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NUTRITIONAL STATUS ZINC IN ADOLESCENT JUDO ATHLETES

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ABSTRACT

Introduction: This study evaluated the nutritional status regarding zinc judo teenagers. Material and Methods: The study involved 25 athletes in judo and a control group (n = 27) of male adolescents, aged between 14 and 19 years. Were carried out assessment of body composition, food intake, plasmatic and erythrocytary zinc. Results: The mean value of zinc in plasma were 72.9 ± 14.6 µg/dL and 71.3 ± 15.9 µg/dL for the athletes and control, respectively. The mean of erythrocytary zinc was 43.1 ± 11.3 µg Zn/gHb for Judokas and 41.2 ± 8.6 Zn/gHb for the control group (p> 0.05). Discussion: The results of this study show a high percentage of adolescents with low concentrations of zinc in plasma and high concentrations in erythrocytes; this reinforces the need for further studies to make it clear which mechanisms are involved in metabolic aspects as a result of physical exercise.

KEY- WORDS:

Exercise, nutritional status, zinc

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**ESTADO NUTRICIONAL RELATIVO AO ZINCO EM ATLETAS JUDOCAS ADOLESCENTES**

**RESUMO**

**Introdução:** Este estudo avaliou o estado de nutrição relativo ao zinco em judocas adolescentes. **Material e Métodos:** O estudo envolveu 25 atletas de judô e um grupo controle (n=27) do gênero masculino, na faixa etária entre 14 e 19 anos. Foi realizada avaliação da composição corporal, do consumo alimentar, zinco plasmático e eritrocitário. **Resultados:** Os valores médios de zinco nas dietas dos adolescentes foram de 20,3 ± 11,7 mg/dia para os atletas e 10,9 ± 3,9 mg/dia para o grupo controle. As médias das concentrações de zinco no plasma foram de 72,9 ± 14,6 µg/dL e 71,3 ± 15,9 µg/dL para atletas e controle, respectivamente. A média de zinco no eritrócito foi de 43,1 ±11,3 µg Zn/gHb para os judocas e 41,2 ± 8,6 Zn/gHb para o grupo controle (p>0,05). **Discussão:** Os resultados desse estudo mostram um percentual elevado de adolescentes com concentrações baixas de zinco no plasma e elevadas nos eritrócitos, o que reforça a necessidade de mais estudos desse natureza que permitam elucidar os mecanismos envolvidos nos aspectos metabólicos resultantes do exercício físico.

**PALAVRAS-CHAVE**

Exercício físico, estado nutricional, zinco

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**ESTADO NUTRICIONAL RELATIVO AL ZINC EN ATLETAS JUDOCAS ADOLESCENTES**

**RESUMEN**

**Introducción:** Este estudio evaluó el estado de nutrición relativo al zinc en judocas adolescentes. **Material y Métodos:** El estudio envolvió 25 atletas de yudo y un grupo control (n=27) del género masculino, en la faixa etaria entre 14 y 19 años. Fue realizada evaluación de la composición corporal, del consumo alimentar, zinc plasmático y eritrocitario. **Resultados:** Los valores medios de zinc en las dietas de los adolescentes fueron de 20,3 ± 11,7 mg/día para los atletas y 10,9 ± 3,9 mg/día para el grupo control. Las medias de las concentraciones de zinc en el plasma fueron de 72,9 ± 14,6 mg/dL y 71,3 ± 15,9 mg/dL para atletas y control, respectivamente. La media de zinc en el eritrocito fue de 43,1 ±11,3 mg Zn/gHb para los yudocas y 41,2 ± 8,6 Zn/gHb para el grupo control (p>0,05). **Discusión:** Los resultados de ese estudio muestran un porcentaje elevado de adolescentes con concentraciones bajas de zinc en el plasma y elevadas en los eritrocitos, lo que refuerza la necesidad de más estudios de esa naturaleza que permitan elucidar los mecanismos envueltos en los aspectos metabólicos resultantes del ejercicio físico.

