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EVALUATION OF SCAPULAR DYSKINESIS IN CROSSFIT®-PRACTICING ATHLETES

AVALIAÇÃO DA DISCINESE ESCAPULAR EM ATLETAS PRATICANTES DE CROSSFIT®

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ABSTRACT

Objective: Evaluate the scapular movement of Crossfit® practitioners and identify whether they present an increased incidence of scapular dyskinesis (SD) compared to non-practitioners. Method: A transversal study was evaluated quantitatively and dynamically, using retro-reflective spherical markers, the scapular movements of ten volunteers composing the control group, and 11 Crossfit® practitioners. The control group's results were used as a normality parameter and compared to those of the Crossfit® practitioner's group. Results: It was identified that the superior scapular rotation in the ascending phase is inferior in the group of Crossfit® practitioners (p = 0.02). Conclusion: The regular practice of Crossfit® causes scapular dyskinesis (SD), with alteration in the scapular superior rotation movement. ***Level of Evidence III: Retrospective comparative.***

Keywords: Scapula. Sports Medicine. Shoulder.

RESUMO

Objetivo: Avaliar o movimento escapular de praticantes de Crossfit® e identificar se apresentam incidência aumentada de discinese escapular (DE) quando comparados a não praticantes. Método: Estudo transversal que avaliou de forma quantitativa e dinâmica, utilizando marcadores retro-refletivos esféricos, os movimentos escapulares de dez voluntários, compondo o grupo controle, e 11 praticantes de Crossfit®. Os resultados do grupo controle foram utilizados como parâmetro de normalidade e comparados aos do grupo de praticantes de Crossfit®. Resultados: Identificou-se que a rotação superior escapular na fase ascendente é inferior no grupo de praticantes de Crossfit® (p = 0,02). Conclusão: A prática regular de Crossfit® causa discinese escapular (DE), com alteração no movimento de rotação superior da escápula. ***Nível de Evidência III: Retrospectivo comparativo.***

Descritores: *Escápula. Medicina Esportiva. Ombro.*

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INTRODUCTION

Crossfit® is a training and fitness program that has been gaining more recognition and interest from the physically active population. This program was initially developed for military training and gradually spread to the general population.[1] Such a program is based on a complex set of exercises that include running, weightlifting, Olympic gymnastics, and ballistic training.[1] Exercises are usually a combination of high-intensity workouts to be performed quickly, repeatedly, and with little or no time to recover between sets.[2]

In Brazil, there are about 440 registered Crossfit® gyms, thus resulting in a total of approximately 40 thousand athletes.[2] This total number of practitioners of an activity with an intense overload onto the upper limb leads to injuries, whether symptomatic or not.[3] Among those is scapular dyskinesis, which is a condition commonly found in athletes with upper-limb overload.[4]

Scapular dyskinesis (SD) consists of dynamic changes in the position of the scapula in relation to the rib cage, resulting in an imbalance of the thoracic-scapular-humeral rhythm. In general, it occurs secondary to fatigue, neurological dysfunction, intra-articular or subacromial disorders. This imbalance can be present in up to 67-100% of athletes with shoulder injuries and are also often found in asymptomatic individuals.

It is debated in the literature that SD is not just a consequence of shoulder injuries, but can rather act as a cause thereof due to an overload on the muscles of the scapular girdle and limitation in both shoulder strength and range of motion, predisposing it to tendinitis of the rotator cuff, subacromial impingement syndrome, and glenohumeral instability.[4]

The current study's hypothesis is that there is a higher incidence of SD among Crossfit® practitioners than in the non-practicing population.

All authors declare no potential conflict of interest related to this article.

The study was conducted at the Shoulder and Elbow Surgery Group at the Department of Orthopedics and Traumatology, Santa Casa de São Paulo School of Medical Sciences and Institute of Physical Activity and Sport Sciences (ICAFE – Instituto de Ciências da Atividade Física e Esporte) at Universidade Cruzeiro do Sul.
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This pioneering study in Brazil aimed to test the hypothesis above by comparing the dynamic and quantitative results from assessing scapular movement in two paired populations: practitioners and non-practitioners of Crossfit®.

