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Relationship between the Training of Young Recruits and Values of Bite Forces

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A B S T R A C T

Analysis of masticatory function is the basis of clinical work in almost all fields of dentistry. Bite forces are the expression and measure of masticatory function. Physical training has an effect on the development of functional ability, motoric ability of the organism and the formation of desired physical proportions. The purpose of this study was to examine the association between physical fitness and bite force values. Because of strictly defined regulations in the army with regard to training and nutrition, Croatian Army recruits were ideal examinees for this examination. The examinees were 135 recruits. Bite forces were measured on three places (area of the central incisors, left and right in the area of the first molars) before and after three-months of training. Of all the examinees, 108 had increased their body weight, 12 had decreased it and 15 had not changed their body weight. The median of measured forces in the recruits prior to training was 291 N in the right (lateral quadrant), 285.5 N in the left lateral quadrant and 205 N in the anterior area. After training the median of measured forces in the right quadrant was 312 N, in the left 313 N and in the anterior area 216 N. Greater bite forces after training on all measured places were statistically proved. Increased activity of masticatory muscles can have the same effect on the values of bite forces as bite training. There are few data on the correlation between physical muscles and values of bite forces. The results of those studies are doubtful. In this study, after three months of conditional training, the body mass of the recruits had increased and they expressed greater values of bite forces. However, correlation between body mass and bite forces cannot be proved with certainty.

Key words: *bite forces, physical training, army recruits, body weight*

Introduction

Analysis of masticatory function is the basis of clinical work in almost all fields of dentistry. Force is the physical category that arises from the dynamic and static muscular stress and depends on the morphological characteristics of the muscles. Contraction of the muscles induces bioelectric and biochemical processes which generate force, depending on the strength of the muscles. The strength of the muscles depends on the muscle activity such as movement, contraction which represents the transfer of force, and on the muscular force, i.e. tension in the tendons. Muscular force however is dependent on the section and length of the muscles, type of muscular contraction, frequency of impulses which activate the muscle, biorhythm, training, gender and age. Bite forces are the expression and measure of masticatory function[1–3]. Dependent variables are influenced by a series of internal and external factors; internal factors are biologically possible forces, while external factors are the condition of the oral cavity, constitution, anthropometric variables, weight and height, etc. Several previous studies examined the relationship between bite forces and facial types[4–6]. Naturally, apart from physical characteristics, the influence of malocclusion on the expression of bite forces is inevitable[7]. The type of food (nourishment) and oral habits must also be taken into account. In an epidemiological study Corruccini[8] concluded that the rural population had stronger bite forces than the urban population, who consume refined food. This is corroborated by the high values of bite forces in Eskimos and Aborigines, who also consume tougher and harder food. At the

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same time the maximal values of bite forces are one of the factors in the choice of construction material used in prosthetics.

When measuring maximal bite forces, it is important to emphasise that stimulation of the muscles, such as training, and also the desire of the subject to attain forceful bite, can also have an influence on the increased bite forces[9–13]. A limiting factor is pain, the patient's fear of breaking a tooth (fillings, crowns etc.), and the characteristics of the measuring instrument itself[14].

Following the independence of the Republic of Croatia in 1995, national army service lasted nine months for adolescents and professional soldiers. Recruits had physical training several times a week and were tested for physical ability.

Physical training has an effect on the development of functional ability, motoric ability of the organism (strength, speed, flexibility, agility, coordination, preciseness and balance) and the formation of desired physical proportions (reduced fatty and increased muscular tissue). Thus, its positive influence on the values of bite forces is anticipated.

The purpose of this study was to examine the association between physical fitness and bite force values. Because of strictly defined regulations in the army with regard to training and nutrition, Croatian Army recruits were ideal examinees for this examination.

Subjects and Method

The examinees were 135 recruits, aged 18–27 years from the »Kralj Zvonimir« Barracks in Zagreb. Basic training involves three months of conditioning, three times a week in the morning, in which the recruits engage in a wide variety of physical activities, which are designed to improve their level of fitness. In addition, they are regularly tested for physical readiness. Bite forces were measured by an electronic gnathodynamometer[1] on three places (area of the central incisors, left and right in the area of the first molars) before and after three--months of training. To familiarize the examinees with the equipment, they were asked to bite three times all the measurement places, and these results were not recorded. Apart from bite forces, body height and weight were measured at the beginning and end of conditioning. A clinical examination of the oral cavity was performed and data on age were recorded.

