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Accuracy of Dietary Assessment Methods as a Measurement of Micronutrient Intake in Adolescents: Scoping Review

Akurasi Metode Penilaian Konsumsi Pangan sebagai Pengukuran Asupan Mikronutrien pada Remaja: Scoping Review

Abdul Malik Simatupang[1]*, Yulia Lanti Retno Dewi[2], Tri Rejeki Andayani[3]

[1]Master Program of Nutritional Science, Graduate School, Universitas Sebelas Maret, Surakarta, Indonesia
[2]Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia
[3]Faculty of Psychology, Universitas Sebelas Maret, Surakarta, Indonesia

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Correspondent:
Abdul Malik Simatupang
abdulmaliksimatupang@student.uns.ac.id

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ABSTRACT

Background: Micronutrient deficiency, including iron, vitamin A, B-12 and folic acid, can cause anemia and harm adolescent health. Accurate dietary assessment methods is crucial to detect micronutrient deficiencies, but existing methods, have limitations, necessitating a review to identify the accurate methods for assessing micronutrient intake in adolescents.
Objectives: To determine the accuracy of dietary assessment methods as suitable option for measuring micronutrient intake in adolescents.
Methods: This study utilized the Preferred Reporting Items for Systematic Review and Meta-Analysis extension for Scoping Review (PRISMA-ScR) flowchart approach. Article were identified from ScienceDirect, PubMed, Scopus, Google Scholar. Articles were included if participants aged 10-19 years, published between 2014-2024, written in English/Indonesian, original research articles and studies related to validation of dietary assessment methods for micronutrient intake. The keywords were "micronutrient intake" OR "dietary intake" AND "dietary assessment" OR "validity" AND "adolescent".
Discussions: 1157 articles were identified, 7 met the eligibility criteria, including 50 to 1081 adolescent. The Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) method was valid for sodium, niacin, folate, thiamine, calcium, phosphorus and reproducible for vitamin A, vitamin C, thiamine, riboflavin, niacin, iron, calcium, phosphorus, potassium, β-carotene. The Food Frequency Questionnaire (FFQ) method was valid for riboflavin, vitamin C, calcium, serum iron biomarkers, and reproducible for retinol, thiamine, riboflavin, vitamin C, vitamin D, iron, calcium. The 24-hour Dietary Recall (24hDR) method showed acceptable validity for serum iron biomarkers.
Conclusions: The SQ-FFQ, completed by adolescents with instruction of nutritionist, using a shorter food list and time intervals, has higher relative validity and reproducibility.

INTRODUCTION

Adolescence is a phase of life that spans between the ages of 10 and 19[1]. It is a crucial period characterized by rapid physical growth, psychological and body composition changes[2]. This rapid growth necessitates adequate nutritional support[3], impacting dietary preferences, nutrient intake, and nutritional status[4]. The energy and protein requirements of adolescents are the highest compared to other age groups and the need for micronutrients such as iron, calcium, zinc and vitamin D increases during adolescence rendering adolescents vulnerable to micronutrient deficiencies[5].

Micronutrients are vitamins and minerals required in small amounts yet play a vital role in physiological and cognitive functions[6]. Micronutrient deficiency indicates a lack of vitamins and minerals in the human body[7]. Micronutrient deficiencies have shown increase the risk of chronic disease and can lead to deficit in cognitive functioning and affecting general intelligence in adolescents[8]. Micronutrient deficiencies, such as iron and vitamin A, folic acid, vitamin B-12 contribute to anemia in adolescents[9]. Epidemiologically, a study has shown that single micronutrient deficiencies rarely occur alone; often, multiple deficiencies like vitamin A, folate, and zinc coexist. These long-term effects harm individual health and negatively impact national economic development and human capital[10]. The prevalence of micronutrient deficiencies is difficult to determine globally because these deficiencies often lack symptoms and are hard to detect[11]. Nevertheless, according to the WHO, nearly one-third of the global population or two billion people suffer from micronutrient deficiencies[11].

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Accurate nutritional intake measurement can be utilized to identify micronutrient deficiencies by collecting data on eating patterns, eating behaviors and diet quality[12]. Nutritional intake is measured using dietary assessment methods systematically gathering, classifying, and synthesizing individual or group intake[13] then compared with nutritional recommendations to identify deficiencies[14]. Accurate dietary assessment methods is crucial for measuring micronutrient intake[15], relationship between diet and health outcomes[16], developing nutrition policies and dietary guidelines[17]. Furthermore, accurate dietary assessment methods are essential for epidemiological studies[18] and evaluating patients in clinical settings[16].

