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Magnesium, Copper, Zinc, Iron, and Chromium Levels in Sweat of Boxers

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Aim: 21 male cross-country boxers were studied to evaluate sweat copper, zinc, iron, magnesium and chromium loss in sweat.
Materials and methods: Sweat samples were collected at 50% VO_{2peak} for 30 min while boxers training at room temperature (~27 ºC, RH=51%) by the whole body method, using polyethylene bags. All samples were analyzed by atomic absorption spectrometry.
Results: The mean concentrations of copper, zinc, iron, magnesium and chromium were found to be 37.7±5.4 μg/dl, 44.4±5.9 μg/dl, 113±9 μg/dl, 76.4±9.4 mg/dl and 9.8±0.6 μg/dl respectively. It appears that substantial quantities of trace elements are excreted in the sweat of those sweating during the training.
Conclusion: For sportsmen, adequate amounts of these minerals are required for physical training and maximum performance. Our results suggest that excretion of trace elements by sweating induces trace element decrease. Mineral elements, including magnesium, zinc, copper, iron and chromium supplementation may be important to ensure good health, consequently optimal physiological function and for maximum performance for the sportsmen.

Key Words: Magnesium, Copper, Zinc, Iron, Chromium, Sweat, Atomic Absorption Spectrophotometer

Boksörlerde Ter Magnezyum, Bakır, Çinko, Demir ve Krom düzeyleri

Amaç: 21 erkek milli boksör üzerinde yapılan çalışmada, ter bakır, çinko, demir, magnezyum ve krom seviyeleri değerlendirildi.
Materyal ve metod: Ter örnekleri %50 VO_{2tepe} içinde 30 dakika süre ile antrenman sırasında oda ısısında (~27 ºC, RH=51%) total vücut metoduyla polietilen tüpler içine toplanmıştır. Bütün örnekler atomik absorbsiyon spektrofotometrede analiz edildiler.
Bulgular: Sonuçlar sırasıyla, bakır 37.7±5.4 μg/dl, çinko 44.4±5.9 μg/dl, demir 113±9 μg/dl, magnezyum 76.4±9.4 mg/dl ve krom 9.8±0.6 μg/dl olarak elde edilmiştir. Bu sonuçlar, antrenman sırasında sporculardaki ter kaybıyla birlikte oldukça fazla miktarda elementin vücuttan atıldığını göstermektedir.
Sonuç: Bu çalışmanın sonuçları terlemeyle atılan elementlerin organizma içinde element konsantrasyonunda bir düşüşe sebep olacağını göstermektedir. Sağlıklı bir yaşam için diyetle magnezyum, çinko, bakır, demir ve krom gibi minerallerin yeterli miktarda alınmasının önemli olduğu gibi, sporcular için optimal fizyolojik fonksiyonlar ve maksimum performans için de bu gereklidir.

Anahtar Kelimeler: Magnezyum, Bakır, Çinko, Demir, Krom, Ter, Atomik absorbsiyon Spektrofotometre

Sweating is the body's defense against excessive rise in core temperature. The volume and composition of sweat is, however, quite variable. Sweat contains not only water but also electrolytes. The most prevalent electrolyte in sweat is sodium. There is a lesser amount of potassium. Depending on the total volume of sweat loss, the quantity of loss of other elements varies. Today we know that a body, which cannot perspire, because the passage of sweat is impeded one way or another, accumulates poisons and dies within a few hours. [1,2] The determination of the metal ions in biological materials such as blood, urine hair and nail are of increasing interest of many clinical and research laboratories. Sweat is also an important biological material for the determination of metal ions and element status. [3-5]

Mineral elements, including magnesium (Mg), Zinc (Zn), copper (Cu), iron (Fe) and chromium (Cr) are required by the body in modest amounts for the maintenance of health and for the development of optimal physiological

function. For sportsmen, adequate amounts of these minerals are required for physical training and performance. Studies of sportsmen during training, as compared to non-training control subjects, indicate the potential for increased losses of minerals in sweat. Some studies report sub-optimal intakes of minerals, particularly among sportsmen who are actively attempting to lose weight to meet standards for competition. However, most sportsmen consume diets that provide adequate amounts of minerals to meet population standards. Sportsmen should be counseled to consume foods with high nutrient density rather than to rely on mineral supplements. General use of mineral supplements can alter physiological function and impair health.[4,6-14]

