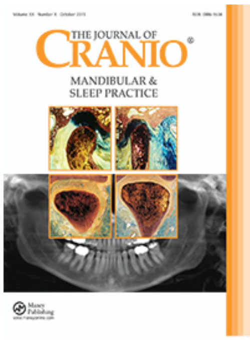

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Potential orofacial hazards of resistance training: A controlled comparative study*

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ABSTRACT

Objective: To evaluate the effect of resistance training (RT) regarding potential hazard for dental wear, tooth abfractions, temporomandibular joint disc displacement, limitation in mouth opening, and existence of cervical spine disorders. The initial study hypothesis was that extensive resistance trainees (ExRT) would suffer from the above-mentioned symptoms more often than recreational trainees (RcT).

Methods: A controlled comparative study among male gym members via questionnaires and a clinical examination.

Results: ExRT had a higher prevalence of teeth indentations on the tongue (26% vs. 2% $p < 0.001$) and a higher prevalence of tooth abfractions than RcT (28% vs. 4% $p < 0.005$). ExRT exhibited a higher prevalence of cervical movement limitations ($p < 0.05$) and inadequate posture ($p < 0.001$).

Conclusion: RT by itself may not be a risk factor for disc displacement. Nevertheless, it may act as a potential risk factor for irreversible hard tooth tissue damage and contribute to neck postural and mobility impairments.

KEYWORDS
Tooth abfractions; temporomandibular disorders; bruxism; resistance training; cervical posture

Introduction

Physical activity is an effective way to improve general health. A common form of exercise is resistance training (RT), which includes weight lifting and bodybuilding. More than 45 million Americans [1] regularly practice RT, and nearly 20% of adults perform some type of RT two or more times per week [2].

While the health benefits of RT are well supported [3], there is growing evidence of potential injury risk associated with different forms of RT [4]. It has been suggested that the prevalence of injuries attributed to RT is relatively high, with 25–30% of RT trainees seeking medical support related to musculoskeletal injury [5]. Moreover, some of those injuries are related to improper training and are severe enough to justify a visit to an emergency room [6].

One of the body areas potentially affected by RT is the orofacial area and masticatory system. It has been demonstrated that RT trainees tend to clench their teeth during submaximal physical activity [7] and sometimes do this to improve their performance [8]. This can resemble the masticatory activity termed bruxism. Bruxism is commonly defined as a repetitive jaw-muscle activity characterized by clenching or grinding the teeth and/or by bracing or thrusting the mandible. Bruxism has two distinct circadian manifestations, including during sleep (sleep bruxism) or during wakefulness (awake bruxism) [9]. While sleep bruxism is a centrally mediated disorder usually associated with sleep arousals, awake bruxism is thought to be related to stress/anxiety and/or concentration [10].

Both entities can have severe physical consequences [10]. Sleep bruxism is mainly of a phasic nature (grinding) and can cause dental attrition [11]. Awake bruxism is characterized by more sustained actions of a tonic nature (clenching) and has a higher probability of pain [11]. Another possible detrimental effect of awake bruxism is the formation of tooth abfractions, defined as loss of dental hard tissue appearing as a V-shaped lesion at the cervical tooth region [12]. These sharp, angular, wedge shaped lesions at the cervical tooth area are attributed primarily to biomechanical loading forces that cause flexure and failure of enamel and dentin. Occlusion loads, mainly during lateral movements, are hypothesized to cause bending forces

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in the tooth. These repetitive strains lead to stretching and sheering forces on the tooth neck, which damages the hydroxyapatite crystal connections and leads to cracks in the tooth enamel, and finally, to tooth material loss. An excessive occlusal load during parafunctional activities, such as clenching, may contribute to the phenomenon [13].

In addition, clenching forces exerted during RT can potentially affect the temporomandibular joint (TMJ), especially the articular disc, and cause its anterior displacement. The etiology of disc displacement is not clear. It has been hypothesized that in most cases, elongated or even torn ligaments binding the disc to the condyle allow the disc to displace. In addition, lubrication impairment, causing a "sticky disc" has also been suggested as a possible etiology of disc displacement. The disc displacement may also be precipitated in osteoarthritis patients.

