Reference Ranges of Iron Profiles in Apparently Healthy Elderly in Sokoto, Nigeria

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Authors' contributions

Original Research Article

ABSTRACT

Background: Iron is an important micronutrient in the body, lead to anaemia, frailty and cognitive disorders in the elderly when deficient.
Aim: This study was aimed to determine reference values of iron profile in apparently healthy elderly persons in Sokoto and compared with the local reference values.
Study Design: This was a comparative study
Duration of Study: The study lasted for a period of one year between January to December, 2020.
Methodology: This was a comparative study involving 105 apparently healthy elderly persons aged 60 years and above in Sokoto metropolis. Serum iron and total-iron binding capacity (TIBC) were determined using Iron Ferrozine method. Serum ferritin, Serum transferrin (Tf) and Serum Transferrin Receptors (sTfR) were assayed using enzyme-linked immunosorbent assay (ELISA). Transferrin Saturation (TS) and Serum Transferrin Receptors ferritin log (sTfR/FL) was calculated. Data were expressed as percentiles, mean and standard deviation and analysed using t-test and one way ANOVA.

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Results: The study established reference ranges of Serum iron,TIBC, Serum ferritin, Tf, sTfR, TS and sTfR/FL was calculated. in Sokoto. The study showed that iron and ferritin have high reference ranges than the local values in Sokoto. The local values for TIBC, ferritin, sTfR, TS and sTfR/FL were not available. Mean Ferritin (µg/L), sTfR (ng/L) and sTfR/Fl the test subjects were significantly higher in males than females in Sokoto (p=0.026), (p= 0.001), (p=0.044) and (p= 0.003) respectively. Iron, ferritin and TS increased as the BMI was increasing (p=<0.001).

Conclusion: In conclusion, normal reference values obtained in this study notably vary with the local reference ranges used in the Sokoto metropolis. There is a need for each locality to have separate reference ranges for the elderly for their proper diagnosis and management of iron related disorders.

1. INTRODUCTION

Iron is a micronutrient in needed by the body. It can cause iron deficiency anaemia in elderly when deficient [1]. Iron deficiency (ID) with or without anemia is common worldwide. ID is a broad definition encompassing decreased total body iron (absolute deficiency) as well as reduced iron supply to erythropoietic and/or other organs with preserved stores (functional iron deficiency, FID), as it occurs in inflammation. In all these cases, hepcidin synthesis is repressed [2]. Iron deficiency is falsely perceived as a minor problem, particularly in the elderly with multi-morbidity, so that it often remains unrecognized and untreated [3]. There is growing evidence that iron metabolism is affected by the ageing process, and researchers have linked iron deficiency with adverse health problems. Yet often, it remains under-diagnosed and undertreated [4]. Moreover, it is important to avoid the risk of high body iron stores (haemosiderosis), as this may have detrimental effects on the brain (Fairweather-Trait *et al.*, 2014).

It was estimated that anaemia affects 32.9% of the world population [5], with Iron deficiency representing by far the most frequent cause (nearly 50%) [6]. Preschool children and women of childbearing age are the most vulnerable population categories, especially in low-income countries [7]. However, ID is a major global health issue with substantial socio-economic burden also in high-income countries [8], where the elderly represent an additional emerging risk category [3]. According to Bianchi [9], Iron deficiency is the third most common cause of anaemia. Is prevalent in older age and likely the cause of decline in serum ferritin concentrations (Fairweather-Trait *et al.*, 2014). Iron is very important to biologic functions, including respiration, energy production, deoxyribonucleic acid (DNA) synthesis and cell proliferation.

The term 'Elderly' is applied to those individuals belonging to age 60 years and above, who represent the fastest growing segment of populations throughout the world [10]. Elderly are those in old age, that's later part of life; the period of life after youth and middle age [11]. According to United Nations age classification, they are within the age of 60years and above [12]. They have two common medical findings; anaemia and frailty. Anaemia in older persons is associated with increased physical impairment, frailty, cognitive decline, depression and mortality [13]. The elderly is expected to have a higher prevalence of anaemia compared to the general population, as longevity is associated with a variety of physiological dysfunctions, chronic and inflammatory diseases and occasionally inadequate diet that lowers reserves and the availability of iron [14].