SAMPLING AND METHODS

This was a cross-sectional study, in which we divided the participants into a control group and a group of Crossfit® practitioners. The inclusion criteria for the control group were: the individuals had to be adults, without any symptoms, changes or previous surgical procedures on their shoulders. It was comprised of ten participants (20 shoulders). In this group, six males and four females were evaluated, and had a mean age of 28.5 years, ranging between 21 and 54 years. All ten patients were right-handed, with a Body Mass Index (BMI) averaging 24.9 kg/m^2 and ranging between 18.65 and 30.68 kg/m^2.

Eleven Crossfit® athletes were evaluated. The Inclusion criteria were that individuals needed to have been Crossfit® practitioners for at least six months prior, at a minimum frequency of three times per week – thus characterizing regular practitioners.[2,5] The exclusion criteria were: practice times shorter than 6 months, training frequency less than three times per week, and/or having already undergone any surgical procedure on either shoulder. Among those evaluated, there were seven males and four females, whose average age was 31 years, ranging from 26 to 36 years, and having a an average Body Mass Index (BMI) of 26.7 kg/m^2, ranging from 20.20 to 32.91 kg/m^2. In comparing the physical characteristics between the two groups, no statistically significant difference was found for the mean weight ($p=0.378$), height ($p=0.724$), and BMI ($p=0.304$). It became evident, however, that the group of Crossfit® practitioners had a greater mean age than that of the control group ($p=0.028$).

After having been included in the study, all participants were inquired about the presence of any ongoing or recent pain or functional complaints with regard to their shoulders with the following question: "Do you have or did you had over the last 6 months any pain and/or difficulty moving your shoulders that lasted more than a day?". All participants gave negative responses.

Following the method of Salvia et al.,[6] scapular movement assessment was performed using spherical retro-reflective markers, which were fixed with appropriate adhesive tape onto specific anatomical landmarks on the trunk and upper limbs, bilaterally, following the recommendations of the International Biomechanics Society.[7] More specifically, these markers were fixed onto the skin over the spinous process of the seventh cervical vertebra (C7), the spinous process of the eighth thoracic vertebra (T8), the inferior-most point of the jugular notch and the xiphoid process, in order to define the trunk segment. To define the scapula, in turn, the markers were fixed onto the skin over the scapular spine trigone, lower angle of the scapula, acromial angle, and the most ventral portion of the coracoid process. To define the arm and forearm segments, the markers were fixed onto the skin on the lateral epicondyle and medial epicondyle of the humerus, and styloid processes of the radius and ulna. In addition to these markers, rigid sets with retro-reflective markers were also attached onto the skin on the flatter region of the acromion, manubrium-sternum angle, and proximal lateral region of the humerus. (Figure 1)

The three-dimensional recording of all markers was performed by eight special cameras (Vicon Bonita 10 Motion Capture Cameras®) controlled by a specific unit (Giganet Lab Unit, Vicon, Inc.®) that allows synchronization of these cameras and sending the acquired signals to a computer via a specific computer software program (Vicon Nexus®). Initially, data were collected from participants in an orthostatic, neutral, and static position in order to register a reference position. Subsequently, the participants underwent the dynamic part of the evaluation and were asked to perform unilateral circling movements to estimate the articular center of the shoulders. Then, with the upper limbs close to the body, following a verbal command, they were instructed to perform six repetitions of maximum elevation and return to a starting position at comfortable time intervals, ranging from three to five seconds. The first elevation performed by each patient was disregarded and only the last five of them were considered. The posterior inclination, upward rotation, and medial rotation of the scapulae (Figure 2) at 60°, 90°, and 120° elevation angles were evaluated, both in the ascending and descending phases.