The main sign of disc displacement is the appearance of clicks during lower jaw movements. This is a distinct and brief sound with a clear beginning and end. This sometimes also includes limitations in the range of mandibular movements (mandibular deviation during opening, limitation in contralateral movement, and pain during mandibular movements, as well as limitation of vertical opening and deviation or deflection, due to retrodiscitis).

Audible clicks may not be present in some cases in which the displaced articular disc is no longer reducible [14].

Another possible consequence of RT is limitations in cervical movements and posture abnormalities due to agonist-antagonist imbalances around the cervical spine as well as limited range of mouth opening due to facial muscular hypertrophy [15].

The aim of this study was to evaluate the effect of RT among males who were engaged in extensive weight lifting activities (ExRT) as compared to male recreational trainees (RcT), regarding the following clinical variables:

(1) Existence of dental wear and abfractions.
(2) Prevalence of articular TMJ disc displacement with reduction (clicks).
(3) Presence of relative limitation(s) in mandibular range of open movements.
(4) Existence of cervical spine disorders.
(5) Existence of posture disorders due to muscular agonist-antagonist imbalances.

It was hypothesized that the two groups (ExRT and RcT) would differ in most of the above-examined variables, with more symptoms appearing among the first group (ExRT).

Materials and methods

The Ethical Committee for Conducting Research on Human Subjects of Tel Aviv University approved this study. The study was performed in male subjects exercising in Tel Aviv gyms.

Population

This controlled comparative study was performed among 123 male participants, members in a Tel Aviv gym. Ninety-nine subjects agreed to participate in the study (80.5% response rate) and signed an informed consent form. Reasons for disagreeing were lack of time (20 subjects) and uneasiness in having a clinical examination in a public setting (4 subjects).

The study population included two groups:

(1) Extensive resistance trainees (ExRT, $n = 50$) – male individuals who were engaged in weight lifting activities using resistance for over six years, with at least four training sessions per week;
(2) Recreational trainees (RcT, $n = 49$) – age matched male individuals who have been exercising in the same gym as a hobby or for recreational reasons. Training frequency was less than four times per week.

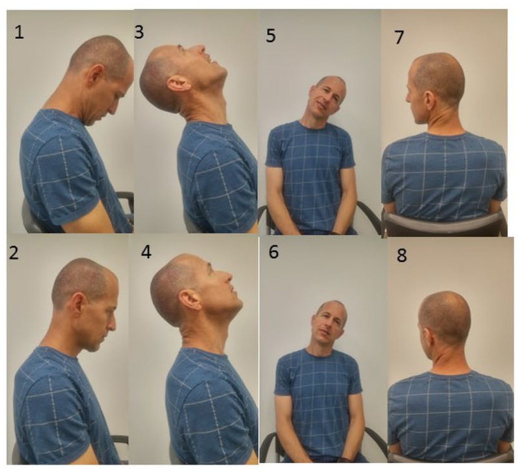
Excluded from the study were individuals who were: involved in additional significant sporting activity; those suspected of having ROM limitation due to a displaced TMJ articular disc without reduction; under the age of 18y; suffering from a severe periodontal disease (as evidenced by a direct inspection of the mouth); suffering from general neurological disturbances (sensory or reflex changes, weakness, etc.); afflicted with uncontrolled hormonal disease (diabetes, thyroid, or parathyroid disease, etc.); suffering with the presence of neoplasm, or known psychiatric problems (as reported in their medical history).

The following information was collected:

(1) Self-report questionnaires
  (a) *Demographic information* – age, type of sporting activity at the gym (e.g. weight lifting, recreational gym activity), years of performing routine weight lifting (RT) at the gym, and frequency of weight lifting activity per week.
  (b) *A questionnaire referring to the awareness of teeth grinding or clenching during wakefulness or sleep*. The questionnaire has been used previously in several clinical studies [16].

1- Normal forward head position **2**- Impaired forward head position **3**- Normal shoulders symmetry
4- Impaired shoulders symmetry **5**- Normal scapular position **6**- Impaired scapular position
7- Normal cervical lordosis **8**- Impaired cervical lordosis

Figure 1. Neck & shoulders posture.



1- Normal flexion **2**- Impaired flexion **3**- Normal extension **4**- Impaired extension
5- Normal side flexion **6**- Impaired side flexion **7**- Normal rotation **8**- Impaired rotation

Figure 2. Neck physiological movements.