Reference range is the basis for results interpretation and patient management; it is highly significant in diagnostic accuracy [15]. This is the most common decision support tool used for interpretation of numerical pathology reports [16]. It is a well-established practice to determine the normal reference values in different parts of the world because of geographical, ethnic and other variations. Due to variation in topographical, social, and health status, it is unsafe to use reference ranges from a different setting/population (race and ethnicity). Other causes of variation in reference ranges include body mass index, sex, age, genetics, altitude, and environmental factors like pathogens [15]. However, in the two metropolises there are no reference values for the elderly. The same values are used for all adults that are both old and young. This has led to misdiagnosis, knowing fully well that the elderly has great

physiological difference with young adults. Therefore, this study was set out to establish separate reference ranges for iron profiles in apparently healthy elderly persons living in Sokoto and Nnewi, Nigeria. This study would possibly show the differences in the established and local reference values, highlight need to have separate values for the elderly and show age, gender and BMI differences on the studied parameters.

2. MATERIALS AND METHODS

2.1 Study Design

This was a comparative study that involved apparently healthy elderly persons aged 60 years and above in Sokoto. Reference ranges of the study variables were determined on elderly and compared with the local reference values used in Sokoto to determine the variation and need to have separate reference ranges for the elderly.

2.2 Study Area

The study was conducted in Sokoto metropolis, Sokoto State. Which lies between longitude 05^0 to 13^0 03' East and latitude 13^0 06 North and covers an area of 66.33km^2 (SSBD, 2007). It has a land area of about 28,232.37sq kilometers and stands at altitudes of 272m above the sea level. The major indigenous tribes in the state are the Hausa and Fulani and other groups such as Gobirawa, Zabarmawa, Kabawa, Adarawa, Arawa, Nupes, Yorubas, Igbos and so on are also resident there, the town being cosmopolitan. The occupation of city inhabitants include; trading, farming, with a reasonable proportion of the population working in private and public domains. Based on 2006 population census, Sokoto state had a population of 3.5million with Sokoto metropolis having a population of 427,760 [17].

2.3 Study Site

The study was carried out in Sokoto metropolise. Laboratory analysis for Iron profiles were assayed at Chemical Pathology Departments of Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto.

2.4 Study Population

Apparently healthy in this context as defined by Azuonwu *et al.* [18] are those in good health condition with no observable signs and symptoms of ill health and free from known illness. The data were collected through interviewers administered questionnaire. Blood samples were collected from those that met the inclusion criteria for assay of parameters under study. Anthropometric parameters were also taken. Height was measured to the nearest 0.1 centimetre with a portable stadiometer [19]. Weight of respondent was measured with a portable electronic weight scale in kilograms with light clothing (without shoes) to the nearest 0.1kg [20]. Body Mass Index (BMI) was calculated from the weight and height values for each individual using the formular = weight (kg)/Height (m) ^{2} [21]. BMI was classified as follows: underweight (BMI <18.5kg/m^2), normal weight (BMI of 18.5-24.9 kg/m^2), overweight (BMI of 25-29.9 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) [22].

2.5 Sample Size Calculation

Sample size was determined with G-Power 3.0 software

2.6 Recruitment of Participants

The test subjects were recruited from Sokoto and Nnewi metropolises in communities and markets through medical outreach. They were consecutively recruited until a required sample size was achieved.

2.7 Inclusion Criteria and Exclusion Criteria

Apparently healthy elderly persons (≥ 60 years) living in Sokoto and Nnewi, who were willing to give informed consent. Those who are HIV negative, having no known illness, not on iron medications or supplements like ferrous sulphate and ferrous glutamate, HIV sero-reactivity was determined using determine rapid kit according to manufacturer's instruction. Participants were categorised as HIV non-reactive when there was no positive reaction on the kit.

2.8 Sampling Method

The sampling method adopted was convenience sampling method as the study design entails going from house to house and organising medical outreaches seeking for those who met the defined criteria.

2.9 Questionnaires

Questionnaires were administered to the eligible subjects to collect anthropometric parameters (height and weight for calculation of Body mass

Index (BMI)) and socio-demographic details (gender and age) and other co-founding factors such as those on iron medications and having known illness.

2.10 Sample Collection

Four millilitres (4ml) of blood was collected and dispensed in the plain tube, labelled with the subject's information for identification. Then, allowed to clot, spurn at 3,000rpm and serum harvested and stored at -20°C for determination of serum iron, serum ferritin, TIBC, serum transferrin, serum transferrin saturation and serum transferrin receptor.

