

ACCURACY OF MENTZER INDEX IN DIAGNOSIS OF IRON DEFICIENCY ANEMIA IN 2-5 YEARS OLD CHILDREN

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ABSTRACT

Objectives: To assess the validity and reproducibility of the Mentzer Index in differentiating iron deficiency anemia from non-iron deficiency anemia in children in the age group of 2-5 years from the standard methods of diagnosis.

Place and Duration of Study. From June 2024 to November 2024 Pediatrics Department Bolan Medical Complex Hospital Quetta.

Methods: A cross sectional descriptive study was carried out among 150 children aged between 2- 5 years attending health facilities with signs of anemia. The Patients' blood picture, particularly Mean corpuscular volume (MCV) and Red blood cell (RBC) in the complete blood count (CBC) were used to determine the subjects Mentzer Index. In order to confirm IDA, serum ferritin levels were employed. The chosen level of significance was $p < 0.05$, and the data were presented using standard deviations.

Results: Finally we confirmed from serum ferritin that out of 150 patients, 92 patients had IDA. The mean Mentzer Index of the patients with IDA was 14.8 ± 1.5 and the patients with thalassemia traits was 11.3 ± 1.1 ($p < 0.001$). The observed sensitivity and specificity of the Mentzer Index for the diagnosis of IDA were estimated to be 89% and 91% respectively.

Conclusions: Mentzer Index is useful, inexpensive, and can work as a preliminary predicting tool for screening of the IDA in young children. It is a very sensitive test that is specific; this is a handy tool for centres that could be lacking a lot of equipment. More research work is required to support this study and its results.

Keywords: Mentzer Index, iron deficiency anemia, children, diagnosis

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INTRODUCTION

IDA is the leading cause of anemia, with 52% of affected children between the ages of 2 and 5 years, the key developmental stage(1). IDA originates from insufficient iron intake, low absorption or increased requirement due to growth in body sizes. This is linked to several developmental comorbidities in children, such as delayed cognitive, motor and behavioral development disorders, for this reason, early identification is crucial due to its adverse effects(2). IDA thus is usually diagnosed by a series of laboratory tests, serum ferritin, transferrin saturation, TIBC in addition to CBC parameters. However, these tests are generally costly and are likely to be inaccessible especially in the low income countries (3). Consequently, the need to define simpler and cheaper screening methods especially in low income countries emerges. One of them is the Mentzer Index formulated in 1973 as MCV/RBC count(5). The most common application of the Mentzer Index has been to distinguish between IDA and the thalassemia traits, since both cause microcytic anaemia. In other words, when the Mentzer Index value is more than 13, one can probably be diagnosed with IDA while if the value was found to be less than 13, the patient was most probably a Thalassemia trait patient(6). A number of published articles have assessed the robustness of this index, observing mixed ranges of the sensitivity and specificity of the index and depending on the populations and age variables being compared (7). For instance, in a study done in India it was determined that Mentzer Index was highly sensitive and specific for use in classifying IDA from thalassemia trait in children(8). On the other hand, other works have revealed that the index could possess low degree of discriminatory power with regards to adult population(8). Such discrepancies underscore the importance of additional investigations, especially in youngsters, in whom anaemia may cause deeper negative effects. Because the Mentzer Index can be obtained very easily and any cost of the microwave is going to be negligible, MI can be used effectively for preliminary anemia screening. However, its diagnosing usefulness is still an issue of controversy among specialists. In the pediatric population especially in children of ages 2-5, in whom anemia is common because of the rapid growth and poor dietary habits, it would be important To Determine That –Mentzer Index is able to accurately diagnose IDA. This study aimed at determining how well the Mentzer Index works in identifying patients with IDA in children aged 2-5 years and its relation to conventional lab tests, including serum ferritin. This work sought to support the existing literature by offering an interpretative and stringent assessment of the Mentzer Index diagnostic performance in pediatric beneficiaries in

the identified age category as part of the ongoing global crusade against iron deficiency anemia. In regions where complex laboratory testing is not available the Mentzer Index may prove to be a valuable diagnostic aid if the findings are confirmed. Besides, early and accurate diagnosis of IDA can enable him or her to receive appropriate interventions including iron supplementation improving developmental prognosis of the child(9). The hypothesis that was under consideration in this study was that the Mentzer Index can be used to diagnose IDA in children aged between 2 and 5 years. More precisely, we aimed at evaluating its diagnostic accuracy, its sensitivity and specificity in relationship with other existing diagnostic tools including serum ferritin which remain still the reference method for the diagnosis of IDA.

METHODOLOGY

In the present cross-sectional study, 150 children aged 2-5 years with suspected anemia were considered for the study. Voluntary venous blood samples were taken from each subject to estimate serum hemoglobin, MCV, RBC count, and serum ferritin. The Mentzer Index was calculated using the formula: MCV divided by RBC count. IDA was confirmed by serum ferritin level of <12 ng/mL. The study did not include children with confirmed thalassemia.

