International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:8, No:2, 2014

Copper Content in Daily Food Rations Planned and Served to Students from Selected Military Academies and Soldiers Doing Compulsory Military Service in the Polish Army

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Abstract**—**The aim of the work was estimation of copper intake with the daily food rations used for alimentation of students of military high schools and soldiers doing compulsory military service in the Polish Army. An average planned copper content in daily food rations used for alimentation of students and soldiers amounted to 2.49±0.35 mg, and 2.44±0.25 mg respectively. The copper content in the daily food ration given for consumption to students amounted from 1.81±0.14 mg to 2.58±0.44 mg while daily food rations served to soldiers delivered from 2.06±0.45 mg to 2.13±0.33 mg. The copper content in the rations planned for students and soldiers alimentation was within the limits of the norms obligatory in Poland. Daily food rations given for consumption, except rations served for students, were within the limits of the recommended norms, but food rations really eaten by examined men didn't cover the requirements for copper.

Keywords**—**Copper, daily food ration, military service.

I. Introduction

HUMAN organism's demands for energy and nutritive elements delivered with food depends on many, connected with each other, factors such as age, body, and physical activity or climate conditions.

From nutritional point of view soldiers serving in the Polish Army make a very special group of people. Military service inside the country as well as abroad is usually connected with huge physical burden causing rise in energetic demands, and different climate conditions significantly influence soldiers' alimentation demands. Hence in alimentation planning and fulfilling particular attention should be paid not only on energy value and macro-elements content in daily food rations but also on proper mineral elements supply, both micro and macro-elements. Researches carried out in different armies imply that supply of mineral elements with daily food rations may not cover all the requirements [1], [2]. Loss of mineral elements, mainly with sweat excreted during trainings and performing military duty as well as small amount of microelements in food significantly increase risk of creating disturbances resulting from their insufficiencies.

Copper is an essential trace element required for the functioning all of organ systems. Because of its ubiquitous nature in many oxidation-reduction reactions, a severe deficiency of copper could have far reaching effects, including effects related to adenosine triphosphate (ATP) synthesis, iron transport, norephinefrine synthesis, connective tissue synthesis, and dismutation of superoxide anion. Fortunately, copper deficiency in humans has not been documented except in cases of genetic disorders (Menkes disease), in total parenteral solutions [3], in prolonged jejunostomy feed [4], and with high zinc consumption [5]. Copper homeostasis is maintained by balancing absorption distribution, storage, and excretion. Copper is absorbed in the upper portion of the small intestine [6], [7] at the same time its absorption from ordinary diet is running about 50%. Increased supply of iron or zinc with a diet reduces copper absorption because these elements compete for absorption place. Turnlund et al. estimated that copper absorption in adults has a set point rate of 0.8 to 1.0mg in 24 hours [8].

Exercise has been associated with an increased urinary and sweat excretion of copper. The studies available suggest that copper levels of at least 300 μg/day and as much as 1000 μg/day can be secreted under conditions of physical activity in heat and humidity [9].

Researches prove that copper content in the diets eaten by people coming from well-developed countries does not cover the daily requirements [10], [11].

Copper can have undesirable effects as well. In compliance with its chemical properties it may participate in free-radical reactions. Copper can oxidize and reduce, and at the same time catalyze the transitory reactions leading to creation of reactive oxygen forms (ROF). Processes leading to ROF generation are considered as a factor responsible for development of serious diseases such as diabetes, circulatory system diseases, cancers, neurone-degeneration diseases, or premature aging [12]. Moreover, long lasting consumption of

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food containing increased copper content is related with risk of poisoning children and infants are especially exposed to. Copper excess in human diet causes different metabolic changes, and far-distant effects are connected with changes in liver, and then kidneys, brain tissue, coronary vessels and cardiac muscle injuries. The most common effects of copper excess may be psychical problems, kidneys injuries and hypertension. Copper excess may cause anemia, disturbances in liver and respiratory system working, chronic inflammation of mucous membrane, immunity decline, nausea and vomiting [13]. Although copper impacts biological functions as a catalyst of enzyme activity - that is, it regulates iron absorption, neurotransmitter metabolism, antioxidant defense, and oxygen use - there is no clear evidence that copper status affects cognitive function and behavior. There are no previous studies that make direct correlations between soldiers' copper intake or status and their cognitive function or behavior. The cognitive and psychological impairments (e.g., sleep disturbances, short term memory loss, depression, confusion, and distraction) found in civilians with marginal copper deficits are consistent with the same problems reported in soldiers during active training and operations [14], [15]. The limited data on copper intake and status of soldiers in various types of training do not provide evidence of overt nutritional deficiencies.