2.11 Laboratory Procedure

This was done using standard procedures; Serum iron and total- iron binding capacity (TIBC) were determined using Iron Ferrozine method Using Iron Nitro PAPs fluid Mono kit from Centromic GmbH Am Kleinfeld, Germany. Which involves dissociation of iron from it s carrier protein, transferrin in an acid medium and simultaneously reduced to the ferrous form? The ferrous ions react with the chromogen Nitro-PAPs to a colour-proportional to the iron contents. Serum ferritin was assayed using human Ferritin Elisa kit using Accubind Elisa Microwells by Monobind Inc. Lake Forest, CA 92630, USA, Serum transferrin (Tf) and Serum Transferrin Receptors (sTfR) were assayed using enzyme-linked immunosorbent assay (ELISA) kit from Nanjing Pars Biochem Co., Ltd, China. And were read at 450-630 nm using Rayto microplate reader RT-2100C. Transferrin saturation (TS) and Serum Transferrin Receptors (sTfR)/Ferritin log (sTfR/FL) were calculated using standard formulas by Barbara *et al.,* [23] as follows:

Percentage Transferrin saturation (%) = $\frac{\text{Serum Iron x 100}}{\text{TIBC}}$

sTfR/FL = $\frac{\text{serum transferrin receptor (sTfR)}}{\text{Ferritin Log}}$

2.12 Data Analysis

Data were collected into excel spread sheet and transferred into the data editor of Statistical Package for Social Sciences (SPSS, Version 23, Inc., Chicago USA) software and was used to analyse data generated. Mean and standard deviation of the iron parameters were determined. Frequency of socio-demographic factors was determined using percentages. Normality of the parameters was determined using one sample Kolmogorov Smirnov test. Mean ±1.96 SD was considered as the normal range for variables with normal distribution, which contains 95% of normal individuals. When distribution was not normal, reference ranges were considered as values between 2.5 and 97.5 percentiles. Independent sample t-test was used to determine gender difference in mean variables in this study. The Gender differences in iron profile were determined using students t-test. Age and BMI differences were determined using one way ANOVA. Error probability was set at p-value < 0.05.

3. RESULTS AND DISCUSSION

3.1 Iron Profiles Reference Ranges of Elderly Study Participants in Sokoto

Established reference ranges of iron profiles in Sokoto were as follows: Iron (µmol/L) (9.00 - 46.00), TIBC (µmol/L) (28.50 – 74.10), Ferritin (µg/L) (29.10 – 487.8), Tf (mg/dl) (158.20 – 370.70), sTfR (ng/L) (2.07 – 6.09), TS (0.12 – 1.03) and sTfR /FL (0.90 – 3.60).

3.2 Reference Ranges of Iron Profile of Elderly Study Participants and Local Reference Values in Sokoto

The study showed that iron and ferritin have high reference ranges than the local values. The local values for TIBC, ferritin, sTfR, TS and sTfR/FL were not available.

3.3 Summary of Socio-Demographic Characteristics of the Test Group

The age of the elderly was classified into five groups; 60-64, 65-69, 70-74, 75-79 and ≥80. The elders that participated in the study in different age groups were as follows: 60-64; 42 (40.0%), 65-69; 37 (35.2 %), 70-74; 5 (4.8%), 75-79; 4 (3.8%) and ≥80; 17 (16.2%). On gender distribution, 69 (65.7%) males and 36 (34.3%) females were part of the study from Sokoto Metropolis.

The basal metabolic index (BMI) (kg/m^2) of the participants in the study was classified into underweight (BMI >18.5 kg/m^2), normal weight (BMI of 18.5-24.9 kg/m^2), overweight (BMI of 24.9-29.9 kg/m^2), obesity (BMI ≥ 30 kg/m^2). The frequencies of participants' groups of BMI were

as follows: underweight were 19 (18.1%), normal weight 51 (48.6%), overweight 28 (26.7%) and obese 7 (6.7%) respectively.

3.4 Serum Levels of Iron Profiles (mean ± SD) of Elderly Study Participants in Sokoto by Gender

Mean Ferritin (µg/L), sTfR (ng/L) and sTfR/Fl the test subjects were significantly higher in males than females in Sokoto (p=0.026),(p=0.001), (p=0.044) and (p= 0.003) respectively.