Dietary assessment methods such as dietary records, 24hDR and FFQs are commonly used to measure nutrient intake[17]. Nevertheless, numerous dietary assessment methods are prone to inaccuracies, often classified as over or under-reporting[19]. Reporting errors in dietary intake that lead to bias can caused by various factors, including memory, social desirability[20], perception, participant burden, the understanding of portion sizes and knowledge[19]. Other potential errors can arise during coding process of reported intake, particularly if the coders are not properly trained[20]. The presence of potential biases and misreporting in dietary assessment methods necessitates a review to identify accurate methods for assessing micronutrient intake, particularly among adolescents. Based on these considerations, a scoping review was chosen, because this method is effective in synthesizing and identifying evidence from various sources to provide a better understanding and address specific questions about the research problem[21]. Therefore, the aim of this scoping review was to assess the accuracy of dietary assessment methods as a suitable option for measuring micronutrients intake in adolescents.

METHODS

This research is the result of study review comprising various journal articles related to dietary assessment method among adolescents. The research design utilizes a scoping review method referring to the Arksey and O'Malley's framework[22], consisting of 5 steps including identifying research questions, identifying articles, selecting articles, extracting data, and summarizing and reporting results. The scoping review is structured based on PRISMA-ScR[22].

Identification of Research Questions

The framework used in developing focus of the review and constructing questions in the research is the Population, Exposure, Outcome, Study Design (PEOS). This framework is commonly used in qualitative questions, but it can be employed in identifying questions and developing searches in conducting a scoping review[23]. Based on the framework in Table 1, the research question obtained is: How accurate are dietary assessment methods in measuring micronutrient intake in adolescents?

Table 1. Population, Exposure, Outcome and Study Design (PEOS) framework

P (Population)	E (Exposure)	O (Outcome)	S (Study Design)
Adolescents age 10-19 years old	Micronutrient intake	Dietary assessment methods	All articles related to dietary assessment methods for micronutrient intake

Article Identification

Article identification was conducted by searching for relevant articles in databases and then extracting and importing them into reference management software (Mendeley). The databases used were Science Direct, PubMed, Scopus, and Google Scholar. The next step was to identify articles based on inclusion and exclusion criteria. The inclusion criteria used in this scoping review were: articles populations adolescents aged 10-19 years old, published between 2014 and 2023, articles in English and Indonesian, original research articles, articles published in journals or proceedings, and articles related to the validation of dietary assessment methods for micronutrient intake in adolescents. Exclusion criteria included review articles, reports, or books, as well as paid articles. Article searches used a search strategy using Medical Subject Headings (MeSH) keywords. The keywords used were "micronutrient intake" OR "dietary intake" AND "dietary assessment" OR "validity" OR "reliability" AND "adolescent".

Article Selection

The article selection process utilizes PRISMA flowchart method. The PRISMA flowchart method is used because this flowchart positively influences the completeness of reporting, thus helping to provide better results regarding the relevance of the needed outcomes. Additonally, this method enhances tranparency in the article selection process[24]. The PRISMA flowchart diagram in this scoping review can be seen in Figure 1.