(2) Clinical examination

(a) *Existence of clicks* – existence of temporomandibular disc sounds (clicks) was assessed according to the Axis I criteria of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD) recommendations [17]. The test was performed during jaw movements, while placing an index finger over the subject's TMJs (preauricular area). Diagnosing clicks was carried out during the following mandibular activity:

- Normal mouth opening – while placing an index finger over the subject's temporomandibular joints (TMJ preauricular area), the subject was asked to slowly open his mouth as wide as possible and close until the teeth were in touch in maximum intercuspation. The exercise was repeated three times [17].
- Mandible lateral movements – while placing the fingers as above, the subject was asked to open slightly and move his mandible as far as possible to each one of the sides (left or right). Each side was repeated three times [17].
- Mandible protrusion – while placing fingers as above, the subject was asked to open slightly and protrude his mandible as far as possible [17]. The exercise was repeated three times.

(b) *Range of mouth opening (according to RDC-TMD)* [17]: Measurement of the intrinsical distance in active (voluntary) maximal mouth opening and in passive (assisted) maximal opening by applying finger pressure to extend the opening to its maximal capacity. Measurement was performed with the use of a ruler. Testing pressures of all tests were according to the RDC-TMD [17] and calibrated as specified below.
(c) *Tooth wear*: The presence of wear facets on teeth was assessed according to a modification of the method by Lobbezoo and Naeije [18] on a tooth-by-tooth basis, using the following scale: grade 0 = no wear; grade 1 = visible wear within the enamel only; grade 2 = visible wear with dentin exposure and mild to moderate loss of clinical crown height; and grade 3 = significant loss of crown height (≥2⁄3). The assessed teeth included incisors, canines, and molars. The most severe worn tooth from each dental group was registered for each subject. In order to prevent bias, any tooth that exhibited severe signs of erosion was excluded.
(d) *Clenching signs*: The presence of indentations on lateral sides of the tongue, as a sign of clenching, was registered. The registration was binary (existing/non-existing).
(e) *Cervical examination*: The examination was performed according to Viikari-Juntura [19], as follows:

- Movements of the cervical spine examined were (1) rotations, (2) lateral flexions, and (3) flexion and extension. Rotations were tested by having the patients rotate their head as far as possible to each side, while the examiner observed from behind. The range of movement (ROM) was estimated and classified as normal (>80°), limited (60°–80°), and markedly limited (<60°). Lateral flexions were tested in a similar manner, and the ROM was classified as normal (>30°), limited (20°–30°), and markedly limited (<20°). Flexion and extension were observed from the side, and the ROM was classified as normal (>45°), limited (30°–45°), and markedly limited (<30°). The examination was performed during relaxed sitting (Figure 1).
- Head posture during relaxed sitting and standing (face, backward, right and left profile), evidence for an existence of defective lordosis or kyphosis. The following data was recorded: equal level of shoulders (face); shoulders bent forward (backwards), or head bent forward (profile) [19] (Figure 2).

(3) Diagnoses

(a) Temporomandibular disc displacement with reduction (DDwR) was diagnosed if a click was heard during opening and closing or eccentric mandibular movements on one of three jaw exercise repetitions as described above (according to RDC-TMD [5]). The DDwR diagnosis could be achieved through combining findings of a questionnaire and clinical examination [17]. Further details can be found at http://rdc-tmdinternational.org.
(b) Bruxism: the diagnosis of bruxism was as follows: Awake bruxism was based on the subject's awareness of clenching while awake (possible bruxism; [9]). Sleep bruxism was based on the subject's teeth grinding awareness (i.e. positive answers for questions regarding awakening signs, such as feeling that the teeth are clenched or that the mouth is sore upon awakening, aching of the temples upon awakening, difficulty in opening mouth wide upon awakening), in addition to clinical dental examination. This is considered as "probable bruxism" [9].
(c) Cervical diagnosis:

- Cervical limitation (CL): Any subject with at least one markedly cervical movement limitation was defined as suffering from cervical limitation.
- Posture: Subjects were defined as suffering from impaired posture (IP) if at least three out of the nine examined posture variables were defective (e.g. head inclination to one side, shoulder inclination forward, etc.)