3.5 Serum Levels of Iron Profiles (mean ± SD) of Elderly Study Participants in Sokoto by Age

Comparison of Iron (µmol/L) of the subjects across age groups showed statistical difference (p= 0.040). This showed that the difference is age related. Comparison of serum TIBC (µmol/L) of the subjects across age groups showed statistical difference (p= 0.023). The TIBC difference was shown in between age group of 60-64 vs 75-79. In this study, age group 75-79 had higher iron, TIBC and Tf levels than other age groups.

3.6 Serum Levels of Iron Profiles (mean ± SD) of Elderly Study Participants in Sokoto by BMI6

Comparison of the Iron (µmol/L) in different BMI in Sokoto metropolis showed significant increase from normal weight to obesity (p=<0.001). Ferritin (µg/L) levels of the subjects in different BMI significantly increased as BMI increases (p=<0.001). Comparison of TS of the subjects in different BMI showed significant increase form normal BMI to obesity (p=<0.001). The sTfR/FL of the subjects in different BMI showed statistical difference (p=<0.001). This showed that Iron, ferritin and transferrin saturation increased from underweight to obesity while sTfR/FL decreased from underweight to obesity. That's as the BMI was increasing.

Table 1. Iron profiles reference ranges of elderly study participants

Parameters	Mean ± SD	Median	2.5th - 97.5th Median percentile
Iron (µmol/L)	19.63 ± 8.44	19.00	9.00 - 46.00
TIBC (µmol/L)	48.17 ± 11.96	45.60	28.50 – 74.10
Ferritin (µg/L)	212.92 ± 131.00	166.00	29.10 – 487.8
Tf (mg/dl)	217.37 ± 53.64	198.00	158.20 – 370.70
sTfR (ng/L)	3.79 ±1.10	3.40	2.07 – 6.09
TS	0.43 ± 0. 21	0.40	0.12 – 1.030
sTfR /FL	1.74 ± 0.66	1.60	0.90 – 3.6

Key: Iron = serum iron, TIBC = total- iron binding capacity (TIBC), Ferritin = serum ferritin, Tf =serum transferrin, STfR =serum transferrin receptor, TS = transferrin saturation, STfR/FL = serum transferrin receptor ferritin log

Table 2. Reference ranges of iron profile of elderly study participants and local reference values in Sokoto

Parameters	Elderly study participants	Sokoto Local Values
	Lower limit – Upper limit	Lower limit – Upper limit
Iron (µmol/L)	9.00 - 46.00	7.00 – 25.00
TIBC (µmol/L)	28.50 – 74.10	N/A
Ferritin (µg/L)	29.10 – 487.8	30.00 – 400.00
Tf (mg/dl)	158.20 – 370.70	N/A
sTfR (ng/L)	2.07 – 6.09	N/A
TS	0.12 – 1.03	N/A
sTfR /FL	0.90 – 3.6	N/A

Key: Iron = serum iron, TIBC = total iron binding capacity (TIBC), Ferritin = serum ferritin, Tf =serum transferrin, sTfR =serum transferrin receptor, TS = transferrin saturation, sTfR/FL = serum transferrin receptor ferritin log, N/A = not available.

Table 3. Summary of socio-demographic characteristics of the test group

Socio-demographic variables	Groups	Sokoto	
		Frequency N=105	Percentage (%)
Age (years)	60-64	42	40.0
	65-69	37	35.2
	70-74	5	4.8
	75-79	4	3.8
	≥ 80	17	16.2
Gender	Male	69	65.7
	Female	36	34.3
BMI (Kg/m^2)	Underweight	19	18.1
	Normal weight	51	48.6
	Overweight	28	26.7
	Obesity	7	6.7

Key: Underweight (BMI >18.5 kg/m^2), Normal weight (BMI of 18.5-24.9 kg/m^2), Overweight (BMI of 24.9-29.9 kg/m^2), Obesity (BMI ≥ 30 kg/m^2).

