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The EDXRF Analysis to Monitor Iron Deficiency Anemia

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Abstract: Iron Deficiency Anemia is a significant global issue, particularly affecting pregnant women and young children. Traditional methods of diagnosing iron-deficiency anemia generally require extensive and costly laboratory procedures. This study explores the feasibility of using portable Energy Dispersive X-ray Fluorescence (EDXRF) technology for assessing iron concentration in whole blood samples from donors diagnosed with iron deficiency anemia. The results indicated a marked decrease in iron levels in the blood samples from patients with anemia compared to the control group. The EDXRF technique demonstrated several advantages, including simplicity in sample collection, rapid measurement time, and low cost. This method is particularly promising for use in situations where biological material is limited, such as in pediatric practices for newborns. The study concludes that portable EDXRF technology is an effective and efficient tool for diagnosing iron deficiency anemia, potentially improving diagnostic accessibility and outcomes.

Keywords: Whole Blood, Iron Deficiency Anemia, EDXRF, Iron concentration.

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Análise de EDXRF para monitorar Anemia por Deficiência de Ferro

Resumo: A Anemia por Deficiência de Ferro é um problema global significativo, especialmente afetando mulheres grávidas e crianças pequenas. Métodos tradicionais de diagnóstico da anemia ferropriva geralmente requerem procedimentos laboratoriais extensivos e custosos. Este estudo explora a viabilidade do uso da tecnologia portátil de Fluorescência de Raios X por Dispersão de Energia (EDXRF) para a avaliação da concentração de ferro em amostras de sangue total de indivíduos diagnosticados com anemia ferropriva. Os resultados indicaram uma diminuição acentuada nos níveis de ferro nas amostras de sangue dos pacientes com anemia em comparação com o grupo controle. A técnica de EDXRF demonstrou várias vantagens, incluindo simplicidade na coleta de amostras, tempo rápido de medição e baixo custo. Este método é particularmente promissor para uso em situações onde o material biológico é limitado, como em práticas pediátricas para recém-nascidos. O estudo conclui que a tecnologia portátil EDXRF é uma ferramenta eficaz e eficiente para o diagnóstico da anemia por deficiência de ferro, potencialmente melhorando a acessibilidade e os resultados diagnósticos.

Palavras-chave: Sangue total, Anemia por Deficiência de Ferro, EDXRF, Concentração de Ferro.

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1. INTRODUCTION

Iron deficiency anemia is a nutritional deficiency of greater magnitude in the world, affecting mainly women and children, it occurs mainly due to an insufficient amount of iron in the diet [1, 2, 3]. It is also related to insufficient intake of folic acid and copper. Iron deficiency anemia results from low or depleted iron stores, which are needed to make red blood cells. Small amounts of iron are lost daily through skin, hair, nails, feces, and urine. In women, there is an additional loss due to menstruation and breast milk [4]. Global data related to the lack of dietary iron fortification affects 40% of children; 30% of women of childbearing age and 38% of pregnant women. Iron deficiency in the body is gradual, until the development of anemia. In Brazil, anemia is considered a public health problem [5]. The importance of obtaining a quick diagnosis, with a simple and low-cost test, motivated the search for an alternative for iron evaluation in the blood. This work proposes the use of portable equipment, based on X-ray Fluorescence technology, to evaluate the iron concentration in whole blood samples for the diagnosis of iron deficiency anemia.

2. MATERIALS AND METHODS

The samples came from Paulista Blood Bank. Whole blood samples were obtained from a group consisting of male (n = 10) and female (n = 10) donors (18-30 age, 55-85kg) diagnosed with iron deficiency anemia. For the blood collection, (CAAE: 69992117.7.0000.0081), a small capillary pin (Clinitubes, Radiometer Copenhagen) was inserted in the subject's finger and 50 (± 0.5 %) μL was dropped on a Whatman no. 41 filter paper (2.2 cm^2) using a calibrated micropipette. Samples were collected in duplicate. The EDXRF analysis was performed using an X-Ray Spectrometer (X-123 SDD model -

Amptek®), with an Au X-ray tube [6]. The characteristic fluorescent X-rays emitted from the samples (Kα line) were measured with a Si Drift detector (25 mm² x 500μm) with Be window (12.5μm) [7]. The excitation conditions were optimized in 30 kV and 5 μA and a counting time of 200s. The spectra analysis was performed using the WinQxas software program [8].

3. RESULTS AND DISCUSSIONS

The Fe concentration determined in blood samples is presented in Table 1. The reference values, from the control group were included for comparison (considering a confidence interval of 95%). To visualize, these results are shown in Figure 1. The control group results are presented in Table 2. The results were expressed by mean value (MV), standard deviation (±1SD), minimum (Min), maximum (Max), and the range for a confidence interval of 95%.