The data acquired during the evaluations were reconstructed with the Nexus software program (Vicon®) and the trajectories of each spherical retro-reflective marker were stored for later analysis in The Motion Monitor (Innovative Sports Training, Inc.®) and Matlab (Math Works, Inc.®).[8] Scapular rotations in the three planes of movement of the right and left scapulothoracic joints were calculated by means of representing the Euler angles and following the convection recommended by Wu et al. and Van Der Helm.[7,9]

Statistical data processing was performed using multivariate analysis of variance (MANOVA) in search for possible differences between the dominant and non-dominant sides within each group. As there was no statistically significant difference between them, multivariate analysis of variance (MANOVA) was then used again for comparing only the participants' dominant side in the control group with the participants' dominant side in the Crossfit® group. The level of significance was calculated using the Statistical Package for the

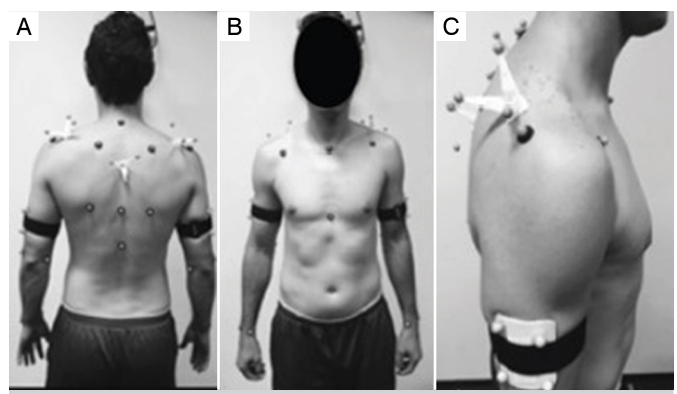

Figure 1. Arrangement of spherical retro-reflective markers. A, posterior view; B, anterior view; C, side view.

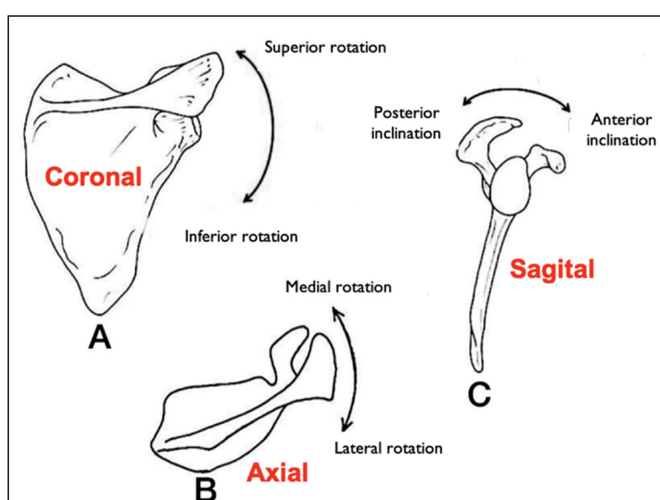

Figure 2. Scapular movements in the three planes. A, coronal plane; B, axial plane; C, sagittal plane.

Social Sciences® program software, version 18.0 (SPSS Inc, IBM Company, Chicago, IL, USA).
The study was approved by the Institution's Research Ethics Committee (document number: 80591817.4.0000.5479) and has no conflict of interest. The devices used in this study were funded by the researchers.

RESULTS

The mean, confidence interval, and standard deviation for inclination, upward rotation, and medial rotation of the scapula in relation to the trunk during the ascending and descending phases of the shoulder elevation movement for the dominant hemibody both in the control group (CG) and the group of Crossfit® practitioners (XFG) are documented in Table 1 and Figure 3.
We found that there was a statistically significant difference between the two groups regarding the upward rotation movement of the scapula in the ascending phase (p = 0.02). Participants in both groups showed an increase in upward rotation of the scapula as they raised their shoulders, but the mean value in the CG was greater than that in the XFG. There was no statistically significant difference between the groups in the descending phase (p=0.06) and both exhibited a decrease in the upward rotation of the scapula as the shoulder descended, as shown in Figure 3.
In relation to the scapular inclination movement, the difference between the groups' mean values was not statistically significant either in the ascending phase (p=0.38) or in the descending phase (p=0.25). Paired comparisons indicated that in both groups there was a decrease in the posterior scapular inclination as the shoulder was raised and vice versa.
For medial rotation of the scapula in the ascending and descending phases, there was no difference between the groups in either phase (p=0.92 and p=0.93, respectively). As with the other movements, in all cases there was an increase in medial rotation of the scapula as the shoulder was raised and vice versa.

Table 1. Mean values (± standard deviation) and confidence interval (CI) for inclination, upward rotation, and medial rotation of the scapula in relation to the trunk during the ascending and descending phases of the shoulder upward movement for the dominant hemibody both in the control group (CG) and group of Crossfit® practitioners (XFG) are documented in Table 1 and Figure 3.