Table 4. Serum Levels of Iron profiles of elderly study participants (Mean ± SD) in Sokoto by Gender

Parameter	Male n=69	Female n=36	t-value	p-value
Iron (µmol/L)	19.1 ± 9.1	20.6 ± 7.1	-0.812	0.419
TIBC (µmol/L)	48.6 ± 10.5	47.4 ± 14.5	0.482	0.631
Ferritin (µg/L)	233.3 ± 137.4	173.8 ± 109.3	2.256	0.026*
Tf (mg/dl)	218.5 ± 55.2	215.3 ± 51.1	0.292	0.771
sTfR (ng/L)	4.0 ± 1.0	3.3 ± 1.1	3.363	0.001*
TS	0.41 ± 0.2	0.47 ± 0.2	-1.364	0.176
sTfR/FL	1.8 ± 0.6	1.6 ± 0.7	2.042	0.044*

*p< 0.05 is significant
Key: Iron = serum iron, TIBC = total -iron binding capacity (TIBC), Ferritin = serum ferritin, Tf =serum transferrin, STfR =serum transferrin receptor, TS = transferrin saturation, STfR/FL = serum transferrin receptor ferritin log

Table 5. Serum levels of iron profiles of elderly study participants in Sokoto by age

Parameter	60-64 n = 42	65-69 n = 37	70-74 n = 5	75-79 n = 4	≥ 80 n = 17	f-value	p-value
Iron (µmol/L)	20.6 ± 9.8	17.4 ± 6.9	13.0 ± 2.7	24.5 ±12.1	22.8 ± 6.1	2.615	0.040*
TIBC (µmol/L)	45.4 ± 12.0	49.0 ± 11.9	49.0 ± 3.1	65.6 ± 9.9	49.0 ± 11	2.964	0.023*
Ferritin (µg/L)	237.4 ± 163.3	217.9± 107.5	86.0 ± 14.1	145.2 ± 62.8	194.8 ± 90.7	1.973	0.104
Tf (mg/dl)	220.4 ± 61.1	217..3 ± 43.0	225.3 ± 47.7	272.8 ± 112.3	194.8 ± 26.6	1.945	0.109
sTfR (ng/L)	4.0 ± 1.1	3.7 ± 1.0	3.0 ± 0.7	3.0 ± 0.5	3.9 ± 1.5	1.686	0.159
TS	0.48 ± 0.3	0.38 ± 0.2	0.27 ± 0.1	0.36 ± 0.1	0.48 ± 0.1	2.225	0.072
sTfR /FL	1.9 ± 0.8	1.6 ± 0.4	1.6 ± 0.4	1.4 ± 0.3	1.8 ± 0.8	1.155	0.335

*p< 0.05 is significant
Key: Iron = serum iron, TIBC = total -iron binding capacity (TIBC), Ferritin = serum ferritin, Tf =serum transferrin, sTfR =serum transferrin receptor, TS = transferrin saturation, sTfR/FL = serum transferrin receptor ferritin lo

Table 6. Serum levels of iron profiles of elderly study participants in Sokoto by BMI

Parameter	Underweight n= 19	Normal weight n= 51	Overweight n= 28	Obesity n= 7	f-value	p-value
Iron (µmol/L)	16.5 ± 4.5	18.3 ± 7.8	20.6 ± 7.4	33.7 ± 11.7	9.952	<0.001*
TIBC (µmol/L)	47.1 ± 12.4	50.2 ± 12.0	46.0 ± 11.8	44.9 ± 10.9	1.003	0.395
Ferritin (µg/L)	116.2 ± 74.0	207.6 ± 138.9	265.9 ± 104.2	302.5 ± 137.9	7.184	<0.001*
Tf (mg/dl)	212.5 ± 59.8	216.4 ± 59.9	227.3 ± 42. 6	198.2 ± 11.4	0.671	0.572
sTfR (ng/L	4.1 ± 1.6	3.6 ± 0.9	4.0 ± 1.1	3.1 ± 0.5	2.303	0.081
TS	0.36 ± 0.1	0.37 ± 0.1	0.50 ± 0.3	0.77 ± 0.2	11.722	<0.001*
sTfR/FL	2.2 ± 1.1	1.6 ± 0.4	1.7 ± 0.5	1.3 ± 0.3	8.438	<0.001*

$p < 0.05$ is significant

Key: Iron = serum iron, TIBC = total- iron binding capacity (TIBC), Ferritin = serum ferritin, Tf =serum transferrin, sTfR =serum transferrin receptor, TS = transferrin saturation, sTfR/FL = serum transferrin receptor ferritin log.

