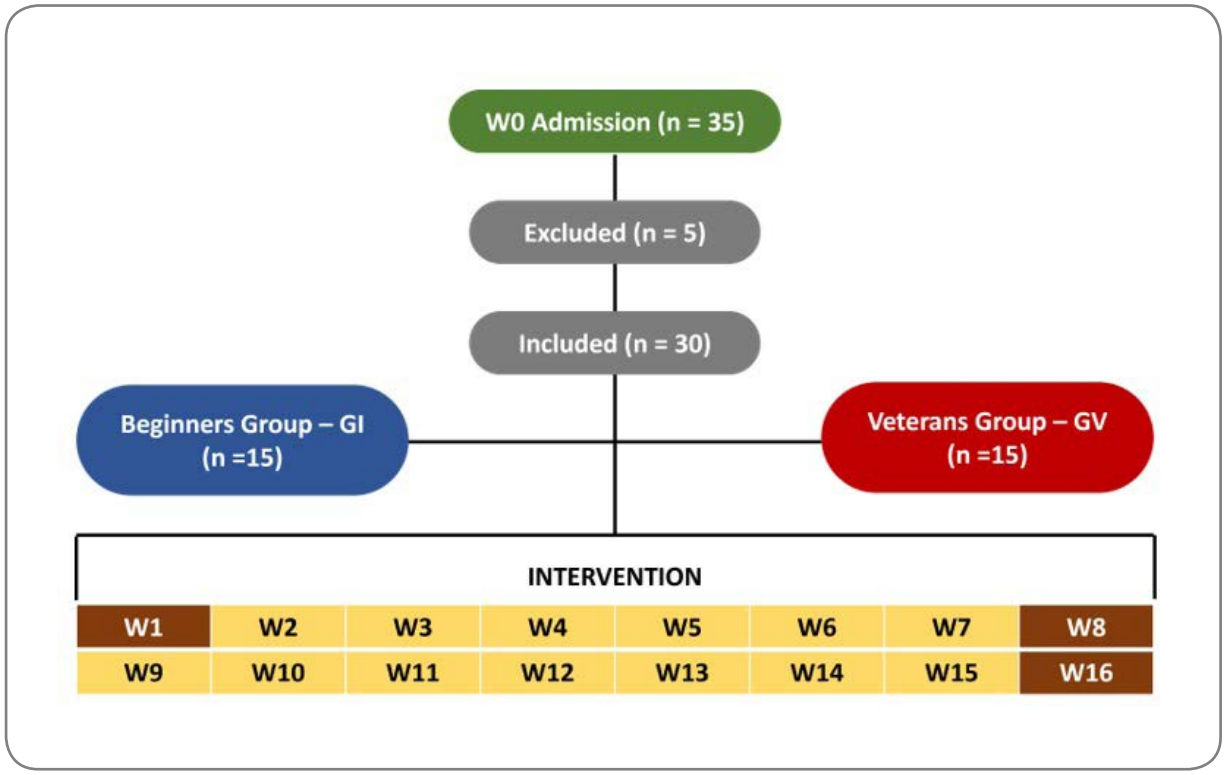
As exclusion criteria, all were instructed about maintaining their normal and routine diet, warned about the loss of segment, and not completing the study, and also about the obligation not to simultaneously participate in any other type of physical training program, for at least 16 weeks.

Ethical criteria

In the methodological procedures of this research, the ethical requirements of Resolution 466/12 of the National Health Council of the Ministry of Health were met. The study was approved by the Ethics in Research Committee of the Federal Uni-

versity of Maranhão (UFMA), CAAE registration: 82959617.1.0000.5087, with opinion nº 2.533.453, as well as by the owner of the selected consultancy. In this intentional sample, all were volunteers and duly informed of the procedures and objectives of the study, agreeing, and signing the free and informed consent form (FICF) [17].

Study design



W = Week; During the weeks 1, 8 and 16 the groups were evaluated
Figure 1 – Study design

Thirty-five volunteers were invited to the research, of which, after the initial W0 assessment (pre-follow-up), five were excluded: two for voluntary withdrawal; one due to loss of follow-up, one due to problems related to renal complications and the other to cardiovascular complications.

After completing this phase, the intentional population of 30 volunteers was then distributed into a control group, composed of beginners who had never practiced the modality and for the first time were participating in a physical training program, the Beginners Group (GI; n = 15). And intervention group, composed of veteran Krav Maga practitioners, with 12 weeks or more of practice, Veterans Group (GV; n = 15), both were submitted to the same regular exercise program, of the Krav Maga fighting modality for a period of 16 weeks, the evaluations and interventions followed in weeks W8 and W16 respectively.