Scapular movement	95% CI	
	CG	XFG
Ascending phase		
Inclination		
60 degrees	-15 - -8	-16 - -10
90 degrees	-12 - -4	-15 - -6
120 degrees	-8 - 4	-11 - -1
Upward rotation		
60 degrees	10 - 17	5 - 12
90 degrees	21 - 30	14 -23
120 degrees	32 - 42	25 - 34
Medial rotation		
60 degrees	-38 - -24	-38 - -25
90 degrees	-39 - -24	-37 - -23
120 degrees	-34 - -17	-33 - -17
Ascending phase		
Inclination		
120 degrees	-6 - 5	-8 -1
90 degrees	-11 - -2	-15 - -7
60 degrees	-16 - -9	-18 - -12
Upward rotation		
120 degrees	33 - 44	27 - 36
90 degrees	22 - 31	16 - 24
60 degrees	8 - 16	4 - 12
Medial rotation		
120 degrees	-31 - -15	-30 - -15
90 degrees	-35 - -22	-34 - -22
60 degrees	-36 - -24	-35 - -24

Note: for the inclination movement, positive values indicate anterior inclination and negative values indicate posterior inclination.

DISCUSSION

The evaluation of SD is still one of the greatest difficulties found in the study of scapular kinetics. Some studies have sought to perform reproducible tests, but in all of them, poor reproducibility was found.[10,11] The most frequently used test in the literature is the one described by Kibler et al.,[12] a qualitative method based on visual observation and therefore prone to subjective interpretations and dependent on the examiner's level of experience.[4]
Considering that we sought greater specificity and sensitivity, we used in our study a quantitative method, since it allows for the objective assessment of scapular movement in three planes and is neither invasive or painful to the participant, relying on specific anatomical parameters, establishing an accurate reproducibility evaluation protocol, in addition to yielding accurate numerical data.[6] Such methodology has been increasingly used for understanding the dynamics of the shoulder as a whole in sports practitioners, especially the scapula.[13-15]
The resulting mean values for scapular kinetics herein presented showed a statistically significant difference between the control group and the athletes evaluated, as made evident by the reduction in the upward scapular rotation.
This finding is similar to the findings reported by Struyf et al. and Thomas et al.,[16,17] who, by means of inclinometers, showed the presence of reduced scapular upward rotation in athletes in different modalities that require raising the upper limb (pitchers, swimmers, tennis players, and volleyball players) with shoulder pain in relation to those who were asymptomatic and also in university baseball athletes when compared to school baseball athletes, respectively. This finding is also related to the subacromial impact in baseball and swimming athletes and glenohumeral instability in pitchers.[18-20]
It is worth mentioning that the participants in the Crossfit® group were asked about occasional pain or functional complaints in their shoulders only after having been included in the study to avoid selection bias. However, as everyone denied having any pain or functional complaints, it was impossible to correlate our findings with any symptoms according to the studies above.
We stress the importance of this work in demonstrating the use of a new, non-invasive dynamic method for evaluating SD in athletes practicing Crossfit®, a sport that currently has been having an important increase in the number of its practitioners. However, we emphasize that the quantitative method used has some deficiencies: a need for technical experience, sophisticated equipment, a lack of predetermined control values, and positioning of the markers onto the skin, with the latter being attributable to a possible superficial reflex of the scapular movement, rather than to the bone structure itself. For this reason, reproducibility in obese patients is more difficult, as the thickness of the adipose layer can hinder the evaluation of the bone movement being analyzed. In our study, there was no statistically significant difference in the mean body mass index (BMI) between the control group and Crossfit® practitioners, making it impossible to correlate BMI with scapular kinematic changes. New studies with a larger sample should allow the identification of this influence with a margin of statistical significance.

CONCLUSION

The regular practice of Crossfit® causes scapular dyskinesis (SD), with changes to the upward rotation movement of the scapula.

