DOES THE TYPE OF SPORT ACTIVITY HAVE AN INFLUENCE ON THE ACCUMULATION OF FLUORIDE IN THE HUMAN ORGANISM?

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ABSTRACT: Athletes are a group characterized by intense and regular physical activity. Systematic exercises may lead to a number of adaptive changes in the organism which influence the skeletal system and the metabolism of some elements. The aim of the study was to determine the influence of physical activity on the level of fluoride excretion in urine. The average urine concentration of fluoride among athletes was 0.54 mg/L and 1.14 mg/L in the control group. It has been proven that physical activity plays an important role in the absorption, metabolism, and excretion of fluoride. These changes might be caused by mechanical factors, the stimulation of the skeletal system, and the adaptation of the human organism to physical exertion.

Keywords: American football; Athletes; Fluoride; Mixed martial arts; Physical activity; Tap water; Urine.

INTRODUCTION

Physical activity is an important factor in the development of health, the formation of habits or other kinds of healthy behaviour and it is also a valuable way of spending free time.[1] Systematic physical exertion, both amateur and professional, leads to a number of adaptive changes in the organism. As a result, all body systems undergo certain changes, including the increase in the activity of the respiratory and circulatory systems and the changes in the tension of the nervous system. In the muscular system, physical activity increases and accelerates many biochemical processes.[1] The increase of the mass of bone tissue and the degree of its mineralization is considered as very important and beneficial in relation to athletes' health. The direction of these changes converges with the prophylaxis of osteoporosis. The physical activity of athletes, which is characterised by regularity and intensity, may have a significant influence on the skeletal system and, hence, on the metabolism of the elements present in this tissue.

The main source of the daily intake of fluorine (F) is drinking and tap water.[2] Due to the widespread presence of F in the environment and diets, the exposure to this element can be considered as chronic. Both, chronic and acute exposure to F may be caused by the presence of the element in the diet or as an effect of the environmental pollution with F compounds. The element is characterised by specific affinity in relation to hydroxyapatite of the bone tissue $Ca_{10}(PO_4)_6(OH)_2$. It is based on the exchange of hydroxyl ions of hydroxyapatite crystals with fluoride (F ions) which build fluorohydroxyapatite or fluoroapatite. This leads to physical changes in the crystals, increasing their crystallinity, and decreasing their solubility. Among young people, about 50% of F is used to rebuild bones which confirms the close association of this element with the skeletal system.[3] The main method by which F is removed from the body is through its excretion with urine and, to a lesser extent, with faeces and sweat.[4] The influence of F on the skeletal system has been a research topic for

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many years. It has been proved that F influences bone cells and the enzymes which take part in the processes of ossification. It stimulates the activity of osteoblasts[5-8] and, by doing so, it decreases the activity of osteoclasts, which leads to the growth of bone mass.[9-11] Literature is divided as to the influence of F on the activity of alkaline and acid phosphatases.[11-13] However, there is no doubt that the element has an influence on these enzymes.[14-16] The effect of long-term activity of F is the imbalance between the formation and solubility of bone tissue, with the dominance of the formation of osteoid with delayed mineralization.[5,17-20] The significance of F influence on the skeletal system is undisputed. Depending on the doses and time of exposure, this can be a physiological influence or one that leads to disorders and pathological changes.[5-8,17-20]

However, it has to be remembered that the changes in the skeletal system may also depend on the type of sport and, hence, on the kind of physical activity (dynamic or static) and its intensity, which reflects the degree of stress put on the skeletal system. The influence of physical activity on the metabolism of F may condition the effect this element has on the organism. However, there are not enough studies describing this relation. This is why the aim of this research was to determine the influence of physical activity of various intensity (the types of sport disciplines: American football and mixed martial arts) on the level of the excretion of this element with urine.

MATERIAL AND METHODS

Examined subjects: 48 men of the Caucasian race, aged 19–43 yr, were qualified for the project. The average age was 28 yr for the studied group and 22 yr for the control group. The studied group consisted of 32 professional athletes of two sport disciplines: mixed martial arts (MMA) (n=15) and American football (n=17). The control group consisted of 16 men who did not do sport professionally. Every participant of the research issued a written consent to take part in the study and was informed of its procedures, profits, and possible side effects. The main exclusion criteria were: age under 18 yr, the occurrence of illnesses including diabetes type 1 and 2, cancer, and selective diets such as vegan or high-fat diets. Furthermore, patients who took part in the research did not take any medicine which included F as an active ingredient.