Calibration

One of the authors (KS), a senior dental student, trained in the dental and orofacial examination, performed all of the clinical examinations. Prior to the opening of the study, the examining investigator practiced the clinical procedure on 10 male subjects who were not part of the study

Table 1. Age, intensity and frequency of training.

	ExRT		RcT		p
	n = 50 (mean ± SD)	ExRT range	n = 49 (mean ± SD)	RcT range	Fisher exact test
Age	26.8 ± 6.3	18–41	27.7 ± 5.6	18–40	NS
Years of training	7.3 ± 4.1	6–21	5.5 ± 2.7	1–10	<0.05
Hours of training per week	11.1 ± 5.1	6–30	5.0 ± 2.0	1–14	<0.001

Note: ExRT – extensive resistance trainees; RcT – recreational trainees; n – number; NS – not significant; SD – standard deviation.

group. Quantification was determined according to the training practice session of the International Consortium for TMD (http://rdc-tmdinternational.org) [17]. Each of these 10 subjects was examined twice, with an interval of at least 30 min between examinations. At the time of the second examination, the results of the first examination were not provided to the examiner. Reliability intra-tester Kappa values ranged from ≥0.75 to 0.87 for non-continuous variables (temporomandibular & cervical examination, dental wear) and was 0.97 for continuous variables (Interclass Correlation) (Range of mouth opening).

Statistical analysis

Data were analyzed using SPSS version 21 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics were provided and presented as appropriate. Continuous and categorical values were presented as mean(s) ± SD(s). Categorical variables were tested with Fisher's exact test. All statistical tests and/or confidence intervals (as appropriate) were performed at $\alpha < 0.05$ (2-sided).

Results

There were no differences between ExRT as compared to RcT, with regards to age. Those in the ExRT group had been practicing RT for a significantly longer time than the RcT group (7.3 ± 4.1 vs. 5.5 ± 2.7 yrs, respectively) and for significantly longer periods (11.1 ± 5.1 hrs per week vs. 5.0 ± 2.0 hrs per week, respectively) (Table 1).

(1) Bruxism, tongue indentations, and dental abfractions: The ExRT group had a higher prevalence of teeth indentations on their tongues (26% vs. 2%; $p < 0.001$), indicating a higher prevalence of clenching. Also, the ExTR group had a higher prevalence of tooth abfractions than the RcT group (28% vs. 4%; $p < 0.005$), and they had a higher prevalence of awake bruxism (20% vs. 6%; $p < 0.05$) than the RcT group (but not of sleep bruxism) (Table 2). As bruxism is considered one of the possible causes of abfractions, the authors repeated the analysis regarding abfractions with subjects who were not diagnosed as performing either awake or sleep bruxism. The results were similar. Namely, also among subjects not diagnosed as bruxists, a significant difference was found in the prevalence of tooth abfractions between ExRT and RcT individuals (16% among non bruxing ExRT vs. 2% among non bruxing RcT, $p < 0.05$) (Table 3).

(2) TMJ disc displacement with reduction: No significant differences were found between groups with regard to prevalence of TMJ disc displacement with reduction (6% among ExRT vs. 8.2% among RcT) (Table 4).

(3) Limitation in mandibular range movements: Regarding mouth opening range (active and passive), no statistical differences were found between groups. The main active opening of ExRT and RcT groups was 47.5 ± 5.6 mm and 47.1 ± 6.6 mm, respectively, while passive opening was 49.0 ± 5.5 mm and 47.7 ± 7.5 mm, respectively.

(4) Cervical spine disorders: The ExRT group exhibited a higher prevalence of cervical movement limitation (66% vs. 45%; $p < 0.05$) (Tables 5 and 6) as well as inadequate posture (84% vs. 22%; $p < 0.001$) (Tables 7 and 8).

Discussion

The aim of the present study was to evaluate possible orofacial and cervical effects of resistance training among young and healthy men (around 30 years old), who have been engaged in extensive RT activities or involved in exercising for recreational reasons. The main purpose of the study was to evaluate whether excessive engagement in RT can affect the orofacial area in a way that it will increase the incidence of TMJ disc displacement with reduction and/or tooth hard tissue damage among this relatively non-susceptible population of young males.