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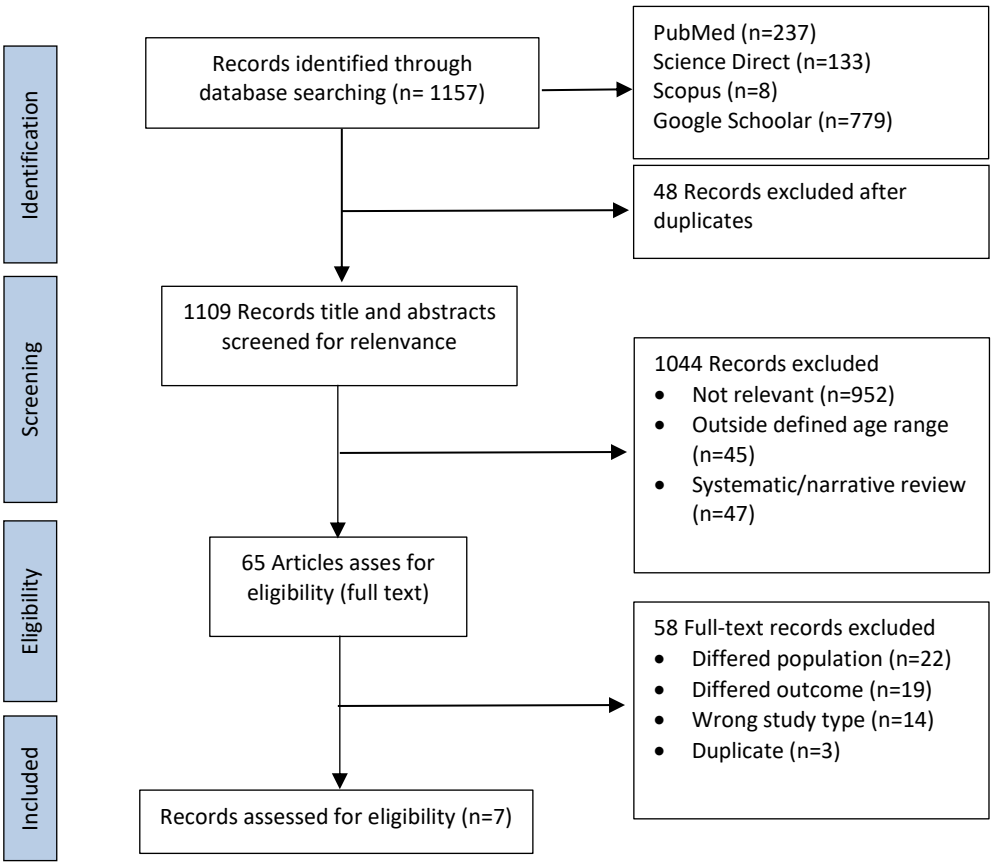

Figure 1. Prisma-ScR Flow Chart

Data Charting

The next stage conducted by the researchers is data charting. This stage involves the organization and synthesis of information. All selected articles are extracted into a table, including: author, year of publication, country, participants, dietary assessment method, reference method, micronutrients, and conclusions. A summary of the article data can be seen in Table 1 below:

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Table 2. Characteristics of included studies

Title/ Author/Year/ Country	Participant	Dietary Assessment Method	Reference Method	Micronutrient	Conclusions
Evaluation of the validity of a food frequency questionnaire and 24-hour dietary recall to assess dietary iron intake in children and adolescents from south american youth/child cardiovascular and environmental study. Collese *et al*. (2022). USA[25]	Fifty adolescents aged 11-17 years.	*FFQ-56 food items, self-administered, intake of three months ago, 11 food groups *24hDR three non-consecutive days (one weekday collected by trained nutritionists, one weekday and one weekend collected by adolescents	Serum iron biomarker, ferritin, hemoglobin	Iron	FFQ shows good validity in determining total iron intake in adolescents. FFQ validation is based on excellent correlation coefficient results of 0.78 for serum iron and ferritin concentration. Meanwhile, 24hDR recall validation shows weak correlation coefficients of 0.28 for both biomarkers.
Relative validity of a semi-quantitative food frequency questionnaire for adolescents. Silva *et al*. (2020). Portugal[26]	80 adolescents aged 10-17 years	*SQ-FFQ-75 food items, intake over the past one month, Self-reported assisted by trained nutritionists, 12 food groups	Three days 24hDR multiple-pass, trained interviewers with knowledge of diet and nutrition	Calcium, sodium, iron, and vitamin C	SQ-FFQ showed acceptable relative validity at individual level for micronutrients such as calcium, sodium and iron.
Biochemical validation of self-administered food frequency questionnaire to assess diet using carotenoids and vitamins E and D in male adolescents in Spain. Notario-Barandiaran *et al*. (2021). Spain[27]	122 adolescent boys aged 15-17 years	SQ-FFQ-104 items, Self-administered	Blood serum biomarker for vitamin E and D	β-carotene, vitamin E, and D	The findings of this study support that FFQ is suitable for self-administered use and may be an acceptable method for assessing dietary intake in epidemiological studies among adolescent boys aged 15-17 years, particularly for antioxidants such as β-carotene. This is based on the significant correlation coefficient between serum β-carotene and β-carotene intake (fruits and vegetables) ($p<0.05$) with an average coefficient value of β-carotene 0.39 and vegetable and fruit β-carotene intake 0.28. Meanwhile, there were non-significant results between serum and vitamin D and E intake with weak correlation coefficients of -0.06 and 0.05, respectively.
Development and validation a food frequency questionnaire	53 adolescents	SQ-FFQ-150 food items, conducted twice over six months by trained staff	24hDR collected three times over six months on weekdays and weekends	Calcium, iron, vitamin B3, retinol, vitamin B2,	The research results offer a valid FFQ for identifying food risk factors. This is indicated by higher correlation coefficient results for calcium 0.54,