Mg status is adequate for most sportsmen, however it is not clear whether Mg supplements can enhance performance.[4,8,11] It has been shown that Mg may be lost in sweat.[15] Sportsmen may have a Zn deficiency induced by poor diet and loss of Zn in sweat and urine. Most of the body Zn content is present in muscle (%60) and bone (%30). Limited data exist on the relationship of performance and Zn status. Widespread deficiencies in Cu have not been documented, and there are also limited data to suggest that Cu supplementation will enhance performance. [4,6,8,9,10,12,13,16]

Because of the low intakes of Cr for the general population, there is a possibility that sportsmen may be deficient.[1] Exercise may create a loss in Cr because of increased excretion into the urine and sweat.[1,8,16,17] Many sportsmen, are Fe depleted, but true Fe deficiencies are rare.[7,8,14]

Kayseri is in the middle Anatolia region of Turkey and has approximately 500.000 populations. According to our literature search, no report has been published about the sweat Cu, Zn, Fe, Mg and Cr levels of sportsmen living in Turkey. In the present study, the sweat Cu, Zn, Fe, Mg and Cr concentrations of twenty-one healthy adult sportsmen (boxers) aged between 19 and 28 and average weight of 66 kg living in Kayseri-Turkey were determined by atomic absorption spectrometry.

Sweat samples were collected at 50% VO_{2peak} for 30 min while boxers training at room temperature (~27 ºC, RH =51%) by the whole body method, using polyethylene bags.

MATERIAL AND METHODS

The present study was carried out in collaboration with the Department of Biochemistry and Department of Parasitology, Medical Faculty, Kayseri, Turkey. None of the subjects (boxers) were smokers and had any known pathologies at the time of sampling. The subjects were informed of the procedures to be used in the study and signed an informed consent statement. Because they were in the sport camp, each subject naturally kept a food diary for 1 week prior to the sample collection.

Prior to exercise, subjects thoroughly washed with liquid soap and dried with towels that had been rinsed in water in order to prevent contamination of the sweat samples. The subjects were informed of the procedures to be used in the study and signed an informed consent statement. The subjects were weighted in their training clothes. Subjects consumed 250 ml of water prior to exercise.

Sweat samples were collected at 50% VO_{2peak} for 30 min while boxers training at room temperature (~27 ºC, RH =51%) by the whole body method using polyethylene bags and were stored in glass tubes, which had been previously cleaned with hydrochloric acid. Briefly; a pre-weighted polyethylene arm bag was placed on one arm and secured with and elastic band at the detoid tuberosity for 30 min. Arm bag sweat volume was measured in grams using a digital scale. Total body sweat rate was calculated from change in body mass measured and corrected for fluid intake and urine volume. Sweat samples were stored at 4 °C in de-ionized tubes until analysis.

The samples were centrifuged at 3500xrpm for 15 min, and the supernatant was filtered through a Whatman 542 filter to remove cellular debris prior to analysis, and the supernatant was used to determine the Cu, Zn, Fe, Mg and Cr contents of the sweat.[18] In addition, to eliminate the possibility of intestinal parasites could be effective on element absorption all subjects were examined for intestinal parasites. For this, wet mount preparations in 0,9 % NaCl, diluted Lugol's iodine and flotation technique in saturated saline solution were used and parasite negative subjects were selected for the study.[19] All chemicals used were of super pure grade unless stated otherwise; aqueous reagents were prepared in double-distilled de-ionized water. Cu, Zn, Fe, Mg and Cr standards were provided from Aldrich chemical company. To prepare working standards, serial dilutions were made with double-distilled de- ionized water. Cu, Zn, Fe, Mg and Cr concentrations of sweat samples were determined by Zeeman atomic absorption spectrometry (Hitachi Z-8000 Model). Sweat was prepared by dilution with de-ionized double-distilled water. We matched the viscosity

Table 1. Sweat Cu, Zn, Fe, Mg and Cr levels in healthy sportsmen.

	Elements						
	Age (Mean ± SD)	Weight (Mean ± SD)	Cu (μg/dl) (Mean ± SD)	Zn (μg/dl) (Mean ± SD)	Fe (μg/dl) (Mean ± SD)	Mg (mg/dl) (Mean ± SD)	Cr (μg/dl) (Mean ± SD)
Boxers	23.2±0.7	66.2±3.2	37.7±5.4	44.4±5.9	113±9	76.4±9.4	9.8±0.6

of the standard solutions to viscosity of diluted sweat by adding an appropriate amount of glycerol.[20] The total levels of Cu, Zn, Fe, Mg and Cr in the samples were determined by regression analysis of the sample absorption data on the standard curve.