4. DISCUSSION

Iron is the most common micronutrient in the world and its deficiency causes most common anaemia which can lead to cognitive disorders, impairment of physical and mental growth and development as well [1]. In order to interpret and determine the clinical implication of laboratory results of any individual in state of health or disease we need to have the knowledge of the normal reference range for that locality or population [24]. Therefore, this study was set out to evaluate iron profile in apparently healthy elderly persons living in Sokoto, Nigeria to establish reference ranges for the elderly on the studied variables in city and compare them with local reference values. This will add value to the management of elderly population in the town on iron and its related disorders. This study showed reference values of serum iron, TIBC, serum ferritin, Tf, sTfR, TS and sTfR/FR the elderly in Sokoto.

In this study, iron and ferritin have high reference ranges than the local values in Sokoto. The local values for TIBC, sTfR, TS and sTfR/FL were not available. The local values for TIBC, ferritin, sTfR, TS, sTfR/FL not available. Iron is essential for human life and it's regulation is complex which is done to preserve iron needed for body activity and most importantly prevent iron hypertoxicity [25]. Multiple factors may contribute to this variation, notably age, diet, nutrition and lifestyle as suggested by reports of Beutler [26], Fauci *et al.* [27], Pagana, Pagana and Pagana, [28], Toniya, Shashi, Jyotsna, Madhab and Ashish [29] and Szoke and Panteghini [30].

This study showed that mean ferritin, sTfR and sTfR/FL levels of the elderly male living in Sokoto were significantly higher than that of the elderly female in Sokoto (p=0.026, 0.001, and 0.044) respectively. The variations and increase in ferritin, sTfR and sTfR/FL in males than the females are in agreement with previous work that reported higher ferritin levels for males than the females [31], Odunukwe *et al.,* 2004; [6]. Furthermore, is in agreement with previous work which stated that iron indices vary with gender [32,33].

There were statistical differences in mean values of iron and TIBC of the elderly in Sokoto when compared based on age (p=0.040 and p=0.023) respectively. This is in agreement with previous work which stated that iron indices vary with age [32,33]. This could be as a result of ageing and body iron demand. In this study, age group 75-79 had high iron, TIBC and Tf levels than other age groups in Sokoto. Though, the reason for this cannot be elucidated but one cannot rule out inflammatory disorders which are common with the elderly.

There were significant increases in mean values of iron, ferritin and TS from low weight to obesity in Sokoto (p= <0.001). The increases in iron, ferritin and TS of the subjects as the BMI increases are in support of previous studies that indicated that those with overweight and obesity have high iron than those with lower BMI [34]. But in contrast with previous work by Haidari, Abiri, Haghighizadeh, Kayedani and Birgani [35], Shekarriz and Vaziri [36] and Stoffel *et al.* [37] reported a decrease in serum iron, transferrin

saturation and TIBC as the BMI increases. Though, the disagreement could be because the later worked on young women between the ages of 18-45years. There were significant decreases in sTfR and sTfR/FL from lower weight to those with obesity in Sokoto ($p<0.05$). Meanwhile, the decreases in sTfR and sTfR/FL are in support of previous reports that iron profiles are affected by BMI [38,39]. And disagrees with Shekarriz and Vaziri [36] who reported that sTfR increases with increase in BMI. Though, Shekarriz and Vaziri [36] worked on young women. The variation in iron profiles based on different BMI agrees with previous work which stated that dietary intake and nutritional pattern can influence iron status of an individual taking into cognizance that dietary pattern plays important role in maintenance of BMI status [29].

5. CONCLUSION

The study established reference ranges of serum iron, TIBC, serum ferritin, Tf, sTfR, TS and sTfR/FR for the elderly in Sokoto. The parameters under study vary with the locally used reference ranges. This emphasises on the need for each local diagnostic laboratory to establish its workable reference ranges for the elderly for proper diagnosis, treatment and management of iron related disorders. There were gender, age and BMI differences on iron profiles. This study showed that Ferritin, sTfR and sTfR/FL were higher in males than females. BMI influence on iron profile of an individual was establised; iron, ferritin and transferrin Saturation increased with increase in BMI.

INFORMED CONSENT

Written informed consent was obtained before recruitment into the study.

ETHICAL CONSIDERATION

Ethical approvals were obtained from Sokoto State Ministry of Health with reference numbers: SKHREC/079)2019.