Initially, the volunteers went through an adaptation period in the first week, in which three 40-minute sessions of exercise with controlled intensity were performed. After this adaptation, the intervention was carried out with 60-minute sessions of physical exercise according to the methodological proposal of the Pro Krav Maga

Brasil, for the initial level [17]. These classes were divided into three stages: l) initial part of 5 to 10 minutes in duration, with exercises with localized effect and general warm-up; 2) main part with technical movements of the modality from 30 to 40 minutes, with punches, kicks, projections, twists, and immobilizations exercises; and 3) the final part of 5 to 10 minutes, with relaxation and stretching exercises. Classes took place three times a week for 16 weeks, totaling 48 classes. (Chart II)

Chart II - Description of the activities proposed in the intervention (intervention protocol)

Part of class	Developed activities
Initial part (5 to 10 min)	Local effects exercises, neck, shoulders, wrist, elbows, hips, knees and ankle. General warm-up: jogging, 2 sets of 10 reps each of: jumping jacks; rower abdominals; push-ups on the floor with an open palm; weightless squats; 40cm high heels on the box; with a 1-minute break between sets.
Main part (30 to 40 min) Techniques Krav Maga	A) Each move was repeated for 10x, in 3 sets, in a time of 2 min each: Combat positions, mdirect, crossed and ascending movements and punches. Open-hand attacks, front and side kicks, front, side and back rolls, elbows, knees, combined attack and defense moves. B) Front and side projections, static and dynamic frontal, lateral and rear choke exits, defenses against sticks, knives, and firearms, exit from wrist, elbow and shoulder locks, simulation of combat under stress.
Final part	Cool down, static stretching exercises lasting 20 to 30 seconds each.

Source: Pro Krav Maga Brazil – Advice on Personal Safety

Anthropometry and body composition

A mechanical scale with a stadiometer (*model R-110, Welmy, Brazil*) was used to measure total weight and body height, as well as to calculate the BMI. An inelastic tape (*model SN-4010, Sanny Medical, Brazil*) to measure the waist circumference (WC) and hip (HC) of the subjects. To determine the body composition, a scientific adipometer, precision of 1mm (*Sanny, Brazil*) was used, 7 measurements were taken of the following skinfolds: subscapular, triceps, pectoral, middle axillary, suprailiac, abdominal and middle femoral. Thus, the total weight (TW) was divided into weight referring to lean mass (LMW), total fat mass (TFM), percentage of body fat (%F) and body density (BD).

Fitness tests

The sit and reach tests, abdominal strength endurance test and lower limb strength endurance test were used as indices of physical fitness of the subjects.

The Sit and Reach test was used to determine muscle flexibility (Flex), following the protocol proposed by Wells and Dillon [18]. For this purpose, the subjects sat on the ground, with their knees extended and the soles of their feet leaning on the box, measuring 30.5 cm x 30.5 cm x 30.5 cm with a scale of 26.0 cm (Sanny, Brazil), each subject performed three attempts to obtain the greatest range of motion among them.

For the abdominal strength endurance test, the individual remained in the supine position, with knees flexed at approximately 90° and feet fully supported on

the floor. During the test, the participant performed as many push-ups and sit-ups as possible.

The arm flexion test was performed on the floor, the participants performed the greatest number of successive flexions possible without interrupting the movement, with the movement starting with extended elbows, touching the pectoral to the ground, and returning the elbows to the extended position.

Determination of handgrip strength (FPM)

The HGS was obtained using a manual dynamometer (*model 5030 J1, Sammons Preston, INC®, Brazil*) with a maximum capacity of 90 kg and an accuracy of 100 g. Basically, the subject pressed the dynamometer as hard as possible for a period of five seconds. The size of the handle was fixed at 5.5 cm. The values of strength of the dominant hand (FPM_D) and non-dominant hand (FPM_N) were evaluated, with three attempts for each hand and considering that the highest value of handgrip obtained in the test was considered the HGS. The mean between the strength of both hands was considered as the mean strength of the individual (FPM_{avg}) [19].

Determination of maximum strength

To determine the maximum strength, the CrossFit Total test was performed, for that, after setting and specific warm-up for this test, the three movements were performed in the respective order: back squat, shoulder press, and deadlift. Each subject had 10 min to reach 1 RM (maximum repetition) of each movement. The sum of the weight lifted in the three exercises was considered as an index of full strength of the individual (F_S) [20].