**PALABRAS-LLAVE**

Ejercicio físico, estado nutricional, zinc

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**INTRODUCTION**

Physical activity promotes various physiological changes, and cardiovascular and respiratory adjustments are necessary to compensate and maintain the effort deployed. During exercise, there is an increase in energetic metabolism with excessive formation of reactive oxygen species (ROS). These species may contribute to tissue and cellular damage, predisposing an athlete to musculoskeletal injury and performance impairment.\(^1\)\(^,\)\(^2\)\(^,\)\(^3\)

Several micronutrients play an important role in these mechanisms, including zinc, which participates in the structure of the superoxide dismutase enzyme, essential for the normal function of the endogenous antioxidant system, and a potent stabilizer of cell membranes, structural proteins and cell signaling.\(^4\)\(^,\)\(^5\)

Zinc is one of the most important minerals for the metabolism. Among its biological functions, this element is a cofactor of over 300 metaloenzymes, and plays a part in the catalytic activity of several enzymes, such as carbonic anhydrase, alcohol dehydrogenase, alkaline phosphatase, enzymes involved in the metabolism of carbohydrates, lipids and proteins.\(^6\)\(^,\)\(^7\) Some of these enzymes are involved in the antioxidant defense system during physical exercise, for example, superoxide dismutase.\(^8\)

Several studies have shown changes in the compartmentalization of zinc in athletes, with values of this mineral in rather controversial biochemical parameters. Studies have shown low, normal or high concentrations of zinc in the plasma, serum and erythrocytes of athletes, which seem to be dependent on the type of sport and the period that biological material is collected for analysis of the mineral.\(^9\)\(^,\)\(^10\)

The results of previously conducted research on athletes who perform anaerobic activity show high concentrations of zinc in plasma soon after completion of intense exercise. This has been attributed to its rapid extravasation from muscle tissue to the extracellular fluid.\(^11\) However, the literature has also demonstrated a further reduction of the mineral in this compartment because of its redistribution to the erythrocytes and the liver by means of circulating interleukins, which
may compromise physiological functions, such as the antioxidant defense system\textsuperscript{12, 13}.

Data on the compartmentalization and the mechanisms involving this trace element and the enhancement of physical performance are still scarce and rather controversial, considering the biochemical and metabolic changes of zinc as a result of physical exercise. Therefore, knowledge about the biochemical parameters for zinc will help to clarify the nutritional status of this mineral in athletes.

\section*{MATERIAL AND METHODS}

The study was approved by the Ethics Committee of the Federal University of Piauí, with opinion No. 12/08, CAAE (Certificate to Ethics Assessment) No.: 0012.045.000-08.

A cross-sectional case-control study was carried out, with 25 professional judo male athletes aged between 14 and 19 years old, who have regularly trained for over a year as part of the Piauí Judo team. The athletes trained for a mean time of 2 hours per day, three times a week. The control group consisted of 27 males, with similar characteristics to the experimental group in terms of age, education and socio-economic status, but they did not practice physical exercise.

To take part in the study, participants had to meet the following inclusion criteria: non-smokers, athletes who have been training for more than 1 year, no use of vitamin-mineral supplementation and/or use of other drugs, and no medical conditions that could interfere with the assessment of nutritional status of zinc.

\subsection*{Anthropometric parameters e bioelectrical impedance}

Body Mass Index was calculated using measures of weight and height. The results were compared with the reference values proposed by the World Health Organization\textsuperscript{14}.

The assessment of the body composition of the participants was carried out using bioelectrical impedance analysis (BIA).

\subsection*{Dietary Intake Assessment}

The dietary intake of zinc was obtained from a three day dietary record, and the nutritional analysis was conducted using NutWin software version 1.5. The Estimated Average Requirement (EAR) reference values for zinc were 8.5 mg/day for males\textsuperscript{15}.

\subsection*{Collection of biological material}

Samples of 10 mL of blood were collected in the morning, between 7 and 9 o’clock, after individuals had fasted for at least 12 hours. The athletes had not engaged in any physical exercise for at least 24 hours. The blood was placed in a glass tube containing 30% sodium citrate as an anticoagulant (10mL of blood) for analysis of zinc.