RECOMMENDATIONS

1. Diagnostic laboratories should establish reference ranges for elderly to enhance better interpretation of results.
2. BMI and Gender should be put into consideration for proper interpretation of iron profiles.

SUGGESTION FOR FURTHER STUDIES

1. The study should be carried out with larger sample size.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Andriastuti M, Imana G, Nawangwulan SA, Kosasih KA. Prevalence of anemia and iron profile among children and adolescent with low socio-economic status. International Journal of Pediatrics and Adolescent Medicine. 2020; 7(2):88-92.
2. Camaschella C, Girelli D. The changing landscape of iron deficiency. Molecular Aspects of Medicine. 2020;100861.
3. Girelli D, Marchi G, Camaschella C. Anemia in the Elderly HemaSphere. 2018;2(3):40.
4. Thachil J. Iron deficiency: still under-diagnosed? British Journal of Hospital Medicine. 2015;76:528-532.
5. Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, Regan M, Weatherall D, Chou DP, Eisele TP, Flaxman SR, Pullan RL, Brooker SJ, Murray CJL. A systematic analysis of global anemia burden from 1990 to 2010. Blood. 2014;123:615-624.
6. World Health organisation (WHO). Serum ferritin concentrations for the assessment of iron status and iron deficiency in populations [Internet]. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization (WHO/NMH/ NHD/MNM/11.2); 2011a.
Available:http://www.who.int/vmnis/indicators/serum_ferritin.pdf (Accessed:11th January, 2021).

7. World Health organisation (WHO). The global prevalence of anaemia in 2011; 2011b,
Available:https://apps.who.int/iris/bitstream/handle/10665/177094/9789241564960_eng.pdf 2015

8. Blank PR, Tomonaga Y, Szucs TD, Schwenkglenks M. Economic burden of symptomatic iron deficiency - a survey among Swiss women. BMC Women's Health. 2019;19:39.

9. Bianchi VE. Anemia in the Elderly Population. Journal of Hematology. 2014;3(4), 95-106.

10. Amarya S, Singh K, Sabharwal M. Ageing Process and Physiological Changes. *Gerontology,* Grazia D'Onofrio, Antonio Greco and Daniele Sancarlo, Intech Open; 2018.
Available:https://www.intechopen.com/chapters/60564

11. World Health Organisation (WHO). Proposed working definition of an older person in Africa for Minimum Data Set (MDS) project. 2002;1-5.

12. World Health Organization (WHO). Elderly population in Health situation and trend assessment. Global Health and Ageing. 2019;1-25.

13. Röhrig G. Anemia in the frail, elderly patient. Dovepress. 2016;11:319—326.

14. Gayar NH, Deghady AA. Iron status in healthy elderly people: an evaluation of the role of soluble transferrin receptors in elderly. Egypt Journal of Obesity, Diabetes and Endocrinology. 2015;1:153-158.

15. Nlinwe NO, Kumenyuy YL, Funwi CP. Establishment of Hematological Reference Values among Healthy Adults in Bamenda, North West Region of Cameroon. Anemia. 2021;1-7.

16. Jones G, Barker A. Reference intervals. The Clinical biochemist. Reviews. 2008;29(1):S93–S97.

17. National Population Commission (NPC). National Census, figures, Abuja, Nigeria. 2006;206-210.

18. Azuonwu O, Nnenna I, Uwuma OE. Evaluation of Haematological Profile of Geriatric Subjects in Port Harcourt Metropolis of Niger Delta of Nigeria. Journal of Clinical and Laboratory Medicine. 2017;2(1):1-8.

19. Catharina S, Trine BR, Sabina S, Stephanie von K, Eva R, Elisabete W. Validity of home-measured height, weight and waist circumference among adolescents. European Journal of Public Health. 2016;26(6):975–977.

20. Bektas MY, Erkan M S, Esra Y. Which anthropometric measurements is most closely related to elevated blood pressure? Family Practice. 2005;22(5):541–547.

21. Suriah AR, Zalifah MK, Zainorni MJ, Shafawi S, Mimie S, Zarina N, Wan ZWA. Anthropometric measurements of the elderly. Malaysian Journal of Nutrition. 1998;4:55-63.