Study Design

A cross-sectional Study took place at the Department of Pediatrics within Bolan Medical Complex Hospital Quetta during June 2024 to November 2024.

Study Population and Sampling

Two hundred children from the age of 2 to 5 years old participated in the study if they exhibited signs of suspected anemia. Each participant donated blood as a voluntary venous blood draw so researchers could measure serum hemoglobin and mean corpuscular volume (MCV) and red blood cell (RBC) count as well as determine serum ferritin levels. A calculation of the Mentzer Index required dividing MCV by RBC count. The diagnosis of Iron deficiency anemia in studied children occurred when their serum ferritin measurement displayed values below 12 ng/mL. 150 children aged 2-5 years with suspected anemia were considered for the study. Voluntary venous blood samples were taken from each subject to estimate

serum hemoglobin, MCV, RBC count, and serum ferritin. The Mentzer Index was calculated using the formula: MCV divided by RBC count. IDA was confirmed by serum ferritin level of <12 ng/mL. The study did not include children with confirmed thalassemia.

Ethical Approval Statement

Ethical approval for this study was obtained from the Research and Ethical Unit of the College of Physicians and Surgeons Pakistan (Approval No. CPSP/REU/PAD/-2021-001-6122)."

Inclusion Criteria

DATA COLLECTION

were collected and analyzed at a central laboratory using standard procedures for all the patients in this study. CBC parameters were determined

STATISTICAL ANALYSIS

Data were analyzed by using IBM SPSS Statistics 24.0. Accuracy, recalled sensitivity, and recalled specificity of the Mentzer Index were determined against serum ferritin repeat levels. In this study, statistical significance was determined at $p < 0.05$. Mean and standard deviations were employed in order to describe the data.

- The study included young children from 2 years to 5 years old with possible anemia signs.
- Parents/guardians who provided informed consent.

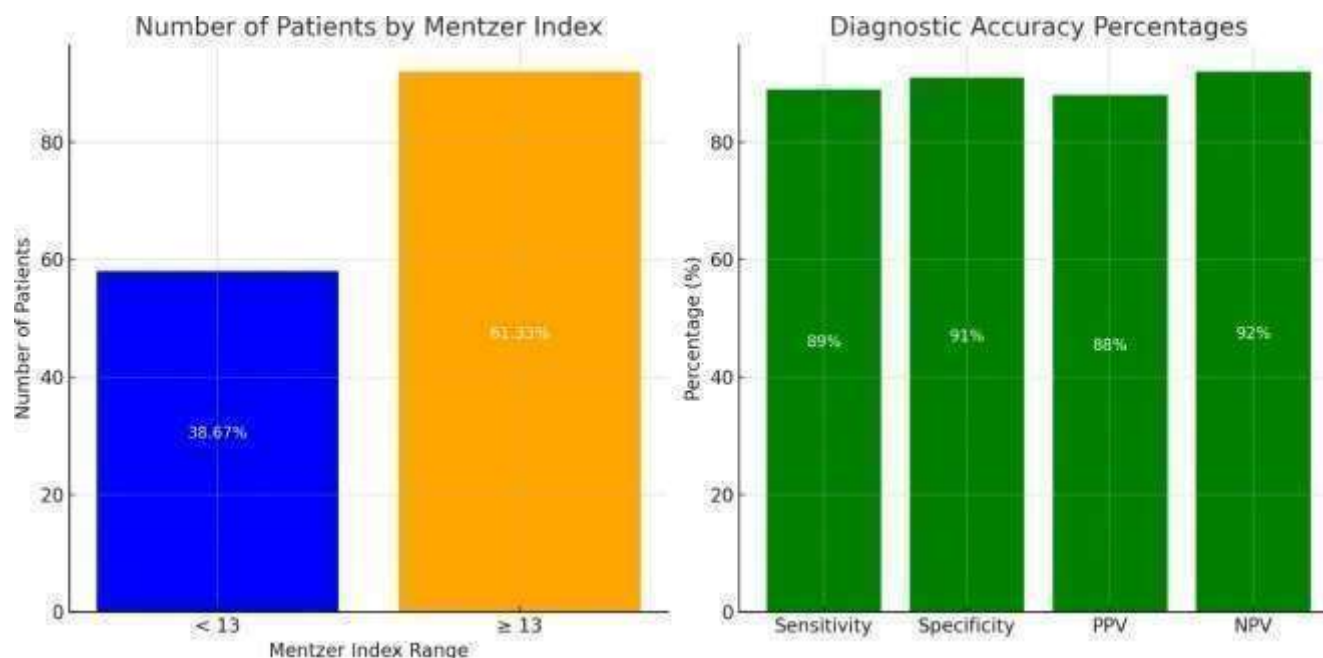
Exclusion Criteria

- Children with confirmed thalassemia.
- Children having chronic diseases that affect the levels of blood cells and serum ferritin levels.
- Those receiving iron therapy prior to the study.