Material collection: Morning urine collected between 7 a.m. and 10 a.m. from the 48 subjects served as the study material for the research. The urine used in this study was excreted from the body directly after a night's rest which lasted at least 8 hr, with at least 4 hr accumulation of urine in the bladder. The morning collection of urine reflects metabolism of F in the body and filtration process in the kidneys, thus limiting the impact of other parameters such as diet or water intake during the day. The material was frozen at –20ºC until the realization of potentiometric analyses. Additionally, samples were taken from tap water in the place of residence of every subject. 10 mL of water were collected between 7 a.m. and 10 a.m. for the purpose of the analyses. The material was delivered by the subjects and frozen at –20ºC until the realization of potentiometric analyses.

The establishment of F content in urine and water: Sample levels of F were determined using a potentiometric ion-selective electrode (Thermo Scientific Orion, USA) on the basis of the works of Gutowska et al.[21,22] F content in urine and water was calculated on the basis of the difference of potentials measured in each sample and the concentration of the added standard. The electrode had been calibrated using standard solutions.

Statistical analysis: The statistical analysis was performed using Statistica 12.5 (Stat Soft, Poland) and Microsoft Excel 2010. The arithmetic means (AMs) and standard deviations of the AM (SDs) were calculated for each studied group. As the distribution in most cases deviated from normal (Shapiro-Wilk test), a non-parametric Mann–Whitney test was used for comparisons between groups. The Spearman's rank correlation test was used for the analyses of the correlations between F content in urine and age. The level of significance was $p \leq 0.05$.

RESULTS

The research showed that both groups of athletes were characterised by a significantly lower concentration of F in urine in comparison to the control group ($p<0.001$). The statistical analysis performed without the division into the type of the practised sport discipline also confirmed the observed difference ($p<0.001$). The average amount of F excreted with urine in the group of men who trained for American football was at the level of 0.43 mg/L, whereas in the MMA group the amount was 0.66 mg/L. The value for the control group was 1.14 mg/L (Figure, Table 1).

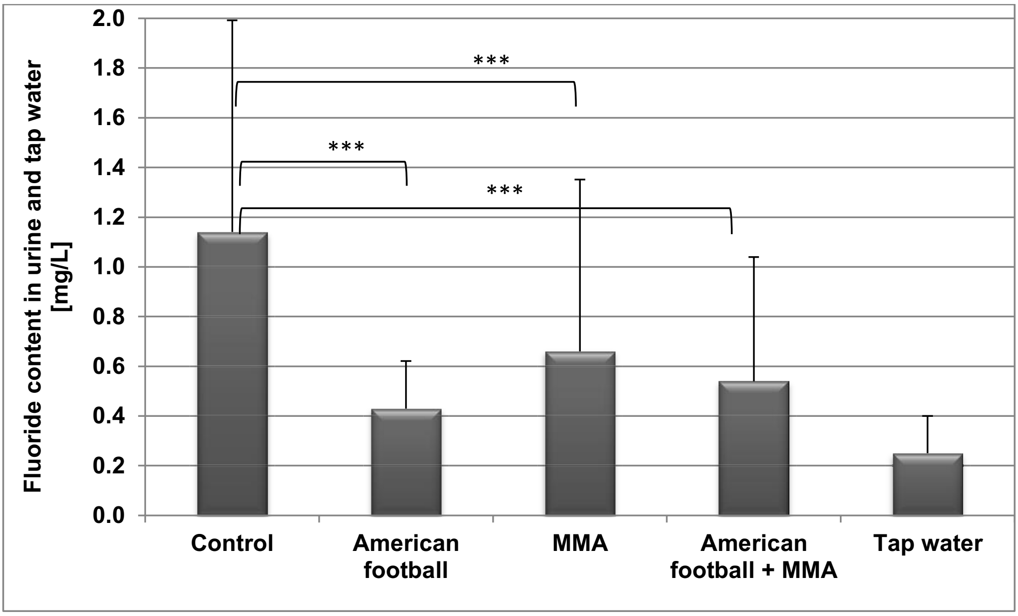

Figure. The content of fluoride in urine and water. *** p value<0.001

The analysis of the content of F in tap water did not show statistically significant differences between the studied water sources. The level of this element in water was at the average of 0.25 mg/L (Figure, Table 1).

The Spearman's rank correlation analysis did not show statistically significant dependencies between the age of the participants and the concentration of F in urine among any of the groups (Table 2).

Table 1. The content of fluoride in tap water and athletes urine [mg/L]

Sample	Group	Fluoride content [mg/L]	
Urine	Control	mean	1.14
		SD	0.85
	American football	mean	0.43
		SD	0.19
	MMA	mean	0.66
		SD	0.69
	American football + MMA	mean	0.54
		SD	0.50
Tap water		mean	0.25
		SD	0.15

Table 2. The Spearman's rank correlation analysis between the content of fluoride in urine vs. age of athletes

Group	R and p value for fluoride content in urine vs. age	
Control	R	0.32
	p value	ns
American football	R	0.38
	p value	ns
MMA	R	0.31
	p value	ns
American football + MMA	R	0.28
	p value	ns (0.067)

R: Spearman's rank correlation coefficient; ns: non-significant

DISCUSSION

This study has shown that physical activity influences the level of F removed from the body in urine. Because this element is excreted from the body mainly via kidneys, the measurement of F content in urine is an indirect method used to study F absorption by the organism.