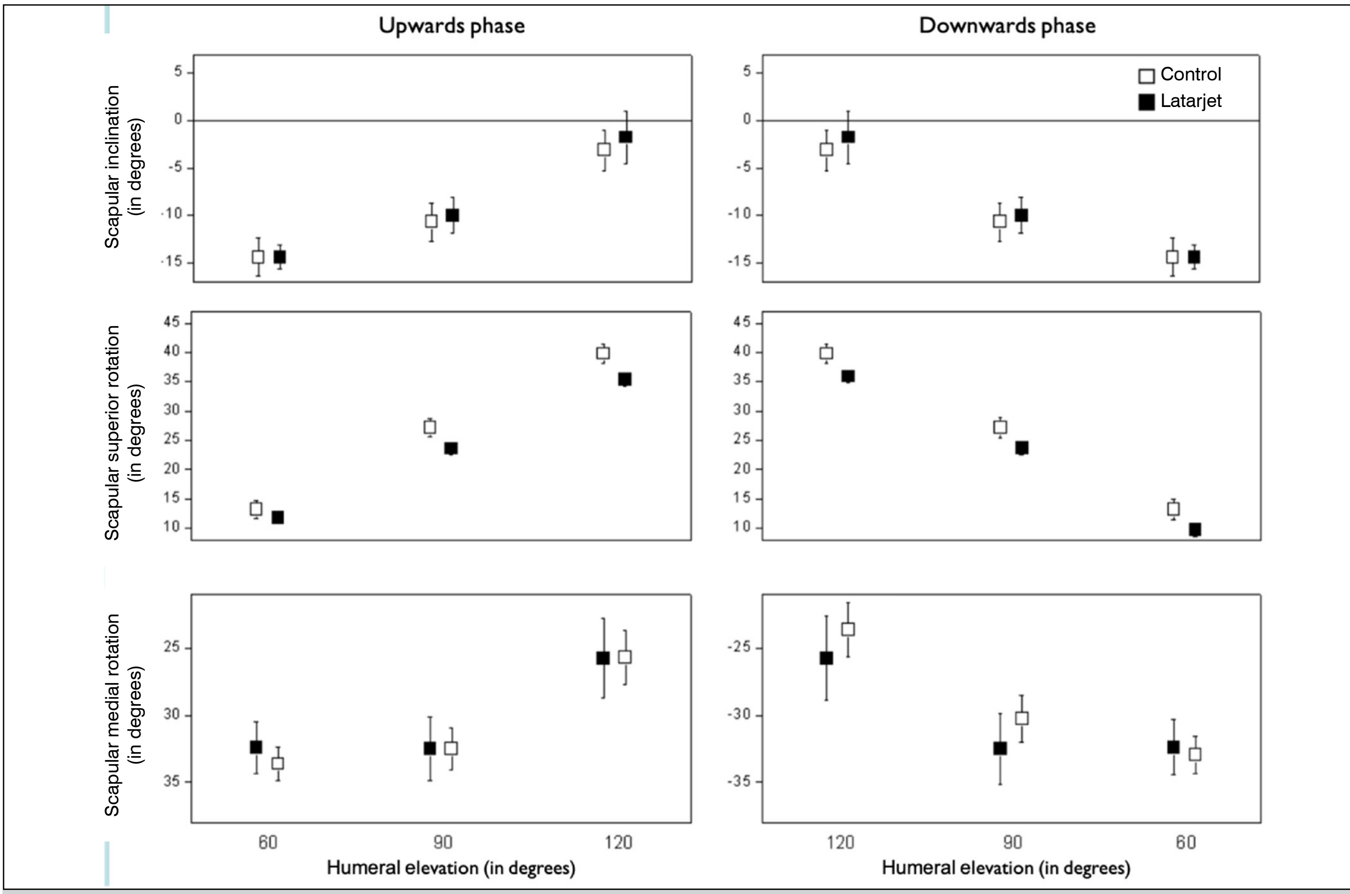

Figure 3. Mean values (± standard deviation) for inclination, upward rotation, and medial rotation of the scapula (in degrees) in relation to the trunk during the ascending (on the left side) and descending (on the right side) phases of the shoulder upward movement for the dominant hemibody in the control group (white squares) and group of Crossfit® practitioners (black sqaures). Note: for the inclination movement, positive values indicate anterior inclination and negative values indicate posterior inclination, as shown in Figure 2.

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