For the protocol, an Olympic bar weighing 20 kg was used, as well as calibrated Olympic weights. The test ended when the subject reached his maximum effort in 1 repetition, or the last load successfully lifted up to the 10-minute time limit.

Statistical analysis

Data from the present study are presented as mean and standard deviation of the mean. The Shapiro-Wilk test was used to determine the normality of the data, while the Levene test was used to determine the homogeneity.

Outlier verification was performed using Box Plot graphics. To compare groups, the Baseyana statistic was used, using the independent t test, adopting the null hypothesis (H0) as the non-difference between groups, while the alternative hypothesis (H1) was considered as the difference between groups [21].

Results

The anthropometric characteristics and body composition of the participants are described in table I, with no statistical differences being found between groups (BF_{10} 0.360 – 0.667, [Evidence for H0]), indicating that both groups have similar physical composition.

Table I - Comparison between anthropometric characteristics and body composition between novice and veteran participants

Variable	G_I (n = 15)	G_V (n = 15)	BF_{10}	ES (95%CI)
Age	32.93 ± 10.94	35.20 ± 12.03	0.385	-0.142 [-0.785, 0.466]
TW (kg)	77.93 ± 14.41	79.62 ± 8.72	0.363	-0.09 [-0.733, 0.512]
Height (m)	1.73 ± 0.07	1.72 ± 0.02	0.360	0.09 [-0.521, 0.723]
WC (cm)	88.33 ± 14.85	86.73 ± 8.86	0.362	0.09 [-0.517, 0.728]
HC (cm)	94.53 ± 11.30	90.56 ± 7.94	0.549	0.299 [-0.314, 0.975]
BD (g/ml)	1.03 ± 0.01	1.04 ± 0.01	0.730	-0.388 [-1,084, 0.235]
LMW (kg)	57.88 ± 6.75	61.48 ± 8.01	0.667	-0.362 [-1,052, 0.258]
%F (%)	26.10 ± 5.18	24.14 ± 4.13	0.564	0.309 [-0.306, 0.987]

G_I = Beginners group; GV = Veterans Group; TW = Total weight; WC = Waist circumference; HC = Hip circumference; BD = Body density; LMW = lean mass weight; % F = percentage of body fat

The comparison between strength data is shown in table II. No differences were found between HGS between groups (BF_{10} = 1,115 – 1,197, [Anecodal]), however, the GV showed statistical differences between the levels of maximum dynamic strength (BF_{10} = 5,400 – 46,350, [Moderate – Very Strong]).

Table II - Comparison between strength profile of Krav Maga practitioners

Variable	G_I (n = 15)	G_V (n = 15)	BF_{10}	ES (95% CI)
FPM_D (kgf)	42.53 ± 7.53	47.80 ± 8.60	1.115	0.499 [-0.143. 1.219]
FPM_N (kgf)	39.93 ± 8.37	45.53 ± 8.30	1.197	0.516 [-0.129. 1.239]
FPM_{avg} (kgf)	41.23 ± 7.77	46.66 ± 8.17	1.238	0.524 [-0.122. 1.249]
ShoulderPress (kg)	36.73 ± 8.73	46.60 ± 10.51	5.400	0.834 [0.117. 1.614]
BackSquat (kg)	58.46 ± 21.92	85.20 ± 15.43	46.350	1.219 [0.414. 2.054]
Deadlift (kg)	89.66 ± 16.84	110.33 ± 20.19	7.601	0.899 [0.166. 1.689]
F_S (kg)	184.86 ± 43.94	242.13 ± 43.52	25.615	1.117 [0.334. 1.938]

G_I = Beginners group; G_V = Veterans Group; FPM_D = Dominant handgrip strength; FPM_N = Non-dominant handgrip strength; FPM_{avg} = Average handgrip strength; F_S = Full strength

Data referring to the participant's physical fitness tests are shown in table III. We observed that G_V participants of the modality have greater strength resistance of the upper limbs in the flexion-arm test (BF_{10} = 3,956, [Moderate]), as well as greater flexibility

Table III - Comparison between the physical fitness of Krav Maga practitioners

Variable	G_I (n = 15)	G_V (n = 15)	BF_{10}	ES (95% CI)
Physical Fitness Test				
Arm flexion	19.00 ± 8.33	27.26 ± 8.93	3.956	0.773 [0.071. 1.544]
Abdominal	53.86 ± 19.34	67.73 ± 16.10	1.805	0.610 [-0.054.1.352]
Flexibility (cm)	24.60 ± 7.61	28.30 ± 7.23	0.691	0.372 [-0.249.1.065]

G_I = Beginners group, G_V = Veterans Group

Discussion

This study aimed to compare body composition, physical fitness and muscle strength levels between veteran and beginner Krav Maga practitioners during 16-week physical training. No differences were found between body composition and fat percentage between groups (G_I and G_V). However, in handgrip strength, flexibility, physical fitness, and voluntary muscle strength were found statistically significant differences.

