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Research Article

Crossfit®: An Approach to Bite Force and Masticatory Muscle Thickness

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Abstract

Crossfit® is based on physical improvements related to strength and endurance. This study aimed to evaluate the molar bite force and masticatory muscle thickness in athletes practicing Crossfit®. This cross-sectional study included 40 participants who were divided into groups: athletes who had been practicing Crossfit® (n = 20) and healthy participants who were not practicing physical exercise (n = 20). The molar bite force (right and left sides) was measured using a dynamometer. The thickness of the masseter and temporalis muscles at rest and dental clenching in maximum voluntary contraction tasks were analyzed using ultrasound. The data were analyzed using a t-test with a 5% significance level. Significant differences were found in the right ($p = 0.001$) and left ($p = 0.008$) maximum bite forces between the two groups. The Crossfit® group showed a greater maximum bite force than the non-sports group. There were significant differences in the thickness of the right ($p = 0.032$) and left ($p = 0.004$) masseter muscles during dental clenching in maximum voluntary contraction, and in the thickness of the left masseter muscle ($p = 0.015$) at rest. The Crossfit® group showed greater muscle thickness than the non-sports group. The results of this study suggest that Crossfit® produces morphofunctional changes in the stomatognathic system when maximum bite force and masseter and temporalis muscles thickness are observed. We highlight the importance of analyzing the stomatognathic system of athletes who practice strength and endurance sports, showing the importance of knowing the functional characteristics of the organism as a whole to improve physical performance.

Keywords: Crossfit®; Physical Activity; Bite Force; Muscle Thickness; Masticatory Muscle

Introduction

Dental science and sports are lining up through increasingly promising discoveries that demonstrate the impact of oral health on the performance of high-performance athletes to promote health and quality of life [1-5]. The physical ability and balance of the body required in sports can be influenced by dental occlusion; for example, by showing the relationship between muscles, clenching of the teeth, sports performance, and health [6].

An understanding of what happens to the human body when it undergoes physical improvement related to strength and endurance with the functional aspects, especially the stomatognathic system, demonstrates that the systems are interconnected and can respond directly to physical stimuli [7].

Sports, when regularly practiced, promote health benefits [8]. For example, training by Crossfit® improves strength and endurance and increases functional performance [9,10]. Crossfit® is known as a high-intensity physical program performed with small or no intervals between sessions, and is practiced worldwide in more than 11,481 official academies [11].

The musculoskeletal system is composed of three main structures: bones, joints, and muscles [12]. Crossfit® known as a sports modality promotes improvement in the functional condition of these structures while working on the muscle mass and body fat ratio, thereby, improving the athlete's performance [13].

It is important to functionally evaluate individuals who regularly engage in physical activities, especially those which are characterized by strength intensity; however, little is known about the impact of these activities on the stomatognathic system, which is complex and interdependent, covering static and dynamic structures [14]. By analyzing this complex system, it is possible to understand how the function and morphology of dynamic structures are influenced by sports activities, providing possible anatomical and functional modifications [15].

Objective of the study

The objective of this study was to evaluate the molar bite force and masseter and temporalis muscle thickness of athletes practicing Crossfit® to demonstrate whether there are functional alterations in the stomatognathic system. The null hypothesis was that there was no significant difference in the molar bite force and the masseter and temporalis muscle thickness between the group of athletes who practiced Crossfit® and the group of healthy individuals who did not engage in physical exercise. This study proposed two hypotheses about athletes who practiced Crossfit®: they have a greater molar bite force and have thicker masticatory muscles.

Materials and Methods

Participants and experimental design

This comparative cross-sectional observational study was carried out at the Laboratory of Electromyography of the Department of Basic and Oral Biology, Faculty of Dentistry of Ribeirão Preto, University of São Paulo, and at the Laboratory of Biomechanical Analysis of Movement of the Claretian Centro Universitário de Batatais, São Paulo, Brazil.

The number of Crossfit® training practitioners in Brazil was not considered during sample size calculation as there were no official records. Therefore, this sample was used for convenience. The *post-hoc* test was performed at an α level of 0.05 and power (π) of 0.81 for the main result of maximum right molar bite force to confirm the sample size (20 individuals in each group) using the G* Power software (v.3.1.9.2, Franz Faul, Universität Kiel, Germany). The mean ± standard deviation (SD) of the maximum right molar bite force was 39.67 ± 17.20 for the group of athletes who practiced Crossfit®, while that of the group of healthy individuals not practicing physical exercises was 27. 41 ± 12.97, producing an effect size of 0.815.