In comparison to the control group (1.14 mg/L) whose members did not professionally practice any sport, F concentration among athletes was half as high (0.54 mg/L). The difference was statistically significant ($p<0.001$) (Figure 1), which might suggest that physical activity significantly influences the metabolism and absorption of F in the body. Furthermore, differences were observed between F concentration in urine and the type of sport practised. The level of F in urine was lower among athletes practising American football (0.43 mg/L) than MMA (0.66 mg/L), and though the difference was not statistically significant (Figure), it might suggest that the type of physical activity also has, to a certain degree, an influence on the accumulation of F in hard tissues. The training sessions in American football or MMA are based on exercises with a varying degree of strain on the organism. American football is a team game characterised by a higher and longer intensity of physical exertion, as well as the possibility of higher stimulation and strain in relation to the skeletal system due to running. The discipline is also associated with falls and attacking other players which additionally increase the strain on the skeletal system. MMA athletes are allowed to fight using a wide variety of techniques. Physical exertion in this case is intense and stamina based. However, it is shorter in comparison with American football. The strain on the skeletal system is also lower among MMA athletes.

Despite the fact that there are no studies concerning the metabolism of F among athletes, there is a lot of data on the influence of physical exertion on the skeletal system.[23-27] It was proved that the main factors that have an influence on bone mineral density (BMD) and bone mineral content (BMC) include genetic factors, the hormonal state, nutrition, and exercises.[28-30] The type of exercises and their intensity may be an important, modifiable parameter conditioning the metabolism of mineral compounds of the skeletal system. Therefore, it is important for the athletes to understand the influence of their sports discipline on their organism. Studies show that strength and stamina based training sessions influence bone density.[23,24] The changes which occur in bones as a response to the applied strain during the training may increase mineralization, inhibit the resorption of bones and activate osteoblasts from their resting state.[25] Certain studies confirm that particular types of sport influence the skeletal structure and that the determining factor is the type of the physical activity performed.[27] The research carried out among athletes practising judo, karate, and water polo showed that these people had higher values of BMD in comparison to the control groups in which the participants were of similar age but did not do sport professionally.[26] This finding is similar to those of other researchers.[31-34] The research carried out among athletes of various disciplines showed that runners were characterized by higher bone density than the control group.[35] Another study pointed to higher values of BMD among athletes whose training sessions were characterized by higher intensity of physical exertion. Furthermore, bone density increased also in the places exposed to increased physical exertion.[36,37] A possible explanation of this situation might be that, as a response to physical exertion and the stimulation of mechanoreceptors, a chemical factor is released with the ability to promote osteoblast proliferation in the area where bones might be damaged.[26] However, there is a lack of studies that would describe the influence of physical activity of athletes on the metabolism of F, the element which is significantly associated with the skeletal structure.

Water is the main source of F for the human body.[2,38] The concentration of F in tap water may be a significant factor determining the daily intake of this element.[2] F moves relatively easily through cell membranes. Even during a brief contact of water with mucous membranes or skin, the element can enter our organism.[38] Thanks to these properties, F also finds its way into vegetables, fruit, tea or fish, increasing its content in our diet.[39-41]

A part of this research was to analyze tap water from various sources from the places of residence of the athletes in order to establish if this factor has a significant influence on F excretion with urine. No statistically significant differences were observed between the analyzed samples, so this factor did not have an influence on the observed differences. Therefore, it can be concluded that physical activity was the determining factor in reference to the removal and absorption of F.

Intense physical exertion and, most of all, sport disciplines characterized by increased mechanical strain on the skeletal system are connected with the stimulation of osteoblasts, increased bone mineral density (BMD) and increased bone mineral content (BMC). The density of bones also increases in the areas which are prone to receive more significant injuries. Our study suggests that F plays an important role in increasing the density and mineralization of bones among actively training people. The situation might be related to the higher absorption of F by the organism and the possible accumulation of this element in the skeletal system. The changes might be caused by mechanical factors, the stimulation of the skeletal system, and the adaptation of the organism to physical exertion. In order to confirm and explain the mechanism of accumulation of F in bones of athletes exposed to increased physical effort, studies involving other factors are necessary. The varied diet, including water consumption, and the check of kidney function, including urinary creatinine level, are important parameters affecting the metabolism and accumulation of F in the body. Further research is necessary to fully understand the correlation between physical activity and the metabolism of F.

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