The aim of the work was estimation of copper intake with the daily food rations and assessment to which degree these rations meet requirements for this microelement among students of the Air Force Academy (AFA) and Military University of Technology (MUT), and soldiers doing compulsory military service in the Polish Army.

II. Material and Methods

Material for examination consisted of daily food rations planned for alimentation and given for consumption to students and soldiers. 20 menus from the AFA, 40 from the MUT and 217 from 3 different military units (MU) were analyzed in the period of 2002-2003. The Polish FOOD 2 software calculated copper content in the daily food rations.

Analytical methods were used to estimate the actual copper supply with served daily food rations. Daily food rations were mineralized and copper content was indicated by atomic absorption spectrometry using the Pye Unicam SP 9 apparatus [16].

III. Results and Discussion

Average planned copper content in the daily food rations used for alimentation of the AFA students amounted to 2.49±0.35 mg, ranging from 2.23, to 2.82 mg. Similar copper content was planned for alimentation of MUT students. It amounted to 2.44±0.25 mg. The lowest planned copper content was 2.10 mg, the highest one 3.02 mg. An average content of examined element declared in the menus prepared for soldiers doing compulsory military service amounted to 2.59±0.37 mg (2.48-2.73 mg) in 2002 and 2.67±0.41 mg (2.27-2.65 mg) in 2003 (Fig. 1.)

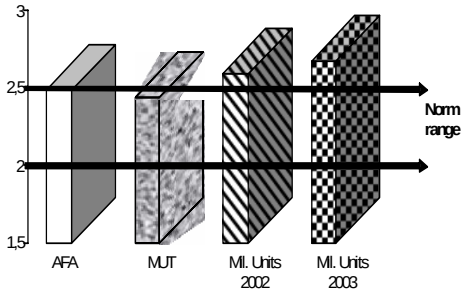

Fig. 1 Copper content in the daily food rations planned for consumption in AFA, MUT and military units (mg)

Copper content planned for daily alimentation of students and soldiers was within the limits of the recommended norm (2.0-2.5 mg) for young, physically active men [17]. Average copper content in the daily food ration given for consumption to AFA students amounted to 2.58±0.44 mg. The highest copper content was found in winter season, from December to February (2.75 mg in an average), the lowest one in May (2.30 mg). Post consumption remains i.e. not eaten parts of a meal contained 0.23±0.17 mg of copper on average. So, copper content in the daily food rations really eaten by students was 2.35±0.33 mg. This value was within the limits of the recommended in Poland norms.

Daily food rations served for consumption to MUT students contained 1.81±0.14 mg of copper on average, ranging from 1.65 mg in June to 2.07 mg in March. Post consumption remains contained 0.20±0.09 mg of copper, thus ration really eaten delivered 1.61±0.18 mg of copper. Taking into consideration norms for copper, obligatory in Poland, it was found that food rations served to students and especially rations really eaten did not meet the requirements. These values were lower than recommended norms.

Average copper content in the daily food rations given for consumption to soldiers doing compulsory military service in 2002 was 2.13±0.33 mg, but in 2003 it was 2.06±0.45 mg. Because in examined military units post consumption remains were not collected, to be in accordance to approved methodology, copper content was reduced by 10%, thus rations really eaten contained 1.92±0.2 mg of copper in 2002 and 1.86±0.2 mg in 2003.

