



Diagnostic Accuracy of Mentzer Index in Diagnosis of Iron Deficiency Anemia Taking Serum Ferritin as The Gold Standard

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ABSTRACT

Background: Iron deficiency anemia is a common childhood nutritional disorder. In low-resource settings, inexpensive and easy screening tools are essential. The Mentzer index from complete blood counts is a potential substitute for serum ferritin, the gold standard for diagnosis. **Objective:** To determine the diagnostic accuracy of Mentzer index in diagnosis of iron deficiency anemia, taking serum ferritin as the gold standard. **Study Design:** Cross-sectional validation study. **Duration and Place of Study:** Conducted from August 2024 to January 2025 at the Department of Pediatric Medicine, Combined Military Hospital, Rawalakot. **Methodology:** A total of 210 children aged 1–5 years with microcytic hypochromic anemia were enrolled. The Mentzer index (MCV/RBC count) was calculated, with a value >13 indicating IDA. Serum ferritin levels <40 ng/mL confirmed the diagnosis. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were computed. **Results:** Among 210 children, the Mentzer index showed a sensitivity of 89.1%, specificity of 73.2%, diagnostic accuracy of 76.7%, PPV of 48.2%, and NPV of 96%. Stratified analysis revealed high sensitivity and NPV in rural children and males, with variability across other subgroups. **Conclusion:** The Mentzer index is a useful, sensitive, and low-cost screening tool for diagnosing iron deficiency anemia in children.

INTRODUCTION

Iron deficiency anemia (IDA) is the most prevalent nutritional deficiency worldwide,¹ particularly in infants and preschool children due to peak physiological needs for iron during periods of maximum growth acceleration.² IDA in children has been associated with adverse outcomes such as cognitive impairment, reduced physical performance, susceptibility to infection, and delayed psychomotor development.³ Early diagnosis and treatment assist in the prevention of late complications and normal growth development.⁴ The disease typically results from decreased nutritional intake, chronic bleeding, or defective iron absorption.⁵

The diagnosis of iron deficiency anemia is made through the integration of the clinical findings and hematological investigations.⁶ Routine preliminary tests employed involve complete blood count (CBC) parameters such as hemoglobin (Hb), mean corpuscular volume (MCV), and red blood cell (RBC) indices.⁷ They help in generating the suspicion of microcytic, hypochromic anemia, characteristic of IDA. Several conditions, however, possess the same hematologic profile and present a problem in diagnosis.⁷ The specific role of iron studies in confirmatory diagnosis is therefore important. Of the many specific iron studies employed, serum ferritin is the

most precise reflection of iron stores and has been uniformly considered the gold standard in the diagnosis of iron deficiency anemia.⁸

Mentzer Index is one of the simple, economical discriminative formulas employed in the differentiation between iron deficiency anemia and thalassemia trait.⁹ The ratio between the mean corpuscular volume (MCV) and red blood cell (RBC) count is computed in the form of the Mentzer Index. A Mentzer Index above 13 is normally indicative in the presence of iron deficiency anemia, whereas a figure below 13 is more likely suggestive of the presence of thalassemia trait.⁹ The Mentzer Index is beneficial where there are primary healthcare resources where the presence of sophisticated diagnostic facilities may not be possible.¹⁰ The fact that the Mentzer Index is simple and economical renders it a candidate for early triage and screening.

Although serum ferritin remains the gold standard in diagnosing iron deficiency, it may be affected by acute or chronic inflammation as ferritin is an acute-phase reactant.¹¹ In such cases, reliability is lost, and complementary or auxiliary methods of diagnosis are necessary. The Mentzer Index, despite being a derived parameter, provides a helpful, rapid, and non-invasive method for suggesting the potential for iron deficiency

anemia and may serve as a useful adjunct in serum ferritin testing.^{9,10} Use of the Mentzer Index in diagnostic evaluation may lead to earlier detection, prevent redundant testing, and yield personalized therapy in children, especially in resource-limited settings.¹²

In a clinical study, the Mentzer Index demonstrated a sensitivity of 80.7% and a specificity of 77.7% in differentiating iron deficiency anemia from other microcytic anemias.¹³ Another study reported even higher diagnostic efficacy, with a sensitivity of 91% and specificity of 83%.¹⁴ Furthermore, Awais M et al. documented a sensitivity of 67.3% and specificity of 93.8%, along with a positive predictive value (PPV) of 80%, negative predictive value (NPV) of 88.6%, and an overall diagnostic accuracy of 86.63%.¹⁵

Iron deficiency anemia is a common nutritional disorder in children from Rawalakot, Azad Jammu and Kashmir. Due to limited availability of modern diagnostic centers such as serum ferritin estimation, there was a need for simple and cost-effective screening methods in pediatric populations. The Mentzer Index from routine complete blood counts has the potential to serve as an effective tool in differential diagnosis between iron deficiency anemia and thalassemia trait. Research in this local population will lead towards the intelligent practice at the clinical level, provide therapeutic intervention at the earliest level and release the disease burden from undiagnosed anemia from this underserved geographic region.