Data were analysed by descriptive statistics and Wilcoxon's rank test, and the computer programme SPSS 13.

Results

The one hundred and thirty-five recruits were aged from 19 to 27 years (mean 22 yrs.). On arrival, the height of the recruits ranged from 160 to 199 cm (mean 180 cm), and body weight from 55 to 126 kg (mean 75 kg). After three months of obligatory training the values of body weight ranged from 59 to 121 kg (mean 78 kg), showing an increase in weight of approximately 3 kg (Table 1). Body weight increased in 108 examinees, decreased in 12 and in 15 their body weight did not change (Table 2). Significant statistical difference was determined in body weight before and after training ($p<0.01$).

During statistical analysis of bite forces, only those examinees with antagonistic contact in the measurement areas and with all teeth were taken into account. Thus of the 135 examinees, 128 had teeth in the right lateral region, 126 in the left and 123 in the anterior region. The measured forces in the recruits prior to training ranged from 107 to 824 N (median 291 N) in the right, and from 104 to 824 N (median 285.5 N) in the left lateral quadrant. Forces measured in the anterior area ranged from 103 to 582 (median 205 N). After training, the measured values of forces in the right quadrant were 101 to 872 N (median 312 N), in the left 108 to 868 N (313 N) and in the anterior area 116 to 600 N (median 216 N) (Figure 1, Table 3). Expression of the values of bite forces, depending on the number of examinees, is shown in the Table 4. Greater bite forces after training on all measured places

TABLE 1
MEDIAN AND INTERQUARTILE RANGE OF MEASURED WEIGHT (N=135)

	X	Interqartile range
Weight I	73	14
Weight II	76	12
Weight II – Weight I	–3	5

TABLE 2
WILCOXON SIGNED RANK TEST OF MEASURED WEIGHT

		N	X Rank
Weight II – Weight I	Negative Ranks	12	49.25
	Positive Ranks	108	61.75
	Ties	15	
	Total	135	
Negative Ranks	Weight II < Weight I		
Positive Ranks	Weight II > Weight I		
Ties	Weight II = Weight I		

TABLE 3
MEDIAN AND INTERQUARTILE RANGE OF MEASURED BITE FORCES

	Median	Interqartile Range
Right I	291	218
Left I	285.5	183
Front I	205	112
Right II	312	226
Left II	313	195
Front II	216	108

were statistically proved (Table 5). Figure 2 shows the increase in the measured variables, body weight and values of bite forces in percentages.

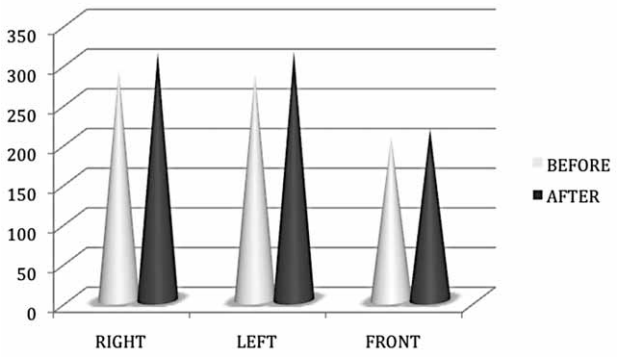

Fig. 1. Graphic presentation of median bite forces (N) before and after training.