RESULTS

Sweat samples of 21 healthy subjects aged between 19 and 28 from Kayseri, Turkey were analyzed for Cu, Zn, Fe, Mg and Cr by Zeeman atomic absorption spectrometry. The sweat levels of Cu, Zn, Fe, Mg and Cr are presented in Table 1. The mean (±SD) Cu, Zn, Fe, Mg and Cr levels were 37.7 (±5.4) μg/dl, 44.4 (±5.9) μg/dl, 113 (±9) μg/dl, 76.4 (±9.4) mg/dl and 9.8 (±0.6) μg/dl respectively.

DISCUSSION

The minerals Cu, Zn, Fe, Mg and Cr are directly involved in maintaining and regulating many of physiological processes, especially those involved in normal carbohydrate, fat and protein metabolism and the ultimate formation of usable energy. Therefore, it is important to establish whether exercise training alter the levels of these trace elements, and to determine the overall effects or of exercise on nutritional status and physical performance.

This paper examines the extent of mineral loss in one of the most effort requining sports (boxing), and challenges therefore accordingly whether supplements of these minerals are necessary to enhance performance. Macromineral of Mg, and trace minerals of Zn, Cu, Cr, and Fe are tested. The same minerals were also tested in sweat samples from the wrestlers (submitted for publication).

It is known that Mg status is adequate for most sportsmen, and it is not clear whether Mg supplements can enhance performance. Serum Mg concentration, although commonly used to measure Mg nutriture in nutritional surveys of physically active persons, is a relatively insensitive index of marginal Mg status. Indeed, its insensitivity generally rules out a conclusion that physical activity does not adversely affect Mg status. On the other hand, we know that serum Mg is in the normal range when intake is adequate, irrespective of physical activity. Another route of Mg loss during exercise is sweat and cellular exfoliation. Men performing controlled work for 8 h on ergocycles in the heat (100°F) lost 15.2–17.8 mg/dl in sweat. The loss of Mg by sweat in our study was 76.4 mg/dl. Mg losses in sweat accounted for 21% of daily Mg intake and 10–15% of total Mg excretion (feces, urine, and sweat). Although the results for Mg loss looked a little bit higher than others, which might be related to the nutritional dietary .[4,8,11] Sportsmen may have a Zn deficiency induced by poor diet and loss of Zn in sweat and urine. Limited data exist on the relationship of performance and Zn status. We found that 44.4 μg/dl loss of Zn in sweat.[4,6,8,9,10,12,13,16] Widespread deficiencies in Cu have not been documented, and there are also limited data to suggest that Cu supplementation will enhance performance.[4] Our study showed that 37.7 μg/dl loss of Cu in sweat. Because of the low intakes of Cr for the general population, there is a possibility that sportsmen may be deficient. Exercise may create a loss in Cr because of increased excretion into the urine and sweat. In other words, exercise results in a marked mobilization of Cr into circulation, while Zn and Cu levels have been shown to either remain stable or increase. However some studies showed that exercise also results in large increases in excretion of Cr, Zn and Cu.[1,8,9,16,17] Urinary Cr excretion has been shown to increase on an exercise day compared with a rest day, while increased Zn losses occur in urine and sweat and increased Cu losses occur in urine, and feces.[1,9,10,13] Our study also showed that Cr loss was to be the minimum with 9.8 μg/dl as compared to the other minerals. Many sportsmen are Fe depleted, but true Fe deficiencies are rare. Fe depletion does not affect exercise performance. Fe supplements have not been shown to enhance performance except where Fe deficiency anemia exists.[7,8,14] Fe lost in sweat was found to be 113 μg/dl with the second highest level in all five minerals.

It is known that poor diets are perhaps the main reason for any mineral deficiencies found in sportsmen, although in certain cases exercise could contribute to the deficiency. This study showed that

losses of some minerals especially Mg and Cr in sweat are also in important quantities. These observations suggest that excretion of trace elements by sweating induces trace element decrease. Therefore, high energy consuming sports (this could also be generalized for workers who work in a hot environment and doing hard labor) and sweat much habitually should ingest adequate amounts of trace elements. When exercise-enhanced mineral losses are coupled with dietary intakes below the recommended levels, which are common, place for both sedentary and exercising individuals, the nutritional status and overall health of exercising individuals may be sub-optimal. Therefore, mineral supplementation can be important to ensure good health, accordingly for maximum performance of the sportsmen.

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