The initial hypothesis was that a connection exists between resistance training and TMJ disc displacement with reduction. This hypothesis was based on the proposed etiology of internal derangement that frictional "sticking" of the disc is the cause the disorder [14]. In addition, the intra-capsular pressure performed during clenching may cause disc displacement by affecting the

Table 2. Clenching signs and bruxism diagnoses.

	ExRT	RcT	
	N (%)	*N* (%)	*p**
Existence of teeth indentations on tongue	13 (26%)	1 (2%)	<0.001
Existence of tooth abfractions	14 (28%)	2 (4%)	<0.005
Diagnosis of awake bruxism	10 (20%)	3 (6%)	<0.05
Diagnosis of sleep bruxism	4 (8%)	2 (4%)	NS

Notes: ExRT – extensive resistance trainees; RcT – recreational trainees; *N* – number; NS – not significant.
*Fisher exact test.

Table 3. Existence of tooth abfractions in subjects without bruxism.

	With abfractions	Without abfractions	
Group	*N* (%)	*N* (%)	*p**
ExRT	8 (16%)	42 (84%)	<0.05
RcT	1 (2%)	48 (98%)	

Notes: ExRT – extensive resistance trainees; RcT – recreational trainees; *N* – number.
*Fisher exact test.

Table 4. Prevalence of TMJ disc displacement (DD) with reduction by groups.

	DD (+)	DD (–)	
Group	*N* (%)	*N* (%)	*p**
ExRT	3 (6%)	47 (94%)	NS
RcT	4 (8.2%)	45 (91.8%)	

Notes: TMJ – Temporomandibular joint; DD (+) – Positive diagnosis of DD; DD (–) – Negative diagnosis of DD; *N* – Number; ExRT – Extensive resistance trainees group; RcT – Recreational trainees group; NS – Not significant.
*Fisher exact test.

Table 5. Cervical measurements.

	ExRT		RcT	
	n = 50		*n* = 49	
	Markly limited (%)	Non-limited (%)	Markly limited (%)	Non-limited (%)
Forward head flexion	12	88	10	90
Back head flexion	20	80	10	90
Head flexion toward right shoulder	12	88	14	86
Head flexion toward left shoulder	12	88	14	86
Head rotation to the right	50	50	14	86
Head rotation to the left	48	52	43	57

Notes: ExRT – Extensive resistance trainees; RcT – Recreational trainees; *n* – number; markly limited – rotation: markedly limited (<60°) cervical movement limitation. Lateral flexions markedly limited (<20°). Flexion and extension markedly limited (<30°).

joint lubrication [14]. This hypothesis was not supported by the results, as no significant differences were found between the two groups regarding this issue. Similarly,

Table 6. Cervical limitation.

	C_Lim (+)	No C_Lim	
Group	*N* (%)	*N* (%)	*p**
ExRT	33 (66%)	17 (34%)	<0.05
RcT	22 (44.9%)	27 (55.1%)	

Notes: C_Lim (+) – existence of cervical limitation (at least one markedly cervical movement limitation needed for diagnosis); ExRT – extensive resistance trainees; RcT – recreational trainees; *N* – number.
*Fisher exact test.

no limitation in relative mouth opening due to a possible masticatory muscular (masseter muscles) hypertrophy was shown, since both groups exhibited similar active and passive mouth opening ranges. However, as actual muscular hypertrophy was not measured in this study, further studies are needed to explore this issue.

While no significant differences between groups were found as to TMJ disc displacement with reduction, an interesting and important finding refers to bruxism, a centrally mediated muscular activity with strong potential detrimental effects. The ExRT group had more signs of awake bruxism and a higher prevalence of teeth indentations on their tongues than recreational trainers, probably due to the overuse of the masticatory muscles during resistance.

As a potential by product of the overuse of the masticatory muscles among the ExRT group, the results show that this group suffers from relatively severe tooth abfraction lesions, as compared to the RcT group. Although the relationship between bruxism and abfractions is still controversial, there is growing evidence that there might be a direct relation between the two syndromes. Recently, a clinical study [20] found a significant difference in the prevalence of abfractions between bruxers and non-bruxers. This was also supported by earlier studies [21,22].