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Title/ Author/Year/ Country	Participant	Dietary Assessment Method	Reference Method	Micronutrient	Conclusions
to estimate intake among children and adolescents in urban peru. Rodriguez *et al*. (2017). Peru[28]	aged 8-14 years			vitamin C, folate, and zinc	niacin 0.54, retinol 0.41, and total folate 0.53 with FFQ completion by both children and caregivers compared to completion by caregivers alone, i.e., calcium 0.35, niacin -0.35, retinol 0.02, and total folate -0.55.
Development and evaluation of dish-based seimquantitative food frequency questionnaire for korean adolescents. Yum J. & Seungmin L. (2016). Korea[29]	1081 adolescents (562 males, 519 females) aged 12-18 years	Dish-based SQ-FFQ-71 food items were conducted twice over 4 weeks collected by trained nutritionists	8-day Food records collected eight non-consecutive days (six weekdays, 2 weekends, twice a week)	Vitamin A, vitamin C, B1, B2, B3, calcium, phosphorus, sodium, potassium, and iron	Dish-based SQ-FFQ shows validity and reproducibility in measuring intake in adolescents.
Reproducibility and validity of food frequency questionnaire for dietary assessment in adolescents in self-reported way. Notario-Barandiaran *et al*. (2020). Spainl[30]	51 adolescent boys aged 15-17 years	SQ-FFQ-104 food items, self-administered, 17 food groups	24hDR Multiple-pass, non-consecutive days, self-reported	Retinol, folate, vitamin C, magnesium, potassium, sodium, zinc, and iodine	FFQ is a tool that can be used to assess dietary intake from various nutrient groups among adolescents
Test-retest reliability and validity of web-based food-frequncy questionnaire for adolescents aged 13-14 to be used in the Norweigian Mother and Child Cohort Study (MoBa). Overby *et al*. (2014). Norway[31]	58 adolescents aged 13-14 years	FFQ-131 food items, Self-reported, Intake over the past four weeks	24hDR two non-consecutive days, collected by three master's students and one undergraduate student Biomarker level *25(OH)D_3	Retinol, D, E, B1, B2, C, calcium, and iron	Retesting for reproducibility shows good results, validity with results ranging from weak to good, with weak absolute validity.

*FFQ (Food Frequency Questionnaire), 24hDR (24-hour Dietary Recall), SQ-FFQ (Semi-Quantitative Food Frequency Questionnaire), 25 Hydroxy Vitamin D_3

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DISCUSSIONS

The search across four databases (PubMed, Science Direct, Scopus, and Google Scholar) yielded 1157 articles matching the keywords of this study. Subsequently, a review for duplicates identified 48 articles while 1044 articles were found to lack relevance based on the abstracts. Consequently, 65 full-text articles underwent comprehensive selection. From this selection process, seven articles were deemed suitable aligning with the research objectives, inclusion, and exclusion criteria. Geographically, the research locations in the seven articles are distributed across several countries: two articles originated from Spain[27,30], one from the United States[25], one from Portugal[26], one from Peru[28], one from Korea[29], and one from Norway[31]. Six articles[26,27,28,29,30,31] analyzed two or more types of micronutrients, and one article[25] analyzed a single type of micronutrient, resulting in a detailed examination of nine vitamins and eight minerals, totaling 17 types of micronutrients. The number of participants in the articles varied from 50 to 1081 adolescents ranging in age from 10 to 18 years.