TABLE 4
WILCOXON SIGNED RANK TEST OF MEASURED BITE FORCES

		N	X Rank
Right II – Right I	Negative Ranks	40	69.04
	Positive Ranks	87	61.68
	Ties	1	
	Total	128	
Left II – Left I	Negative Ranks	51	53.83
	Positive Ranks	73	68.55
	Ties	2	
	Total	126	
Front II – Front I	Negative Ranks	45	64.68
	Positive Ranks	78	60.46
	Ties	0	
	Total	123	
Negative Ranks	Bite Forces II < Bite Forces I		
Positive Ranks	Bite Forces II > Bite Forces I		
Ties	Bite Forces II = Bite Forces I		

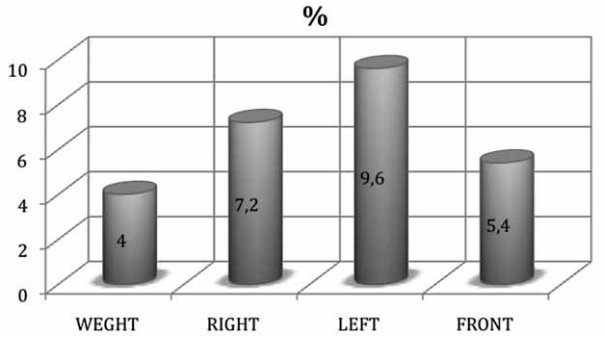

Fig. 2. Increase in the values of weight and measured bite forces expressed in percentages.

Discussion

In this study an attempt was made to demonstrate the influence of physical training on the strength of masticatory muscles by measuring bite forces. Examinees were recruits from the Croatian Army, who underwent intensive training of physical readiness over a period of three months. Measurement of bite forces before and after training showed statistically significantly increased bite forces on all three measured places ($p>0.01$ for force measured on the posterior teeth and $p>0.05$ on the anterior teeth). The increased values of forces amounted to 5.4% in the anterior quadrant, 9.6% in the left and 7.2% in the right lateral quadrant.

Investigation of bite forces has intrigued scientists for many years. The literature points out that males seem to show higher maximal biting forces than females[1,15,16]. As in this study only male subjects were examined, the influence of gender cannot be discussed, although it has been demonstrated that gender does influence maximal biting force. The best method to eliminate the variable of gender would be to limit the study to only one gender which we have done. Ivaniš et al.[15] found correlation between measured anthropometric dimensions and bite forces in males, aged between 18 and 24 years, in which the influence of weight was significant and positive, while the influence of height was not found. Shian and Wang[17] also achieved a similar result in a sample of 2034 high school and students. They consider that bite force depends more on gender than on the muscular strength of the body. At the same time, they established that individuals with stronger musculature show greater values of bite forces. Braun et al.[18] determined statistically significant and positive correlation with gender in a sample of 142 students (aged 26–40 years), while the coefficient

TABLE 5
STATISTICAL SIGNIFICANCE OF MEASURED BITE FORCES

	Right II – Right I	Left II – Left I	Front II – Front I
Asymp. Sig. (2-tailed)	.002	.005	.023

Wilcoxon Signed Ranks Test

correlation for age, weight and physical type was small, although greatest for weight (r=0.401).

Increased activity of masticatory muscles can have the same effect on the values of bite forces as bite training[7,9–13]. Brekhus et al.[9,10] showed an increase in bite forces in males after fifty days of chewing small cubes of paraffin wax for one hour daily, but also a drop in the same values two weeks after training was stopped. The values of bite forces after training were up to 20% greater compared to the initial values. This indicates the incomplete use of the conditions of the bite mechanism in civilised individuals. Kiliaridis et al.[11] consider that chewing hard chewing gum one hour daily for a period of 4 weeks has an influence on the functional capacity of masticatory muscles and increases their strength. Individuals who chew with one side also show greater values of force in that area[1]. However, there are studies in which increase in the values of forces after training was not recorded. On the contrary, in a study by Brekhaus[9] forces were weaker after training than in a control group who had not carried out training. Thompson et al. believe that training of chewing is similar to running, which does not increase strength, at least not significantly, but rather increases endurance, and thus the authors consider that the training of chewing does not have a significant influence on the expression of maximal bite forces[7]. Apart from strength of the muscles, receptors in the periodontal membrane have a major role in differentiating the intensity of forces, and sensitivity to pain. The consequences of training the masticatory musculature in acrobats, who can hang loads from their teeth or pull them with the teeth, are well known. In such individuals the strength of the relevant teeth on the apparatus is primarily a measure of the resilience of the periodontal membrane, and not the strength of the masticatory muscles. In individuals who chew with great force hypertrophy of the periodontal tissue occurs and hence such individuals show great values of force. The psychological factor in the demonstration of greater forces should also not be overlooked. Parafunctional movements are associated with contraction of the muscles and teeth grinding. It has been demonstrated that bruxism increases the activity and volume of the masticatory muscles, although its influence on bite forces is controversial[19].