\subsection*{Determination of Zinc in the Plasma and the Erythrocytes.}

The plasma was separated from whole blood by centrifugation at 3000 x g for 15 minutes at 4°C. Two aliquots of each plasma sample were diluted 1:4 with Milli-Q \textsuperscript{®} water and aspirated directly into the flame of the instrument. Tritizol \textsuperscript{®} (Merck), prepared by dilution with Milli-Q \textsuperscript{®} water with 3% glycerol at 0.1, 0.2, 0.3, 0.5 and 1.0 mg / mL dilutions was used as standard.

For the separation of erythrocytes, the erythrocyte mass obtained from the blood was rinsed three times with 5mL of a 0.9% saline solution, homogenized by inversion and centrifuged at 10,000 x g for 10 minutes (SORVALL\textsuperscript{®} RC-SB) at 4 oC and the supernatant was discarded. After the last centrifugation, the saline was aspirated and the mass of erythrocytes extracted with micropipette was placed in demineralized “eppendorf” tubes, and stored at -20 oC for analysis of zinc and hemoglobin. To express the results in terms of mass zinc/mass of hemoglobin (µg/g Hb), an aliquot of 20µL of erythrocyte lysate was diluted in 5mL of Drabkin solution and measured by the cyanmethaemoglobin method\textsuperscript{16}. The analysis of zinc in plasma and erythrocytes was carried out using atomic absorption spectrophotometry\textsuperscript{17}. Tritizol was prepared by dilution in Milli-Q water at concentrations of 0.1, 0.2, 0.3, 0.5 and 1.0 µgZn / mL and used as standard.

\subsection*{Sports Performance Parameters}

To determine the physical fitness of adolescents participating in the study, maximum oxygen consumption (VO\textsubscript{2max}) was assessed directly through an ergoespirometric test carried out on a treadmill. The maximum oxygen consumption (VO\textsubscript{2max}) was measured with the VO\textsubscript{2000} gas analyzer (Medgraphics), coupled to a microcomputer, equipped with: the Elite software produced by Micromed, a nose clip, disposable razor blades, disposable sandpapers, and 70 \% GL alcohol.

The ergometer used for the ergoespirometric tests was an electric Inbrasport treadmill model Super ATL.
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The ramp protocol was used to carry out the test because it allows a better identification of anaerobic threshold and higher levels of VO$_{2\text{Max}}^{\text{18}}$. The test was applied until the individual reached a state of exhaustion, where it was then finalized and rated as a maximum test.

**Statistical Analysis**

The data were analyzed using the statistical program SPSS 10.0 for Windows. For the variables of normal or approximately normal distribution, parametric tests were applied such as the Student’s t-test to assess the equality of means, assuming a significance level of $p < 0.05$.

**RESULTS**

The study was conducted with 25 Judokas aged between 14 and 19 years old, male, with a mean age $16.6 \pm 1.3$. The control group consisted of 27 male adolescents, who do not take part in any kind of physical activity, with mean age $15.6 \pm 1.4$ years. There was no statistical difference in the age of individuals participating in the study ($p<0.05$).

The results of anthropometric parameters and bioelectrical impedance are shown in table 01. Differences were statistically significant ($p<0.05$) in relation to weight, BMI, percentage body fat, lean weight and fat mass in groups.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Athletes Mean ± SD</th>
<th>Control Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (Kg)</td>
<td>$68.7^* \pm 15.9$</td>
<td>$57.9^* \pm 8.9$</td>
</tr>
<tr>
<td>Height (m)</td>
<td>$172.0 \pm 7.9$</td>
<td>$168.4 \pm 7.9$</td>
</tr>
<tr>
<td>BMI (Kg/m$^2$)</td>
<td>$23.0^* \pm 3.5$</td>
<td>$20.3^* \pm 2.5$</td>
</tr>
<tr>
<td>PF (%)</td>
<td>$12.3^* \pm 5.2$</td>
<td>$19.3^* \pm 6.4$</td>
</tr>
<tr>
<td>LM (Kg)</td>
<td>$59.7^* \pm 10.1$</td>
<td>$49.8^* \pm 22.1$</td>
</tr>
<tr>
<td>FM (Kg)</td>
<td>$9.0^* \pm 7.0$</td>
<td>$19.3^* \pm 6.4$</td>
</tr>
</tbody>
</table>

* Values significantly different between the groups of athlete and control, Student’s t-test ($p <0.05$).