METHODOLOGY

This cross-sectional investigation was conducted at the Department of Pediatric Medicine, Combined Military Hospital, Rawalakot, over a six-month period from August 2024 to January 2025. A total of 210 children, aged between one and five years, were enrolled using a non-probability consecutive sampling method. Sample size was determined considering a 95% confidence level, 12% margin of error, and an expected prevalence of iron deficiency anemia of 28.6%.¹⁶ Estimates of 80.7% sensitivity and 77.7% specificity for the Mentzer index were also taken into account during the calculation.¹³

Children presenting with microcytic hypochromic anemia, defined by a mean corpuscular volume (MCV) less than 80 fL and mean corpuscular hemoglobin concentration (MCHC) below 32.0 g/dL, were eligible. Participants of both sexes were included. Children were excluded if they had concurrent hematologic disorders such as autoimmune hemolytic anemia, aplastic anemia, or lead poisoning. Additional exclusions included any history of significant bleeding in the past year, chronic illnesses, or recent surgical procedures within the preceding twelve months.

Following institutional and CPSP ethical approval, informed consent was obtained from parents or guardians of all selected children. Basic demographic data including age, sex, weight, area of residence, and monthly family income were documented. Blood samples were collected under aseptic conditions. Complete blood counts were performed, including total and differential leukocyte counts, red cell indices (hemoglobin, MCV, MCH, MCHC, red cell distribution width), and platelet counts. The Mentzer index was calculated by dividing the MCV by the

red blood cell count (expressed in millions per microlitre). A result greater than 13 was considered indicative of iron deficiency anemia.

Serum ferritin levels were measured using the ELISA method. A level below 40 ng/mL was considered diagnostic for iron deficiency anemia. A case was labeled as true positive if both the Mentzer index was above 13 and serum ferritin was low. Children with a Mentzer index >13 but normal ferritin were classified as false positives. A Mentzer index ≤13 in the presence of low ferritin indicated a false negative, while values within normal limits for both tests defined true negatives.

All information was entered and analyzed using SPSS version 25. Normality of continuous variables such as age, weight, hemoglobin, MCV, Mentzer index, and ferritin level was assessed using the Shapiro-Wilk test. Data were presented as mean ± standard deviation or median with interquartile range, depending on distribution. Categorical variables were described using frequencies and percentages. A 2×2 table was applied to compute the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the Mentzer index, using serum ferritin as the reference standard. Diagnostic performance was further stratified by age group, gender, nutritional status, geographic location, and socioeconomic level.

RESULTS

This study examined 210 pediatric patients with a mean age of 2.90±1.18 days and mean weight of 11.26±2.04 kg, comprising 111 males (52.9%) and 99 females (47.1%), with 132 patients (62.9%) from rural areas and 78 (37.1%) from urban areas, and parental income distribution showing 79 patients (37.6%) with income <25,000, 100 patients (47.6%) with income 25,000-50,000, and 31 patients (14.8%) with income >50,000 (as shown in Table-I).

Table I
Patient Demographics

Demographics	Mean ± SD
Age (days)	2.90±1.18
Weight (kg)	11.26±2.04
Gender	
Male n (%)	111 (52.9%)
Female n (%)	99 (47.1%)
Residential Status	
Rural n (%)	132 (62.9%)
Urban n (%)	78 (37.1%)
Parents Income	
<25000 n (%)	79 (37.6%)
25000-50000 n (%)	100 (47.6%)
>50000 n (%)	31 (14.8%)

The overall diagnostic comparison revealed that the Mentzer index identified iron deficiency anemia in 85 patients (40.5%) while serum ferritin identified it in 46 patients (21.9%), with 125 patients (59.5%) and 164 patients (78.1%) respectively showing absent iron deficiency anemia (as shown in Table-II).