Nishigava et al.[20] demonstrated that forces expressed by bruxism during sleep are identical to the maximal values expressed during the day. Lamey et al.[21] showed that individuals with migraine have a greater volume of masticatory muscles and express 70% greater values of bite forces than people without the aforementioned symptoms.

There are few data on the correlation between physical muscles and values of bite forces. Jenkins considers that athletically built individuals, in spite of the general superiority of their muscles and neuromuscular control, do not express greater bite forces[22]. Linderholm & Wennström[23] did not find correlation between bite forces and general muscular strength or physical constitution in young men. Misch considers that tall, athletically built individuals express greater values of bite forces[16].

On the other hand, in this study changes in the physical weight of recruits after conditional training were taken as a variable. It was anticipated that muscular mass and consequently body weight increases after training. The average increase in body weight of 3 kg after training in 108 of the 135 recruits was statistically significant ($p<0.01$). All the recruits were included in the statistical analysis of the changed bite forces, regardless of the increase in body weight, as they had all completed the same training.

Military personnel must meet the body composition and physical fitness standard[24]. Conditional training and the quality of nutrition contribute to this. The good general and oral health of military personnel has a positive influence on the performance of conditional training and combat readiness. Musculoskeletal injuries are the leading cause of lost productivity in the armed forces. A low level of physical fitness is associated with risk for cardiovascular morbidity, even in younger individuals[25]. Greater values of bite forces in healthy individuals have been determined in relation to individuals of poor health[14]. Brajdić et al.[26] also found poor dental status in recruits and active army personnel, in spite of the fact that dental care was provided. Thus, during evaluation of the values of bite forces the condition and number of teeth should not be overlooked. According to Škec, combat readiness in the Croatian Army is low because of the need for frequent dental interventions[27].

Conclusion

In conclusion it can be said that after three months of conditional training the body mass of the recruits had increased and they expressed greater values of bite forces. However, correlation between body mass and bite forces cannot with certainty be proved, although training had an indirect influence on increased strength of the masticatory muscles, individual endurance, and consequent ability to express greater values of bite forces.

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POVEZANOST TRENINGA MLADIH ROČNIKA I VRIJEDNOSTI ŽVAČNIH SILA

S A Ž E T A K

Analiza žvačne funkcije temelj je kliničkog rada skoro u svim područjima stomatologije. Žvačne sile su izraz i mjerilo žvačne funkcije Tjelovježba djeluje na razvoj funkcijske sposobnosti, motoričkih sposobnosti organizma i formiranje poželjnih tjelesnih proporcija. Svrha ove studije je bila ispitati utjecaj fizičke aktivnosti na promjenu žvačnih sila. Zbog strogo definiranog režima prehrane i vježbanja za ispitivanje su izabrani ročnici hrvatske vojske. Ispitivanje je bilo na 135 ročnika. Mjerene su žvačne sile u području inciziva, lijevih i desnih molara, visina i težina. Prvo mjerenje bilo je na početku obuke, a drugo nakon 3 mjeseca. Od svih ispitanika 108 je dobilo na tjelesnoj težini, 12 ih je smršavilo, a 15 nije promjenilo tjelesnu težinu. Median izmjerenih žvačnih sila prije treninga bio je 291N desno, 285.5N lijevo i 205N u fronti. Nakon treninga median žvačnih sila bio je 312N desno, 313N lijevo i 216N u fronti. Statistički su dokazane veće žvačne sile nakon obuke na svim mjerenim mjestima. Pojačana aktivnost žvačnih mišića može imati jednaki utjecaj na vrijednosti žvačnih sila kao i žvačne vježbe. O povezanosti tjelesnih mišića i vrijednosti žvačnih sila malo je literaturnih podataka. Rezultati tih studija su dvojbeni. U ovom radu nije se moglo sa sigurnošću povezati promjene tjelesne mase i žvačnih sila, ali je dokazano povečanje tjelesne težine i žvačnih sila nakon obuke.