The maximum oxygen consumption (VO$_{2\text{Max}}$) of the adolescents participating in the study are shown in table 02. The values of VO$_{2\text{Max}}$ show a significant difference between groups, being higher for the group of athletes ($p < 0.05$).

<table>
<thead>
<tr>
<th>(VO$_{2\text{Max}}$)</th>
<th>Athletes Mean ± SD</th>
<th>Control Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen (mL/kg.min)</td>
<td>$41.6^* \pm 7.3$</td>
<td>$24.0^* \pm 7.1$</td>
</tr>
</tbody>
</table>

* Values significantly different between athletes and control group, Student’s t-test ($p <0.05$).

The analysis of the diets consumed by the patients did not show significant difference ($p>0.05$) regarding the carbohydrate or protein intake between the groups. However, there was a statistically significant difference ($p<0.05$) regarding fat intake, which was higher in the experimental group (Table 03).

Table 04 shows the concentration of zinc found in the adolescents’ diets. The values show a higher zinc intake by athletes when compared with the control group ($p < 0.05$).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Athletes Mean ± SD</th>
<th>Control Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc (mg/day)</td>
<td>$20.3^* \pm 11.7$</td>
<td>$10.9^* \pm 3.9$</td>
</tr>
</tbody>
</table>

Reference values for zinc intake: EAR = 8.5 mg / day [INSTITUTE OF MEDICINE, 2001]

* Values significantly different between athletes and control group, Student’s t-test ($p <0.05$).
The concentrations of plasmatic and erythrocytary zinc, revealed no significant difference between groups (p > 0.05), and the means of the groups were within the parameters of normality (Table 05). Dividing the judo athletes in weight category (<60kg and > 60kg), according to table 06, there was no significant difference between the zinc concentrations of plasma and erythrocyte.

**Table 05** – Mean values, standard deviations, minimum and maximum values of plasma and erythrocyte zinc concentrations in adolescent athletes and control group.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Athletes</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean ± SD</td>
<td>minimum</td>
</tr>
<tr>
<td>Plasma (µg/dL)</td>
<td>72.9 ± 14.6</td>
<td>50.0</td>
</tr>
<tr>
<td>Erythrocyte (µg Zn/gHb)</td>
<td>43.1 ± 11.3</td>
<td>24.5</td>
</tr>
</tbody>
</table>

Plasma reference values: 70-110 µg/dL (GIBSON, 1990)
Reference values for erythrocyte: 40 - 44 µg Zn /g Hb (GUTHRIE; PICCIANO, 1994)
There was no statistical difference between groups, Student’s t-test (p > 0.05).

**Table 06** – Mean values, standard deviations of plasma and erythrocyte zinc concentrations in adolescent athletes with > 60kg and <60kg.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Athletes &gt;60Kg</th>
<th>Athletes &lt;60Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Plasma (µg/dL)</td>
<td>71.9 ± 14.2</td>
<td>75.7 ± 16.2</td>
</tr>
<tr>
<td>Erythrocyte (µg Zn/gHb)</td>
<td>45.36 ± 11.2</td>
<td>37.6 ± 10.5</td>
</tr>
</tbody>
</table>

Plasma reference values: 70-110 µg/dL (GIBSON, 1990)
Reference values for erythrocyte: 40 - 44 µg Zn /g Hb (GUTHRIE; PICCIANO, 1994)
There was no statistical difference between groups, Student’s t-test (p > 0.05).