Table 1: Fe concentrations (mg/L) result in whole blood by EDXRF analysis

Female [326 - 570]*	**Male [386 - 622]***
n=20	
262 ± 16	271 ±13
211 ± 13	259 ± 16
171± 10	238 ± 14
270 ± 16	217 ± 13
212 ± 13	279 ± 17
234 ± 14	277 ± 17
242 ±15	218 ± 13
248 ± 15	254 ±15
276 ±17	234 ±14
241 ±14	279 ±17

n: number of samples

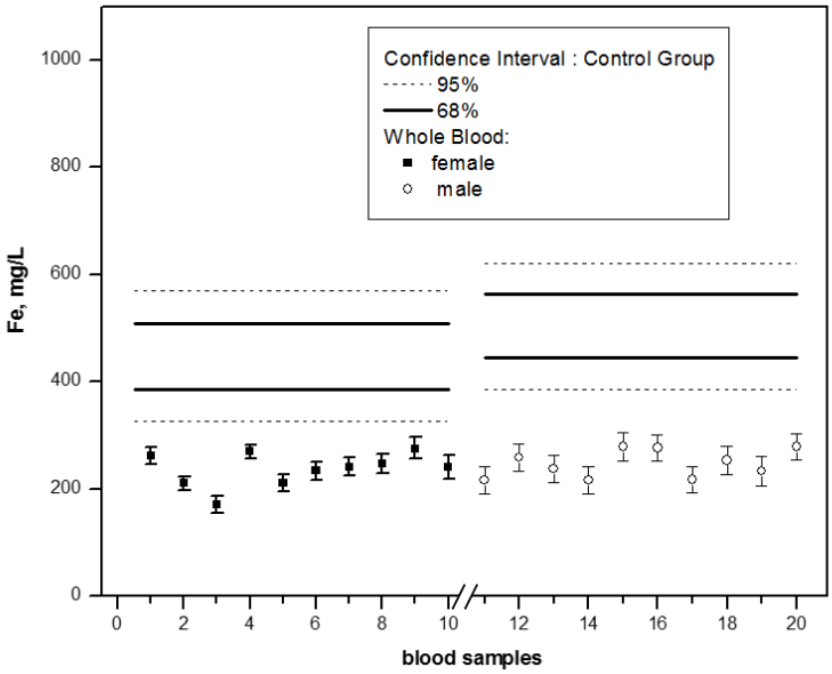
*Reference values

Table 2: Control Group Fe results (mg/L) by EDXRF

Fe (mg/l)	Male n = 42	Female n = 40
MV	504	448
1DP	59	61
Min	374	307
Max	589	587
Range	386 - 622	326 - 570

n: number of samples
*Reference values

Figure 1: Fe concentration results in whole blood samples by EDXRF technique**.**



Source: Author.

The Fe concentrations in whole blood of subjects with iron deficiency anemia were decreased when compared to reference values. This method enables quick diagnosis of iron deficiency anemia through a simple and low-cost test. Other studies [9, 10] have explored alternative methods for iron measurement, with EDXRF technique also proving to be a suitable option. Regarding EDXRF, some advantages can be highlighted: the simplicity of whole blood collection and sample preparation, as well as the rapid measurement time (minutes).

4. CONCLUSIONS

The use of the EDXRF technique allowed an efficient evaluation of Fe in whole blood samples. In addition, this procedure has potential use when the biological material is scarce, case of the pediatric practice in newborns due to the high prevalence of iron deficiency anemia in this age group.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

REFERENCES

[1] WEFFORT, V. R. S., Anemia ferropriva carencial. **Rev Med Minas Gerais**; 21. (3 Suppl.1):19-21, Jul/Set, 2011.

[2] ANDREWS, N. C., Iron metabolism: iron deficiency and iron overload. **Annu Rev Genomics Hum Genet**, 1, pp.75–98, 2000.

[3] AMARANTE, M. K., Otigossa, A., Sueiro, A. C., Coral de Oliveira, C. E., & Quintal de Carvalho, S. R. Anemia Ferropriva: uma visão atualizada. **Biosaúde**, *17*(1), 34–45. 2016.

[4] CAPPELLINI, M. D., Santini V, Braxs C, Shander A. Iron metabolism and iron deficiency anemia in women. **Fertil Steril**.;118(4):607-614. doi:10.1016/j.fertnstert.2022.08.014, 2022

[5] JORDÃO, R. E., at al. Prevalência de anemia ferropriva no Brasil: uma revisão sistemática. **Revista Paulista de Pediatria**, 27(1), 90–98, 2009.

[6] AMPTEK, Mini-X User Manual Rev D2. 2016.

[7] AMPTEK, DPPMCA Display & Acquisition Software. 2019.

[8] WinQXAS, Quantitative X-ray Analysis System for MS operating system, version 1.40. International Atomic Energy Agency, 2002.

[9] ELSUCCARY S. A., Salem A. A. Novel flow injection analysis methods for the determination of total iron in blood serum and water. **Talanta**. 131:108-115. doi:10.1016/j.talanta.2014.07.068, 2015.

[10] JABLAN J., Besalú E., Žarak M., Dumić J., Marguí E. Analytical potential of total reflection X-ray fluorescence spectrometry for simultaneous determination of iron, copper and zinc in human blood serum and plasma. **Talanta**. 233:122553. doi:10.1016/j.talanta.2021.122553. 2021.

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