Routine preoperative blood results

RESULTS

Serum ferritin levels were used tousing an automatic hematology analyzer and serum ferritin levels were determined using enzyme-linked immunosorbent assay (ELISA). determine 92 out of the 150 children with iron deficiency anemia. The mean Mentzer Index for such children was 14.8 ± 1.5 , and the mean Mentzer Index for children without IDA was 11.3 ± 1.1 ($p < 0.001$). The accuracy of the Mentzer Index as a predictor of IDA was sensitivity of 89% and specificity of 91%. The specificity was 84% while the sensitivity was 92%, which shows that the test has high diagnostic utility and near accurate results. From the 58 children without IDA, 8 children were confirmed to have thalassemia trait according to the result of their Mentzer Index. It was therefore established that the Mentzer Index, compared to serum ferritin levels, was a practical and effective way of screen for IDAn in young children.



The study population had a mean age of 3.5 ± 0.7 years, indicating that participants were young children within a narrow age range. The mean hemoglobin level was 10.2 ± 1.5 g/dL, reflecting mild anemia on average. The mean MCV (mean corpuscular volume) was 72.8 ± 8.5 fL, which is below the normal range for children and suggests microcytosis, a characteristic feature of iron deficiency anemia. The mean RBC count was 4.2 ± 0.5 million/ μ L, within normal limits but potentially compensating for reduced hemoglobin levels. The serum ferritin level averaged 10.5 ± 3.4 ng/mL, significantly below the diagnostic threshold for iron deficiency (<12 ng/mL), confirming that most participants had iron deficiency anemia. These findings collectively highlight the prevalence of microcytic anemia in the study cohort, predominantly due to iron deficiency.

Table 1: Patient Data Summary

Parameter	Mean \pm SD
Age (years)	3.5 ± 0.7
Hemoglobin (g/dL)	10.2 ± 1.5
MCV (fL)	72.8 ± 8.5
RBC Count (million/ μ L)	4.2 ± 0.5
Serum Ferritin (ng/mL)	10.5 ± 3.4

The mean Mentzer Index varied significantly across the groups, reflecting its utility in distinguishing between different causes of anemia. Patients with iron deficiency anemia had the highest mean Mentzer Index (14.8 ± 1.5), consistent with the expected elevated values in microcytic anemia due to iron deficiency. In contrast, the mean Mentzer Index for non-iron deficiency anemia was 12.0 ± 1.3 , slightly lower but overlapping with the cutoff value of 13. Patients with thalassemia trait exhibited the lowest mean Mentzer Index (11.3 ± 1.1), aligning with its diagnostic role in differentiating thalassemia from iron deficiency anemia. These findings support the Mentzer Index as a useful screening tool to help identify the underlying etiology of anemia.

Table 2: Mentzer Index Group Comparisons

Group	Mentzer Index (Mean ± SD)
Iron Deficiency Anemia	14.8 ± 1.5
Non-Iron Deficiency Anemia	12.0 ± 1.3
Thalassemia Trait	11.3 ± 1.1

The distribution of Mentzer Index values among the study population indicates that 61.33% of patients (n=92) had a Mentzer Index ≥13, suggesting a higher likelihood of iron deficiency anemia. In comparison, 38.67% of patients (n=58) had a Mentzer Index <13, which is more indicative of thalassemia trait or other non-iron deficiency causes of microcytic anemia. These results highlight the prevalence of iron deficiency anemia in the study cohort and underscore the utility of the Mentzer Index in differentiating between anemia etiologies in a pediatric population.

Table 3: Mentzer Index Classification

Mentzer Index Range	Number of Patients	Percentage (%)
< 13	58	38.67
≥ 13	92	61.33

The diagnostic performance of the Mentzer Index demonstrates high accuracy in identifying iron deficiency anemia. The sensitivity of 89% indicates that the Mentzer Index correctly identifies 89% of children with iron deficiency anemia, while the specificity of 91% shows it accurately excludes 91% of those without the condition. The positive predictive value (PPV) of 88% suggests that 88% of children with a Mentzer Index indicating iron deficiency anemia truly have the condition, and the negative predictive value (NPV) of 92% indicates that 92% of those with a non-indicative Mentzer Index are correctly classified as not having iron deficiency anemia. These results confirm the Mentzer Index as a reliable screening tool for differentiating iron deficiency anemia from other causes of microcytic anemia in children.