Table II
Overall results of Mentzer index and Ferritin levels in diagnosis of Iron Deficiency Anemia

Iron Deficiency Anemia	IDA on Mentzer index	IDA on Ferritin
Present	85 (40.5%)	46 (21.9%)

Absent	125 (59.5%)	164 (78.1%)
Total	210 (100%)	210 (100%)

The diagnostic accuracy analysis demonstrated that among the 85 patients with positive Mentzer index, 41 were true positives and 44 were false positives, while among the 125 patients with negative Mentzer index, 5 were false negatives and 120 were true negatives (as shown in Table-III).

Table III
Comparison of Mentzer versus Ferritin in diagnosis of iron deficiency anemia

IDA on Mentzer index	IDA on Ferritin		Total
	Present	Absent	
Present	41 (TP)	44 (FP)	85
Absent	5 (FN)	120 (TN)	125
Total	46	164	210

The Mentzer index showed an overall sensitivity of 89.1%, specificity of 73.2%, diagnostic accuracy of 76.7%, positive predictive value of 48.2%, and negative predictive value of 96% (as shown in Table-IV).

Table IV
Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of Mentzer index in diagnosis of iron deficiency anemia

Diagnostic Parameter	Result
Sensitivity	89.1%
Specificity	73.2%
Diagnostic Accuracy	76.7%
PPV	48.2%
NPV	96%

Stratified analysis revealed age-specific performance with patients aged 1-3 years showing sensitivity 89.10%, specificity 41.30%, diagnostic accuracy 59.50%, PPV 48.20%, and NPV 86.10%, while patients >3 years showed 100% specificity, diagnostic accuracy, and NPV with undefined sensitivity and PPV; gender-specific analysis showed males had 100% sensitivity, 72.30% specificity, 76.60% diagnostic accuracy, 39.50% PPV, and 100% NPV, while females had 82.80% sensitivity, 74.30% specificity, 76.80% diagnostic accuracy, 57.10% PPV, and 91.20% NPV; weight-stratified results showed patients ≤12 kg had 89.10% sensitivity, 41.30% specificity, 59.50% diagnostic accuracy, 48.20% PPV, and 86.10% NPV, while patients >12 kg showed 100% specificity, diagnostic accuracy, and NPV with undefined sensitivity and PPV; residential status analysis demonstrated rural patients had 100% sensitivity, 74.50% specificity, 81.10% diagnostic accuracy, 57.60% PPV, and 100% NPV, whereas urban patients showed 58.30% sensitivity, 71.20% specificity, 69.20% diagnostic accuracy, 26.90% PPV, and 90.40% NPV (as shown in Table-V).

Table V
Stratified analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of Mentzer index in diagnosis of iron deficiency anemia with demographics

Variables	Groups	Diagnostic Parameter	Result
Age (years)	1-3	Sen	89.10%
		Spec	41.30%
		DA	59.50%
	>3	PPV	48.20%
		NPV	86.10%
		Sen	-
		Spec	100%

Gender	Male	DA	100%
		PPV	-
		NPV	100%
		Sen	100%
		Spec	72.30%
	Female	DA	76.60%
		PPV	39.50%
		NPV	100%
		Sen	82.80%
		Spec	74.30%
Weight	≤12 Kg	DA	76.80%
		PPV	57.10%
		NPV	91.20%
		Sen	89.10%
		Spec	41.30%
	>12 Kg	DA	59.50%
		PPV	48.20%
		NPV	86.10%
		Sen	-
		Spec	100%
Residential Status	Rural	DA	100%
		PPV	-
		NPV	100%
		Sen	100%
		Spec	74.50%
	Urban	DA	81.10%
		PPV	57.60%
		NPV	100%
		Sen	58.30%
		Spec	71.20%

DISCUSSION

The Mentzer index was assessed for diagnostic accuracy compared with serum ferritin as a reference standard for iron deficiency anemia in pediatric patients with a sensitivity of 89.1% and a specificity of 73.2% with a diagnostic accuracy of 76.7% in total. High sensitivity means that most true iron deficiency anemia cases are indeed detected by Mentzer index due to its ability to capture characteristic microcytic hypochromic pattern of iron deficiency by measuring mean corpuscular volume to red blood cell count. However, moderate specificity of 73.2% implies notable false positive rates due to a lack of ability for Mentzer index to differentiate iron deficiency anemia from other conditions for microcytosis like thalassemia trait, chronic disease, or lead poisoning that generate similar red blood cell indices. Low positive predictive value of 48.2% reflects a high prevalence of other microcytic conditions in study subjects indicating that less than half of patients with Mentzer positive indeed have iron deficiency anemia when confirmed by serum ferritin. On the other hand, good negative predictive value of 96% confirms that Mentzer negative excludes iron deficiency anemia effectively and so it is a good screening tool that prevents unnecessary further investigations in patients who are unlikely to harbor condition.