The results of zinc concentrations in plasma and erythrocytes were also expressed in relation to the distribution of adolescents who were in the range of reference values. Regarding the frequency of the values of plasmatic zinc, it was found that 52% of athletes and 43% of the control group had concentrations of the mineral below the normal values and 48% of the athletes and 57% of the control group had values within normal limits and no one had zinc concentrations above the upper limit of reference, as shown in GRAPH 01.

Analyzing the frequency of the values of erythrocytary zinc (GRAPH 02), it was found that 16% of the athletes and 26% of participants in the control group had concentrations within the normal range; 38% of athletes and 48% of the control group had values lower than normal, and 46% of athletes and 26% of the control group had values higher than normal.
DISCUSSION

In this study, analyses were carried out of zinc concentrations in plasma and erythrocytes in adolescent Judo athletes and sedentary individuals. The mean values of zinc found in plasma in both groups were within the normal range without significant differences \((p>0.05)\). These results are consistent with those demonstrated in studies by Koury et al.\(^{15,20}\) made with judo athletes, after measuring plasmatic zinc concentration 24 hours after completing physical exercise.

Scientific literature is very scarce regarding data from research conducted on judo athletes obtained 24 hours after completing physical exercise. Most studies have been devoted to investigation of changes in the metabolism of zinc in a more acute phase, such as immediately after physical activity. According to some researchers, the increase of zinc in plasma, found in the initial moments after exercise, may be due to its leakage from the muscle tissue towards the extracellular fluid, and it could be normalized within 24 hours after the completion of exercise\(^{21}\). Therefore, it should be emphasized that the collection of biological material for analysis of zinc in this study was conducted 24 hours after exercise, which probably contributed to the lack of statistically significant differences between the evaluated groups.

Another important aspect to be highlighted concerns the total consumption of oxygen during physical activity. In this context, it is worth highlighting that anaerobic activity, unlike aerobic exercise, has an insignificant effect on oxygen consumption \(\text{VO}_{2\text{ max}}\). Judo, for example, is a sport that displays characteristics of intermittence, and therefore requires supra-maximal effort, with breaks for recovery, favoring the anaerobic lactic metabolism\(^{23,24}\).

However, although oxygen consumption by judo athletes is not relevant, it is capable of generating free radicals that can promote changes in the metabolism of zinc. The results of this study showed that adolescent Judokas had higher \(\text{VO}_{2\text{ max}}\) values when compared with the control group \((p<0.05)\). Similarly, the study by Barros Neto et al.\(^{25}\) also found higher consumption of \(\text{VO}_{2\text{ max}}\) among judo athletes, when compared with sedentary individuals.

Although oxygen consumption was higher among the athletes surveyed in this study, this does not seem to have contributed to the plasma concentrations of zinc, because there was no statistically significant difference between groups \((p>0.05)\). Differently, in a study by Arikan et al.\(^{26}\) observed reduced plasma zinc levels in weightlifters when compared with the control group \((p<0.01)\).

An important fact to be discussed concerns the influence of dietary zinc on the biochemical parameters of zinc assessment. The diets of both groups evaluated in this study contained high concentrations of the mineral, because the values of Estimated Average Requirement (EAR) for zinc of the individuals assessed, according to the new nutritional recommendations were 8.5 mg/day, which may have contributed to the average concentrations found in plasma and erythrocytes\(^{15}\).

The analysis of the concentration of zinc in the diet of the participants of this study, showed mineral values of 20.3 mg/day, which are higher than those found for the control group (10.9 mg/day). These results are consistent with those demonstrated by Soares, Ishii and Burini\(^{27}\) which found 22.0 mg of zinc/day in the diet of athletes.

On this point it should be mentioned that the diets consumed in the region of origin of athletes evaluated in this study had large quantities of food sources of zinc such as red meat and milk. Accordingly, it is appropriate to highlight the importance of an adequate diet regarding zinc intake, which is one of the key factors in maintaining adequate concentrations of the mineral in the body. According to Koury and Donangelo\(^3\), although there are no specific recommendations for athletes, this population group seems to need a higher intake of nutrients in order to compensate for increased sweat and urinary losses, as well as to meet the high biochemical demand from intense exercise. The fact that the concentration of zinc found in the diet of athletes participating in this study exceeded the recommendations may have contributed to the mean values of the mineral found in the plasma.