22. Tsai AG, Wadden TA. Obesity. Annals of Internal Medicine. 2013;159(5):1-15.

23. Barbara JB, Imelda B, Micael AL. Dacie and Lewis Practical Haematology. 12th edition, China: Elsevier. 2017;165-186.

24. Olawumi HO, Durotoye IA, Afolabi JK, Fadeyi A, Desalu OO, Aderibigbe SA, Babatunde AS, Ernest SK, Fawibe AE, Salami AK, Saadu R, Adeboye MAN, Aboyeji AP. Reference Values of Haematological Parameters of Healthy Adults in the North Central Zone of Nigeria. East African Medical Journal. 2015;92(8):420-425.

25. Rufaida MAM, Nazik EOSAH. Changes in serum iron, Total- iron binding Capacity and Transferrin Saturation Percent in Sudanese Females Newly Diagnosed with Breast Cancer at Khartoum Oncology Hospital: A case –Control Study, "Sudan Journal of Medical Sciences. 2017;12(3):119-132.

26. Beutler E. Disorders of Iron Metabolism. Prchal JT KK, Lichtman MA, Kipps TJ, Seligsohn U, ed. Williams Hematology. 8th edition, New York: McGraw-Hill. 2010;93-141.

27. Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo AJ. Harrison's Principles of Internal Medicine. 17th Edition, McGraw-Hill Professional Publisher. 2008;2432.

28. Pagana KD, Pagana TJ, Pagana TN. Mosby's Diagnostic and Laboratory Test Reference. 14th edition, St. Louis, Mo: Elsevier. 2019;600-650.

29. Toniya R, Shashi K, Jyotsna R, Madhab L, Ashish S. Biochemical status of serum iron in histopathological grades of oral submucous fibrosis. Journal of Oral Biology and Craniofacial Research. 2020;10(4):753-757.

30. Szoke D, Panteghini M. Diagnostic value of transferrin. Clinical Chimica Acta. 2012;413(15-16):1184-1189.

31. Ilkovska B, Kotevska B, Trifunov G, Kanazirev B. Serum hepcidin reference range, genderdifferences, menopausal dependence and biochemical correlates in healthy subjects. Journal of International Medical Association of Bulgaria. 2016;22(2):1127-1131.

32. Oh HL, Lee JA, Kim DH, Lim JS. Reference values for serum ferritin and percentage of transferrin saturation in Korean children and adolescents. Blood Research. 2018;53(1):18.

33. Saathoff E, Schneider P, Kleinfeldt V, Geis S, Haule D. Laboratory reference values for healthy adults from Southern Tanazania. Tropical Medicine and International Health. 2008;13(5):612–625.

34. Shattnawi KK, Alomari M, Al-Sheyab N, Bani SA. The relationship between plasma ferritin levels and body mass index among adolescents. Scientific Reports. 2018;8(1):1-6.

35. Haidari F, Abiri B, Haghighizadeh MH, Kayedani GA, Birgani NK. Association of hematological parameters with obesity-induced inflammation among young females in Ahvaz, South-West of Iran. International Journal of Preventive Medicine. 2020;11:55.

36. Shekarriz R, Vaziri MM. Iron Profile and Inflammatory Status of Overweight and Obese Women in Sari, North of Iran. International journal of hematology-oncology and Stem Cell Research. 2017;11(2):108–113.

37. Stoffel NU, El-Mallah C, Herter-Aeberli I, Bissani N, Wehbe N, Obeid O, Zimmermann MB. The effect of central obesity on inflammation, hepcidin, and iron metabolism in young women. International Journal of Obesity (London). 2020;44(6):1291-1300.

38. Freixenet N, Remacha A, Berlanga E, Caixàs A, Giménez-Palop O, Blanco-Vaca F, Bach V, Baiget M, Sánchez Y, Félez J, González-Clemente JM. Serum soluble transferrin receptor concentrations are increased in central obesity. Results from a screening programme for hereditary hemochromatosis in men with hyperferritinemia. Clinica Chimica Acta. 2009;400:111–116.

39. Yanoff LB, Menzie CM, Denkinger B, Sebring NG, McHugh T, Remaley AT, Yanovski JA. Inflammation and iron deficiency in the hypoferremia of obesity. International Journal of Obesity (London). 2007;3:1412–1419.

40. Girelli D, Nemeth E, Swinkels DW. Hepcidin in the diagnosis of iron disorders. Blood. 2016;127:2809-2813.

41. Sokoto State Business Directory (SSBD). A publication of the commerce department, ministry of commerce, industry and tourism Sokoto. 2007;14-18.

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