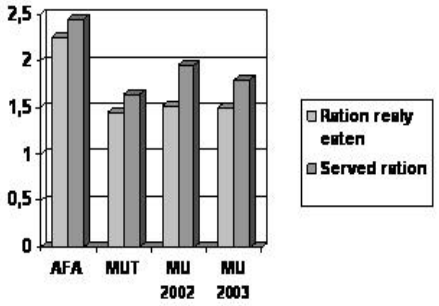

Fig. 2 Copper content in the daily food ration given for consumption and really eaten in examined academies and military units (mg)

Providing that average copper content in the daily food rations given for consumption to soldiers doing compulsory military service was within the bottom limit of the norm, in so much copper content in the ration really eaten didn't reach the limit.

Examined food rations really eaten by students from the AFA met from 117.0% to 94.0% of the recommended norm. Rations eaten by the MUT students met 80.5%-64.4% of the norm and eaten by soldiers 96.0%-76.8% of it in 2002, and 93.0%-74.4% in 2003.

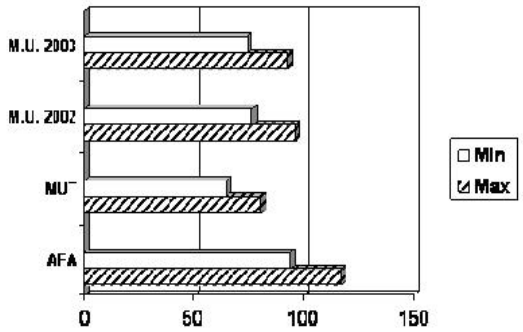

Fig. 3 Meeting the requirements for copper by the daily food rations really eaten (%)

It was found that the intake of copper in soldiers' daily food rations amounted 3.31 ± 0.5g [18].

The study by the military reported that under hot conditions sweat, skin and hair copper losses may increase several fold from the average basal amount of 250 µg/day to up to 1600 µg/7 hour at 37°C. It is not known, however, whether such high increased losses are sustained. There are reports of higher copper losses in the heat (up to 1600µg/7 hour at 37.8°C). The Committee on Military Nutrition Research concludes that these losses need to be considered and recommends an upper limit of 1600µg/day in the ration. Levels above this might result in interferences with the bioavailability of other nutrients [19].

Results of many years' researches on mineral elements content, including copper, in the daily food rations really eaten by Polish soldiers presented low level of this element that didn't reach the recommended limits. Results of examinations of copper supply with the daily food rations that were carried out in 1996, revealed the copper content in amount of 0.95 mg [20], while researches carried out in 1989/90 shown that copper content in the rations was 1.79±0.5 mg, and in 2001/02 - 1.30±0.30 mg [21]. Copper deficiencies were found in the rations served to medical students from the Medical Academy in Warsaw. Copper content in the food rations of male students amounted to 1.39±0.49 mg, making only 69.5% of the recommended norm [22]. Low copper consumption among students was found by Oledzka et al. [23]. Authors presented copper consumption among students at 1.35±0.7 mg, what met 61% of the recommended norm on the safe level.

Surveys carried out in Poland revealed that copper supply with a common Pole's diet amounted to 1mg in 2003 and was lower by 50% that recommended amount [24]. Researches carried out by Szponar et al. [24] revealed that diet of Polish men aged 19-25, living in the cities delivered 1.76±0.60 mg of copper, while diet of men living in the country delivered 1.88±0.64 mg of it.

In nineties, the copper content in the diets of world population was different and depended on copper content in particular ingredients of eaten rations. It was found that Belgian diets contained 1.3mg, Canadian 1.9-2.1mg, Danish 0.3-0.4mg, French 2.0-2.5mg, British 0.9-1.5mg, Spanish 5.6 mg, Swedish 1.3-3.3mg and American 0.4-3.0mg of copper [25].

IV. Conclusions

1. Copper content in the rations planned for soldiers and military academies students' alimentation was within the limits of the norms obligatory in Poland, recommended for alimentation of young men whose work is related with huge physical activity.
2. Daily food rations given for consumption, except rations served in the MUT, were within the limits of the recommended norms.
3. Food rations really eaten by examined men didn't cover the requirements for copper.
4. Because of copper deficiency in really eaten food rations, special attention should be paid on proper planning and fulfillment of alimentation in the army, taking into consideration raw materials and other products delivering adequate amounts of copper.

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