A total of 60 participants aged between 25 and 35 years and following the inclusion and exclusion criteria were evaluated, of which 20 participants were selected (12 women and 8 men) as the group that had been practicing Crossfit® (GI) training for a minimum of two years, with a practice routine of five days per week. The Crossfit® practitioner's level is advanced. The group of healthy participants who did not practice physical exercises (GII), known as the control group, was constituted by means of individual-to-person pairing with the GI observing age and body mass index. The characteristics of the participants in both groups are shown in table 1.

Groups	Age	Body Mass Index
GI	30.8 ± 0,9	25.1 ± 0.5
GII	30.0 ± 1.2	23.3 ± 0.7
p-value	0.63	0.08

Table 1: Differences in characteristics (mean ± standard error) between athletes who practiced Crossfit® (GI) and healthy participants who do not engage in physical exercises (GII).

* Significant difference, Student's t-test (i.e., $p < .05$).

The recruitment of participants who practiced Crossfit® training was carried out in two gyms in the city of Ribeirão Preto and the metropolitan region of São Paulo, Brazil, which maintained the same standard of physical training. The exercises encompassed high-intensity, constant functional movements, and sustained variations during the session. The instructor determined a sequence, and all participants performed the same physical exercises while maintaining the daily protocol.

All selected individuals met the following inclusion criteria: age between 25 and 35 years, normal occlusion (Angle Class I), presence of all teeth except for third molars, non-smokers, absence of cardiovascular and neurological diseases. The exclusion criteria were as follows: presence of temporomandibular disorders (Research Diagnostic Criteria for Temporomandibular Disorders), muscle injuries in the last five months, use of medications and/or dietary supplements that could interfere with muscle function, ulcerations, open wounds or skin hypersensitivity, systemic pathologies (decompensated), and orthodontic treatment.

Ethical consideration

The study was conducted under the ethical standards of the Helsinki Declaration and was approved by the local Ethics Committee (process # 19828619.5.0000.5419). Written informed consent was obtained from all participants.

Measurement of the maximum bite force

The maximum bite force was measured using a digital dynamometer (Kratos Equipment model IDDK, São Paulo, Brazil) with a bite fork [16,17]. The equipment consisted of two rods with Teflon discs at the ends, on which the maximum bite force was captured. The dynamometer was cleaned with alcohol, and the device's bite rods were protected with disposable latex finger cots (Wariper-SP) following the biosafety criteria.

All participants received information on the maximum molar bite force. The tests were performed by squeezing the equipment rods before the records were obtained to ensure the reliability of the protocol. The measurements, which were reported in newtons, were performed in the region of the first molar, detecting both the right and left arches. Each participant was asked to bite the nails three times, with maximum effort, resting for two minutes between records [18,19]. The maximum molar bite force value was recorded and used for statistical analysis.

Measurement of masticatory muscle thickness

A portable ultrasound device (NanoMaxx; SonoSite Inc., Bothell, WA, USA) with a 13-MHz linear transducer positioned on the fibers of the masseter and temporalis muscles was used to measure thickness during mandibular rest and dental clenching tasks during maximum voluntary contraction.

During the performance of the protocol with the function of recording the ultrasound images, the individuals remained seated in an upright posture, without head fixation, with the soles of their feet on the ground and the palms of their hands resting on their thighs. Specific guidelines were provided asking the individual to remain calm during data collection. The locations of the masseter and temporalis muscles were confirmed by digital palpation [16,20,21].

In this protocol, a water-based electroconductive gel was used between the integumentary tissue and the linear transducer, with the objective of suppressing the air so that it does not interfere with the capturing of the ultrasonographic image. The transducer was positioned transversely to the direction of the muscle fibers, considering that the belly of the masseter muscle is located approximately 2.75 cm above the angle of the mandible towards the upper eyelid and the anterior portion of the temporalis muscle, approximately 1.25 cm behind and above the external angle of the eye [22].