Based on the review of the seven eligible articles, three methods for assessing micronutrient intake in adolescents were found. These three methods are the SQ-FFQ method, FFQ method and 24hDR method. Furthermore, synthesis results from the articles revealed five articles testing the SQ-FFQ method, three of which tested SQ-FFQ with a 24hDR[26,28,30], one with a food record and blood serum biomarkers[27]. Additionally, two articles tested the FFQ method, one article with 24hDR[31] and two articles with blood serum biomarkers[25,31]. Then, one article tested the 24hDR method with blood serum biomarkers[25]. Table 2 shows the relative validity and reproducibility of Spearman and Pearson correlation coefficient values, food lists, time periods, and respondents in the articles as aspects of the method for assessing micronutrient intake. The correlation coefficient values in the scoping review refer to previous studies where they are considered good if the correlation coefficient is ≥0.50, acceptable if it is 0.20-0.49 and weak if it is <0.20[32].

The SQ-FFQ method was tested for relative validity in five articles[26,27,28,29,30] and reproducibility in three articles[28,29,30]. The tests were conducted using various reference methods including 24hDR, food record and blood serum biomarkers. Table 2 shows that a total of 16 micronutrients were tested for relative validity with a range of correlation coefficient values from -0.53 (iron) to 0.54 (niacin, phosphorus). Then, 17 micronutrients were tested for reproducibility with correlation coefficient values ranging from -0.02 (retinol) to 0.79 (thiamine). The correlation coefficient values for SQ-FFQ validation with blood serum biomarkers ranged from 0.06 (vitamin E) to 0.39 (β-carotene). The SQ-FFQ methods used in the studies varied in the number of food items listed, ranging from 71 to 150 food items included in the research questionnaire. The SQ-FFQ was designed to collect data on foods commonly consumed by adolescents over a period ranging from four weeks to one year. The SQ-FFQ was filled out by adolescents in three articles[26,27,30], by caregivers alone, caregivers along with adolescents in one article[28] and with guidance from a nutritionist in another article[29].

The FFQ method was tested for relative validity in articles[25,31] and reproducibility in article[31] using the 24hDR reference method and blood serum biomarkers. Table 2 shows seven micronutrients tested for relative validity with correlation coefficient ranges from 0.22 (vitamin D) to 0.55 (calcium) and reproducibility from 0.50 (retinol) to 0.66 (vitamin C). The correlation coefficient values for validity with blood serum biomarkers show a correlation coefficient of 0.00 between vitamin D and 25 hydroxy vitamin D_3 (25(OH)D), as well as iron and blood serum iron biomarkers at 0.78. The food lists used in both articles consist of 56 and 131 food items with a three-month and four-week period, respectively and intake data collected by adolescents.

The 24hDR method was only found in one article[27] with validation testing against blood serum iron biomarkers. The correlation coefficient result is 0.28. Collection of 24hDR intake data was conducted over three non-consecutive days, with one day during the workweek by a nutritionist and one day during both the workweek and weekend by the adolescents.

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Table 3. Aspects of Dietrary Assessment Methods

