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EVALUATION OF IRON IN BLOOD OF ATHLETES BY THE EDXRF TECHNIQUE

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ABSTRACT

The aim of this study was evaluate Fe in blood of athletes from different modalities (judo athletes, cyclist and long distance runners) by X-ray Fluorescence methodology using portable equipment, as an alternative for clinical practice. The study showed the practicality and efficacy of using this methodology for successive clinical evaluations, during the preparation period of competitions, providing data that help in the elaboration of a balanced diet, as well as contribute to the proposal of new clinical evaluation protocols. In addition, the results emphasize the need to adopt differentiated diets for adequate iron intake as a function of sports activity.

1. INTRODUCTION

Minerals are essential for metabolic and physiologic processes in the human body [1]. Among them Iron play an important role for physical performance and health of the athlete. The human body contains approximately 3–5 g of iron [1,2], found in hemoglobin, myoglobin, cytochromes, and also in various enzymes involved in numerous metabolic processes, such as, delivery of oxygen to tissues, cell respiration, and energy production [3]. Furthermore, Iron also contributes to regulate body temperature (after physical exercise), the cardiovascular system, the immune defenses, the brain function, among others [2,3].

Athletes are commonly diagnosed with Iron deficiency [4,6], which may limit the capture, transport and use of oxygen by tissues, thereby reducing the cardiorespiratory function [7,9]. Its severe deficiency results in anemia, characterized by a decrease in hemoglobin concentration, which increases the risks of fatigue, overtraining syndrome and vulnerability to infection [10]. On the other hand, iron excess may be associated with oxidative stress and DNA damage, increasing the risk of infections, resulting in decreased performance [2,4].

Furthermore, the iron overload plays an important role in the pathogenesis of atherosclerosis, carcinogenesis and neurodegenerative disorders [3].

In practice, conventional laboratory test (Fe dosage performed in serum) helping to understand the modifications induced in the body by the intensity in the physical exercise. However, the use of alternative technology that allow individual evaluation, according to the metabolism characteristic of the modality practiced, contributes to the improvement of the athlete's performance. The aim of this study was investigate the iron levels in whole blood of athletes from different modalities, by X-ray Fluorescence methodology. The major advantage for using this alternative methodology is the viability to use small quantities of whole blood (0.05 mL), compared to conventional analyses performed in serum (using at least 5–10 mL). Moreover, this procedure offers a non-destructive, fast and efficient alternative for clinical usage [11].

2. METHOD

2.1. Subjects

Twenty-eight athletes in constant training from different modalities (cyclist, long distance runners and judo athletes) participated this study. Details about age, mean weight, height and training time are presented in Table 1**.** The athletes had a balanced diet, without multivitamin/mineral supplements. The control group was composed of 44 healthy subjects, male donors selected from Paulista Blood Bank (at Sao Paulo city, Brazil), with the same range of age and weight, but not involved with intense physical activities. This study was performed with the approval of the Ethical Committee (CAAE: 0200.0.146.000-08).

2.1.1. Sample preparation

The blood samples were collected in the morning, before the physical training. The procedure consists in puncturing the finger with a lancet and deposit a whole blood drop (~50 μL) in filter paper (Whatman – nº41), and store in an appropriate receptacles, no need cooling. The blood collection for control group was performed at Paulista blood bank following the same procedure.

Table 1: Data on training volume

Modalities	Number athletes (male)	constant training, years	age, years	mean weight, kg	mean height, cm	training volume, week
Professional trained-cyclists	5	6	32.0 ± 6.2	77 ± 5	179 ± 6	8 – 13 h
long distance runners	18	5	34.8 ± 5.6	69 ± 10	174 ± 9	24 – 50 km
judo athletes	5	2	18.2 ± 1.0	86.0 ± 17.3	174 ± 1	8 – 10 h

2.1.2. Whole blood analyses

The Energy Disperse X-Ray Fluorescence analysis (EDXRF) was performed using X-Ray Spectrometer (X-123 SDD model - Amptek®), with Silver (Ag) X-ray tube. The characteristic fluorescent X-rays emitted from the samples (K_α line) was measured with a Si Drift detector (25 mm^2 x 500 μm) with be window (12.5 μm). The excitation condition was optimized in 30 kV, 5 μA and counting time of 100 s. The analysis was performed using WinQxas 1.40 software program.

3. RESULTS AND DISCUSSION

The Fe concentration (MV: Mean Value) determined in blood samples are presented in Table 2. The standard deviation (±1SD), minimum (Min) and maximum (Max) values, and the range (considering a confidence interval of 95%) are also presented. The Control Group (CG) was included for comparison.

Table 2: Fe concentrations results in whole blood of athletes

Fe, mg/L	Control Group [range]*	Groups of Athletes (modalities)		
	CG n = 44 [249 – 457]*	professional trained-Cyclists n = 5	long distance runners n = 18	Judo athletes n =5
MV	353	533	443	542
±1SD	52	98	76	69
Min	267	460	290	418
Max	482	664	563	625

*considering the confidence interval of 95% (adopted in clinical practice as a normal range)
n: number of samples

The Fe concentrations results in whole blood of athletes when compared with the Control Group showed an increase. Statistical analysis (*t - test*) demonstrated significant differences ($p<0.05$) for three modalities showing that the blood iron levels for athletes may differ from sedentary people or from people not involved with intense physical exercise. Related to the alternative procedure (EDXRF) some positive aspects can be emphasized: the simplicity involved in the blood collection and sample preparation, the storage of the sample without the need for refrigeration as well as the speed to perform the measurements.

4. CONCLUSION

The use of the EDXRF technique allowed an efficient evaluation of Fe in whole blood samples. The results established for the three groups investigated (cyclist, runners and judo athletes)

show significant differences for Fe in blood, suggesting that a strong dependency of these limits in function of sport modality and intensity of the physical training. Besides, these data can be considered in a preparation of a balanced diet and can also be used for evaluating the performance of athletes during the preparation period for competitions as well as to propose as to propose new clinical protocols.

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