It is widely known and accepted that biological systems, when subjected to constant and repeated imbalances, that is, repeated stimuli of a similar nature, adapt towards an improvement in that mechanism or function, in this case the Krav Maga physical training was the stimulus adaptive [4,18].

In this sense, epidemiological and cohort studies dedicated to fights have shown a strong association between obesity and physical inactivity [22], as well as an inverse association between physical activity, body mass index (BMI), waist-hip ratio (WHR) and waist circumference (WC).

These studies demonstrated that the benefits of physical activity on obesity can be achieved with low, moderate, or high intensity, indicating that the maintenance of an active lifestyle, regardless of which activity is practiced, can prevent the development of related diseases [22-24].

In similar studies were verified results similar to those found in this study, with both beginners and veterans of Brazilian Jiu-Jitsu in the modality [23-25]. In addition, the participants in this study presented %F values higher than those reported with Olympic boxing, judo, taekwondo and Westerling athletes, inferring this similarity to the difference in the training level of the study participants.

Krav Maga is a fighting modality with characteristic of acyclic gestures, for not presenting repetition of movements and for the speed at which these are performed are different [17]. Having as one of its goals the neutralizing of the opponent. For this, different technical combinations are used, among which, manual strength and trunk flexibility stand out.

In a study that compared elite Judo and Jiu-Jitsu athletes, higher levels of HGS were found in veterans, compared to athletes of moderate levels and beginners respectively [24]. This difference is due to the physical demands of the modalities that require fighting on the ground, with approximately 49% of the time in the judo fight the athletes perform gripping movements, demanding the handgrip strength [25]. However, in the case of the present study, no differences were found in handgrip strength, and the mean strength values of G_V larger.

However, higher indices of FS were found in the G_V compared to the GI, probably this fact is due to the specific training of the modality, although there are still no studies that validate the physical and physiological demands of the specific training of Krav Maga [17,25].

In addition to the FS levels, in the G_V, higher levels of strength resistance of the upper limbs were also verified in the arm and abdominal flexion test, Di Bacco et al. [13] corroborate these findings, when they evidenced the development of upper limb strength with the specific training of Jiu Jitsu, a modality analogous to Krav Maga. Thus, it can be inferred that strength training is essential for the F/MA/CSM.

The present study had some limitations, initially for being unique, a longitudinal study comparing two different groups at the time of evaluation. However, this comparison will help to understand some adaptations arising from the modality. In addition, indirect methods were used to assess the physical fitness of individuals, as they have low cost, ecological validity and are accessible to coaches and instructors, in addition to being frequently used in studies related to F/MA/CSM [24-28].

The data listed here are preliminary on Krav Maga, pointing out several gaps to be filled, regarding its practice as physical exercise. In this sense, it is crucial to compare the information pointed out in this study with data collected in other analogous sports, in order to reflect on the physiological impacts caused by its practice.

Conclusion

We can conclude that veteran Krav Maga practitioners developed higher levels of general muscle strength, upper limb strength endurance and physical fitness when compared to active men who were new to the sport.

The data from the present study allow other practitioners, teachers, and coaches to have a better understanding of the adaptations arising from the modality, in addition to providing reference values.

Acknowledgments
To the Graduate Program in Adult Health at the Federal University of Maranhão and to the students of Pro Krav Maga Brasil - Personal Safety Advisory who voluntarily provided their data and were willing to collaborate with the development of this research.
To the Professors and Lieutenant Colonels of the Colégio Militar de Brasília, Fernanda Pomperek and Luiz Fernando for their constant encouragement and support in this journey in search of knowledge.

Potential conflict of interest
No conflicts of interest have been reported for this article.

Financing
The present study was carried out without funding.

Authors' contributions
Conception and design of the research: Andrade Neto JB; **Obtainment, statistical analysis and/or interpretation of data and Writing of the manuscript:** Andrade Neto JB, Foresti YF; **Critical review of the manuscript:** Navarro AC, Navarro F, Salgado Filho N.

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