In addition, the importance of occlusal overloading is controversial. A review study presented evidence to support the thesis that occlusal loading can contribute to the loss of hard tissue in the cervical region [23], while an in vitro study found that axially-loaded teeth exhibited significantly less tooth wear. This study further found that non-axial loads might not significantly alter the size and shape of cervical dental lesions. The authors concluded that the application of theoretical forces might not necessarily play a significant role in the progression of cervical tooth wear [23]. The same group claimed that analyses of the periodontal ligament and alveolar bone have shown that those structures may dissipate occlusal loading forces from the cervical areas [11]. On the other hand, Bartlet and Shah [24] published a critical review and concluded that the literature primarily contains mainly laboratory, but not clinical, studies indicating abfraction.

Table 7. Posture variables.

	ExRT $n = 50$		RcT $n = 49$	
	Impaired measurement (%)	Normal measurement (%)	Impaired measurement (%)	Normal measurement (%)
Even level of shoulders – sitting	16	84	71	29
Head deflection – sitting	18	82	90	10
Even level of shoulders – standing	18	82	90	10
Head deflection – standing	12	88	5	95
Head side shifted – sitting	90	10	19	81
Head side shifted – standing	88	12	29	71
Forward head inclination – sitting	94	6	95	5
Forward head – standing	90	10	33	77
Defective lordosis/kyphosis	78	22	19	81

Note: ExRT – extensive resistance trainees; RcT – recreational trainees; *n* – number.

Table 8. Inadequate posture*.

	Impaired posture	Normal posture	
Group	*N* (%)	*N* (%)	p**
ExRT	42 (84%)	8 (16%)	$p < 0.001$
RcT	11 (22.4%)	38 (77.6%)	

Notes: *N* – number; ExRT – extensive resistance trainees; RcT – recreational trainees.
*Impaired posture: at least three out of the nine examined posture variables were defective; **Fisher exact test.

Dental erosion and abrasion, combined with interocclusal activity, such as chewing, swallowing, stress, and parafunction, may contribute to the creation of abfraction lesions [25]. Thus, loading forces may be a contributing factor to the creation of tooth abfractions. The present findings indicate that abfractions are significantly more prevalent among ExRT than RcT, possibly due to the tendency to clench teeth and jaws during activities such as weight lifting.

Abfractions can be detrimental to oral health. A survey performed among USA veterans concluded that abfraction lesions can serve as a possible explanation for cervical dental lesions and that toothbrush abrasion is strongly suspected as contributing to the formation of the majority of wedge-shaped lesions [26]. Loss of enamel is irreversible, since no regeneration is possible [27]. Once lost, the tooth loses its protection, and the affected cervical area is prone to develop sensitivity and caries, a process that can eventually lead to further dental treatments, such as root canal treatment, crown, etc. The increased presence of tooth abfractions among young men should be seriously considered.

The presence of indentations on lateral sides of the tongue is indicative of clenching (during wakefulness and/or sleep) [28]. In the present study, the existence of teeth indentations on the tongue was significantly ($p < 0.001$) more common in the ExRT group. This finding was expected, since RT can be accompanied by clenching [7].

The notion that there is a connection between resistance training activities and cervical spine disorder was supported by the findings in the current study because men who have been engaged in extensive RT activities had a higher prevalence of cervical movement limitations and inadequate posture versus those involved in exercising for recreational reasons. The postural and mobility impairments seen in the ExRT group may be explained by the fact that participants were not professional athletes but rather amateur body builders. Such unsupervised physical activity, without proper post-training stretching, may lead to muscular imbalance between agonists-antagonists muscle groups in the upper body and contribute to cervical spine mobility and posture problems [29,30].

Conclusion

Within the limitations of this study, it can be concluded that extensive resistance training by itself may not be a risk factor for TMJ disc displacement with reduction. Nevertheless, it may act as a potential risk factor for irreversible hard tooth tissue damage, due to the excessive forces on the trainee's teeth. It may also contribute to neck postural and mobility impairments.

Practical applications

It is suggested that resistance trainees use mouth guards during training to prevent tooth damage and get supervision by a professional trainer or physiotherapist to avoid neck and postural impairment.

Contributors

In this manuscript, all authors have made a significant contribution to the findings and methods. All authors have approved the final draft of the manuscript.

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Conflicts of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements) or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript. The authors deny any conflicts of interest. The authors declare self-funding of the research, as well as that the results of the present study do not constitute endorsement by ACSM.

Disclosure statement

None of the authors had any financial support or relationships posing conflict of interest.

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