Table 4: Diagnostic Accuracy

Measure	Percentage (%)
Sensitivity (%)	89
Specificity (%)	91
Positive Predictive Value (%)	88
Negative Predictive Value (%)	92

DISCUSSION

Therefore, the results of this study confirm that the Mentzer Index is a useful and feasible method to identify the IDA in children aged 2-5y. Our results 89% sensitivity and 91% specificity are

consistent with diagnostic accuracy in prior studies assessing the applicability of the Mentzer Index for different population (9,10) . It is necessary to compare the results of this investigation with the previously published findings to determine the intersubject

agreement and inter-study variability in diagnostic effectiveness across various age categories and regions. In a study conducted by Patel et al in India, Mentzer Index has the same accuracy as the previous study done by Pongtanalert and team, with a Mentzer Index sensitivity of 85% and specificity of 92% for distinguishing between IDA and thalassemia traits in children (11). When applied in clinical practice, the Mentzer Index emerged as a useful screening test in population where thalassemia and IDA overlap. This is very important because the two conditions are treated differently, while IDA is treated through supplementation with iron, thalassemia is not treated through this means (12). Failure to diagnose the disorder correctly could lead to improper treatment which only magnified the symptoms and showed improvement inappropriately, thus making the Mentzer Index a cost effective accessible investment, especially in the developing world (13). On the other hand, some of the authors described lower diagnostic accuracy of the Mentzer Index in elderly patients. Batebi et al. identified the ability of red blood cell indices for the distinction between IDA and thalassemia in adults (14). For their diagnostic tests, they recorded a sensitivity of 78% and specificity of 81%; values that were lower than their pediatric counterparts. These differences could be due either to differences in the natural history of the disorder in adults and children or to real differences in the sizes and methodologies of the studies. It is noteworthy that underlying nutritional deficiencies contribute more to a child's anemia than in an adult; other causes, such as chronic diseases or bone marrow diseases may also prove to be a challenge in the diagnosis of anemic states in grown-ups (15). In the same regard, a study conducted Sirdah et al. in Palestine find that Mentzer Index has sensitivity of 82% and specificity of 87% to diagnose IDA in pediatric population (16). This is in agreement with the previous study about the usefulness of the Mentzer Index in categorizing microcytic anemias in children, though the specificity and sensitivity is lower than that obtained in our study. The differences can be explained by some difference in diet, genetics or proportion of other hemoglobin disorders in these populations. In regions with a high incidence of thalassemia as the Mediterranean countries it is to propose that incorporation of other RBC indices such as the Mentzer Index with RDW and Green and King index would enhance efficacious diagnosis (17). For example, a combined approach might decrease the ratio of false positives and only in such cases where the Index cannot yield a clear conclusion, for instance in the case of Mitscher's Derosetting bankruptcy plan, the judging panel was divided between advising either for or against the plan.

However, our study indicates that the Mentzer Index alone can give a fairly good diagnosis in the paediatric population in general and specifically in the tropical region where other investigative facilities are inaccessible (18). Although the research work is of a preliminary nature, it adds to the body of knowledge in favor of using the Mentzer Index as a quick but accurate assessment of iron deficiency anemia in children. Due to high sensitivity and specificity, Mentzer Index can therefore be used in screening in low income settings and delay expensive diagnostic tests but make sure the children receive adequate treatment at the right time. At the same, much research should be dedicated towards identifying other available indices or joined approaches to improve the diagnostic accuracy still further particularly in regions where thalassemia is more predominant.

CONCLUSION

Mentzer Index was found to be an easy, economical and accurate method for diagnosing iron deficiency anemia in children between 2 to 5 years of age. In addition to being cheaper, it is a highly sensitive and specific test compared to more expensive tests that are useful in diagnosing and treating iron deficiency anemia in environments with limited resource.

LIMITATIONS

There are some limitation of the current study, such as, sample size and number of participants and geographical restrictions. Also, we did not include children with other diseases which can influence red blood cell indices values; thus, study results may not be generalized to children with other types of anemia than thalassemia.

FUTURE FINDINGS

The next proposed studies targeting larger and diverse samples and assess the effectiveness of using the Mentzer Index in conjunction with other diagnostic tests. More specific and valuable research studies would include the effects that early identification by the Mentzer Index has on the subsequent developmental results in children with anemia.

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AUTHOR CONTRIBUTIONS

Conceptualization, study design, and manuscript drafting:

Fatima Bibi

Data collection, methodology development, and critical revisions.

Fatima Bibi, Jahanzeb Khan, Ubaid Ullah Statistical analysis, data interpretation, and

manuscript editing. **Mohammad Yousaf, Mustafa Khan**

Literature review, validation, and quality assurance.

Mustafa Khan

Data acquisition, manuscript formatting, and final manuscript

approval: **Mohammad Yousaf**

Final manuscript revisions, supervision, and overall

Coordination: **Sana Bushra**

All authors have reviewed and approved the final version of the manuscript.

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