Among the indirect methods for the assessment of nutritional status, the most frequently used are those obtained from dietary surveys, which show the qualitative or quantitative adequacy of food consumption of an individual that belongs to a family or a population group\(^{28}\).

As for the results in the evaluation of the composition of the diet consumed by athletes and the control group, it is found that the daily recommended intakes (DRIs) for macronutrients were achieved by both groups, with no statistically significant difference \((p<0.05)\), except the consumption of lipids, which was higher for athletes. According to the DRIs\(^{21}\), the percentage of energy delivered by macronutrients is approximately 10 to 30% for protein, 45 to 65% for carbohydrate and 35% for lipids. Thus, this study found that the diets of both groups had adequate concentrations of macronutrients.

On the other hand, by analyzing the percentual distribution of participants in the study, according to plasmatic zinc, it was found that more than half of the
athletes (52.3%) had values below 70 µg/dL, which is considered the normal value standard. Therefore, although the results from this study revealed an average concentration of zinc in the diet higher than recommended, a high percentage of individuals had a hypozincemia status. This fact can be attributed to physiological changes commonly seen after physical activity.

Accordingly, some studies have shown that physical exercise promotes an increase of circulating interleukins, which stimulate the synthesis of metallothionein, a protein that promotes redistribution of zinc from plasma to the liver and/or erythrocytes. The effects of these pro-inflammatory cytokines on the homeostasis of zinc in the body go beyond its influence on the expression of metallothionein. These substances stimulate the cellular influx of zinc through a regulation of the Zip transporter 14 in the hepatocyte membrane, which suggests that this transporter contributes to hypozincemia in athletes.

The concentrations of zinc in erythrocytes in athletes and individuals in the control group showed mean values within the normal range without significant differences between the groups (p<0.05).

These results are consistent with those demonstrated in the study by Mundie and Hare¹⁰, which also found no difference in erythrocyte zinc concentrations 24 hours after the completion of anaerobic activity in athletes when compared to the control group. In the study by Olive et al.¹⁴, there was no significant difference in relation to erythrocyte after 12 weeks of training in soccer players (p > 0.001), but the researchers observed a significant increase in plasma zinc concentration (p < 0.001). The concentration of zinc in erythrocytes is about 10 times higher than in plasma. However, this parameter reflects changes, in the medium and long term, in the stocks of this mineral in the body due to the long half-life of erythrocytes.

The analysis of the percentage of participants of this study, according to the concentration of zinc in erythrocytes showed that 46% of athletes and 26% of subjects in the control group had concentrations higher than 44 µg Zn/g Hb. In this respect, an important fact worth highlighting is the changes in the distribution of zinc that appears to be dependent on the period of collection of biological material. There is a redistribution of zinc from plasma to erythrocytes, usually found after the period of rest that follows physical activity.

However, the results of the study conducted by Saliba, Tramonte and Faccin in athletes who performed aerobic activity revealed reduced erythrocyte zinc concentrations after 36 hours of exercise and sufficient mineral content in the diet. According to these authors, the concentration of zinc found in the erythrocyte could reflect the content of zinc found in diets consumed by athletes.

The results of this study show the existence of changes in the distribution of zinc in athletes, given the high percentage of subjects with concentrations of zinc in erythrocytes and plasma above and below the recommendation for this mineral, respectively, while the mean values for both parameters were within the parameters of normality.

This fact reinforces the need for more studies of this nature with a methodology that allows one to elucidate the mechanisms involved in the metabolic aspects arising from physical exercise, which favor disturbances in the antioxidant defense system. The consequences of this knowledge can guide other experimental studies to clarify that the use of zinc supplements by athletes is not needed, since it seems that there is no deficiency of this mineral in these individuals but rather a change in its compartmentalization in the body.

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