Three ultrasonographic images of the masseter and temporalis muscles were obtained at rest and during dental clenching in the maximum voluntary contraction task, with an interval of two minutes between images [16,21]. Measurements were performed by a single qualified professional. From the three measurements of each masticatory muscle in centimeters, mean values were obtained for statistical analysis.

Statistical analysis

Data were analyzed using Student's t-test, considering bite force and muscle thickness as variables. The level of statistical significance was set at $p < 0.05$. Statistical analysis was performed using IBM® SPSS® (version 26.0; IBM SPSS Inc., Chicago, IL, USA). The Shapiro–Wilk test was applied to verify the normal distribution of data on bite force and muscle thickness.

Results

The maximum bite force and masticatory muscle thickness in athletes who practiced Crossfit® and healthy participants who did not practice physical exercise are shown in table 2. Significant differences were found in the right ($p = 0.001$) and left ($p = 0.008$) maximum bite forces between the two groups. The Crossfit® group showed a greater maximum bite force than the non-sports group. There were significant differences in the right (p = 0.032) and left (p = 0.004) masseter muscle thickness during dental clenching in maximum voluntary contraction and the left masseter muscle thickness (p = 0.015) at rest. The Crossfit® group showed greater muscle thickness than the non-sports group.

Variables	GI	GII	p-value
Bite Force (N)			
Right	389.02.± 168.67	268.80 ± 127.19	0.01
Left	359.41 ± 135.52	247.12 ± 119.15	0.008
Muscle thickness (cm)			
Rest			
RM	1.21 ± 0.21	1.15 ± 0.22	0.42
LM	1.24 ± 0.30	1.06 ± 0.12	0.01
RT	0.52 ± 0.10	0.51± 0.11	0.79
LT	0.51 ± 0.11	0.50 ± 0.10	0.87
MVC			
RM	1.42 ± 0.20	1.29± 0.15	0.03
LM	1.47 ± 0.32	1.22 ± 0.16	0.004
RT	0.57 ± 0.11	0.56 ± 0.12	0.88
LT	0.58 ± 0.14	0.55 ± 0.12	0.42

Table 2: Differences in mean values (± standard deviations) of variables between groups.

GI, athletes who practiced Crossfit®; GII, healthy participants who did not engage in physical exercises; RM, right masseter; LM, left masseter; RT, right temporalis; LT, left temporalis; MVC, maximum voluntary contraction; significant difference, Student's t-test ($p < 0.05$).

Discussion

The null hypothesis of this study was rejected because there were significant differences in maximum bite force, left masseter muscle thickness at rest, and masseter muscle thickness (right and left) in dental clenching during maximal voluntary contraction between the two groups, showing the relationship between the functional mechanism of physical training and the stomatognathic system.

Our first hypothesis was that the athletes practicing Crossfit® had experienced an increase in the maximum bite force. This hypothesis was based on previous studies that found an association between strength, power, and physical conditioning [23]. Therefore, the first hypothesis was accepted because the group of athletes practicing Crossfit® showed an increase in the maximum bite force with significant differences compared to the healthy individuals who did not practice physical exercise.

In high-intensity exercises that are considered anaerobic, fast-twitch muscle fibers are the most activated because they have the electrochemical capacity to transmit action potentials [24]. During this type of exercise, the muscle fibers used are known as type II (white) or fast-twitch muscle fibers, which increase in volume due to the increased spacing of the Z lines that delimit the repetitive unit of the myofibrils [25]. This fact could explain the greater bite force of the group of athletes practicing Crossfit® because of the relationship between the size of muscle fibers of the masseter muscles (which are type II muscle fibers) and the bite force of adult participants [26,27].

Our second hypothesis was that the group of athletes practicing Crossfit® experienced an increase in the thickness of the masseter and temporalis muscles. This hypothesis was based on scientific reports that showed that sports modalities promote greater recruitment of striated skeletal muscle fibers that can modify morphofunctional parameters and improve neuromuscular efficiency [28]. The second hypothesis of this study was also accepted.

There are hypotheses that could explain the results of these variables, based on the functional and physiological assumptions. First, we need to reflect on the behavior of the static and dynamic structures of the stomatognathic system regarding the training of Crossfit® athletes. It is known that during the practice of many sports that require both physical effort and concentration, teeth clenching is present, and can develop involuntarily [6].