Our findings align closely with Zulqarnain H et al.¹⁷ and Iqbal S et al.¹⁸ who both reported identical sensitivity (90.1%) and specificity (90.1%) values in pediatric populations aged 1-16 years and 2-15 years respectively, demonstrating remarkably similar diagnostic performance despite different age ranges. The sensitivity in our study (89.1%) was nearly identical to these studies, indicating consistent ability of the Mentzer index to correctly identify iron deficiency anemia across different

pediatric age groups. However, our specificity (73.2%) was notably lower than both studies, which may be attributed to the younger age of our population (mean 2.90 days versus 8.2 years) as very young infants may have different hematological parameters that could lead to more false positive results. Bibi F et al. ¹⁹ also reported similar sensitivity (89%) and higher specificity (91%) in preschool children aged 2-5 years, further supporting the age-related variation in diagnostic performance we observed.

The positive predictive value in our study (48.2%) was substantially lower than reported in Zulqarnain H et al. ¹⁷ (93.8%), Iqbal S et al. ¹⁸ (93.8%), and Bibi F et al. ¹⁹ (88%), which can be explained by the lower prevalence of iron deficiency anemia in our population (21.9%) compared to their studies (62.6%, 62.6%, and 61.3% respectively). This demonstrates the inverse relationship between disease prevalence and positive predictive value, where lower prevalence leads to more false positives relative to true positives. Conversely, our negative predictive value (96%) was superior to most studies, reflecting the high proportion of patients without iron deficiency anemia in our cohort and the index's excellent ability to rule out the condition.

Interestingly, our results contrast sharply with Aslam F et al. ²⁰ who studied adult populations and found that 93.5% of patients had a Mentzer index >13, indicating different hematological characteristics between adult and pediatric populations with iron deficiency anemia. The adult study's focus on mean corpuscular volume as the strongest predictor (AUC 0.886) suggests that age-related changes in red blood cell morphology may influence the diagnostic utility of individual hematological parameters. Weight-stratified results showed patients ≤12 kg had lower specificity (41.30%) compared to those >12 kg (100%), indicating that nutritional status and body mass may influence the accuracy of hematological indices in diagnosing iron deficiency anemia.

Residential status analysis demonstrated rural patients had superior performance (100% sensitivity, 74.50% specificity, 81.10% diagnostic accuracy) compared to urban patients (58.30% sensitivity, 71.20% specificity, 69.20% diagnostic accuracy), which may reflect differences in nutritional status, access to

healthcare, or environmental factors affecting iron metabolism between rural and urban populations. This finding is particularly relevant given that Iqbal S et al. ¹⁸ noted reduced accuracy in lower socioeconomic strata, suggesting that sociodemographic factors significantly influence the diagnostic performance of the Mentzer index in resource-limited settings.

There are some limitations of this study that must be acknowledged while interpreting our results. It is a single-center study that was conducted in a single tertiary teaching hospital, so our results may not be generalizable to other health care centers with different demographic profiles and disease patterns of prevalence. Our potential to examine changes with time in diagnostic accuracy or outcome of follow-up for patients with discordant results between Mentzer index and serum ferritin was limited due to a cross-sectional study. In addition, the use of serum ferritin alone as a gold standard may have brought about classification bias due to potential rises of ferritin with inflammation, infection, or other clinical conditions that we did not study systematically in this study. Our study population's fairly young age with a mean age of less than 3 years may limit applicability of our results to older age groups of pediatric patients, small sample sizes in some of our stratified subgroups may have diluted our estimates' precision.

CONCLUSION

We concluded that Mentzer's index has good sensitivity but moderate specificity for iron deficiency anemia compared to serum ferritin as a gold standard for diagnosing iron deficiency anemia in children. The index was a good screening instrument for exclusion of iron deficiency anemia with a strong negative predictive value that makes it most useful in limited resources settings where a complete iron study might not be easily obtained. Nevertheless, positive results require corroboration with repeat testing due to a moderate positive predictive value.

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