Dental occlusion can affect the physical capacity and body balance. During teeth clenching as a result of physical activity, there is an increase in tension due to isometric muscle contraction, which can lead to muscle hypertrophy [29,30]. According to this hypothesis, it could have occurred in athletes practicing Crossfit®, causing an increase in the thickness of the masticatory muscles. In this study, we did not investigate whether the athletes clenched their teeth during sports.

On the other hand, after training with maximum effort, the body responds physiologically through changes in muscle glycogen, blood lactate, heart rate, and hormonal levels [31]. When observing a physically fit athlete, the body can, for example, reduce the lactate levels in the muscles recruited during high-intensity physical efforts. When evaluating the lactate concentration, it cannot be said that it is a waste product of metabolism; rather, it is a source of chemical energy, a product of glucose metabolism, which accumulates as a result of high-intensity exercise and stimulates muscle hypertrophy [32].

After lactate is formed in the skeletal striated musculature, it propagates in the interstitial space and into the bloodstream, undergoes tamponade, and is removed from the site of energy metabolism, associating its concentration with the release of growth hormone (GH), a hormone that may have an indirect influence on the muscle hypertrophy process [33].

Type 1 insulin-like growth factor or somatomedin C, also known as IGF-1 (insulin-like growth factor-1), is a hormone that mediates the effects of GH [34], produced in the liver, which acts as a hypertrophic inducer of muscle cells [35] resulting from increased protein synthesis by stimulating the intracellular signaling pathway P13K/AkT/mTOR in physiological hypertrophy, resulting from strength training [36,37]. This factor may also be associated with the increased thickness of masticatory muscles in the group of athletes who practice Crossfit®. In this study, the IGF1 test was not performed to quantify growth hormones.

Through a neuromuscular approach, we can also suggest the reason for the increase in the thickness of the masseter and temporalis muscles in the group of athletes who practice Crossfit®. They develop a workout with anaerobic muscle characteristics, thus promoting strength with an increase in the volume of muscle fibers, especially those of the white type, and due to the increased spacing of the Z lines, hypertrophy is triggered in the skeletal striated musculature [38]. This is another factor that could be associated with of the masticatory muscles thickness.

During physical conditioning of the human organism through a sport modality, all systems, including the stomatognathic system, produce instantaneous or delayed responses to maintain the biochemical and physiological balance. Crossfit® training is directly related to the strength and endurance of the upper and lower limbs, which is linked with anaerobic energy production that promotes an improvement in the functional performance [39].

Physical exercise challenges homeostasis and the human body always tries to find new ways to maintain the dynamic balance of the body through adaptive responses of the metabolic, immune, and hormonal systems [40]. When evaluating the stomatognathic system of athletes, the scientific community needs to understand how this system behaves as a result of the physical stimuli of physical conditioning and, therefore, understand the importance of the relationship between dentistry and sports to demonstrate that high-performance athletes show morphofunctional changes that may or may not interfere with physical and sporting performances.

This study had some limitations. The first limitation was the inability to assess the clinical signs of tooth clenching during sports. The second limitation was the use of a convenient sample, as there are no official data on the number of athletes in Brazil who practice Crossfit®. The third limitation was that the IGF1 test was not performed to measure growth hormone levels that could explain masticatory muscle hypertrophy.

The clinical relevance of this study is that the practice of Crossfit® does not affect the function of the stomatognathic system, when observing muscle strength and thickness, with a good stomatognathic system being an important factor for the athlete's physical performance in sports competitions and in daily life.

Conclusion

The results of this study suggest that individuals who practice Crossfit® training have morphofunctional alterations in the stomatognathic system, especially in the maximum molar bite force and masseter muscle thickness. Continuous, intermittent and high-intensity sports training provides an increase in strength and thickness of the masticatory muscles, which indicates that the systems of the human body are interconnected, responding to physical stimuli provided by continuous training, and is an important factor in understanding the functional characteristics that will improve an athlete's performance.

Therefore, future research will be needed to further explain the findings of this study, which shows that there are still gaps in sports dentistry when evaluating the dynamic structures of the stomatognathic system associated with high-intensity sports modalities.

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