Aspect	Dietary Assessment Methods							
	SQ-FFQ					FFQ		24hDR
	Silva et al. (2020)[26]	Notario-Barandarian et al. (2021)[27]	Rodriguez et al. (2017)[28]	Yum J & Seungmin L. (2016)[29]	Natario-Barandaria et al. (2020)[30]	Collese et al. (2022)[25]	Overby et al. (2014)[31]	Collese et al. (2022)[25]
*Relative Validity/ Validity	Vitamin C: 0.48 Iron: 0.40 Calcium: 0.32 Sodium: 0.50	Blood serum biomarker β- carotene: 0.39 Vitamin D: 0.05 Vitamin E: -0.06	Caregiver and child, the child themselves: Retinol: 0.41 Riboflavin: 0.13 Niacin: 0.54 Folat: 0.53 Vitamin C: 0.11 Iron: 0.10 Calcium: 0.54 Zinc: -0.05 Caregiver: Retinol: 0.02 Riboflavin: 0.20 Niacin: -0.35 Folat: -0.55 Vitamin C: 0.02 Iron: -0.53 Calcium: 0.35 Zinc: -0.10	Vitamin A: 0.22 Thiamin: 0.53 Riboflavin: 0.48 Niacin: 0.44 Vitamin C: 0.24 Iron: 0.25 Calcium: 0.36 Sodium: 0.28 Fosfor: 0.54 Potassium: 0.36 β- carotene: 0.10	Retinol: 0.27 Folat: 0.35 Vitamin C: 0.17 Calcium: 0.32 Sodium: 0.08 Zinc: 0.15 Potassium: 0.21 Magnesium: 0.25 Iodine: 0.22 β- carotene: 0.24	Blood serum biomarker FFQ Iron: 0.78	Retinol: 0.42 Thiamin: 0.46 Riboflavin: 0.50 Vitamin C: 0.50 Vitamin D: 0.22 Iron: 0.30 Calcium: 0.55 Blood serum biomarker Vitamin D 25(OH)D_3: 0.00	24hDR Iron: 0.28
*Reproducibility	*NA	NA	Calcium: 0.10 Iron: 0.12 Niacin: 0.11 Retinol: -0.02 Riboflavin: -0.01 Folat: 0.09 Vitamin C: 0.16 Vitamin D: 0.08 Vitamin E: 0.21 Zinc: 0.07	Vitamin A: 0.66 Thiamin: 0.79 Riboflavin: 0.78 Niacin: 0.74 Vitamin C: 0.72 Iron: 0.70 Calcium: 0.77 Sodium: 0.28 Fosfor: 0.74 Potassium: 0.77 β- carotene: 0.64	Retinol: 0.39 Folat: 0.45 Vitamin C: 0.50 Calcium: 0.44 Sodium: 0.31 Zinc: 0.37 Potassium: 0.35 Magnesium: 0.39 Iodine: 0.30 β- carotene: 0.58	NA	Retinol: 0.50 Thiamin: 0.57 Riboflavin: 0.60 Vitamin C: 0.66 Vitamin D: 0.59 Iron: 0.53 Calcium: 0.58	NA
Food items	75 food items	104 food items	150 food items	71 food items	104 food items	56 food items	131 food items	NA

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Aspect	Dietary Assessment Methods							
	SQ-FFQ					FFQ		24hDR
	Silva et al. (2020)[26]	Notario-Barandarian et al. (2021)[27]	Rodriguez et al. (2017)[28]	Yum J & Seungmin L. (2016)[29]	Natario-Barandaria et al. (2020)[30]	Collese et al. (2022)[25]	Overby et al. (2014)[31]	Collese et al. (2022)[25]
Time period	1 month	1 year	6 months	4 weeks	9-12 months	3 months	4 week	3 non-consecutive days
Respondents	Self-reported	Self-reported	1. Caregiver and child, child themself 2. Caregiver	Nutritionist's instruction	Self-reported	Self-reported	Self-reported	24hDR: 1 working day: by nutritionist 1 working day and weekend self-reported

*NA: Not available; Relative Validity/Validity and Reproducibility are defined by correlation coefficient (CC) values considered good if CC: ≥0.50, acceptable: 0.20-0.49, and weak: <0.20

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This scoping review evaluates the accuracy and realibility of a dietary assessment method measures the micronutrients intake among adolescents, focusing on it's validity and reproducibility. Relative validity testing measures the comparison of intake between one dietary assessment method to another, referred as the reference method[33]. It should be noted that no method is devoid of potential errors; hence, relative validity is conducted to minimize these errors[26]. Meanwhile, reproducibility testing is performed to measure the consistency and reliability between two identical dietary assessment methods[34]. Dietary assessment method testing can also be conducted using blood serum biomarkers because blood serum biomarkers can reflect nutrient intake and metabolism[35], thus resulting in a more comprehensive validation[36].

Based on the analysis of the scoping review, the relative validity testing of the SQ-FFQ method yielded valid results with good correlation coefficients (r: ≥0.50) for six micronutrients: sodium, niacin, folate, thiamine, calcium and phosphorus. The reproducibility testing results showed good correlation coefficients for 10 micronutrients: vitamin A, vitamin C, thiamine, riboflavin, niacin, iron, calcium, phosphorus, potassium and β-carotene. The validity results of blood serum biomarkers showed acceptable correlation coefficients (r: 0.20-0.49) for β-carotene and were weak for vitamin D and E (r: 0.05; -0.06). The low correlation coefficient values of SQ-FFQ in some articles were due to limitations during the study, thus several factors that might affect the validity in the research were identified.

The study by Rodriguez et al.[28] indicated weaker validity when the SQ-FFQ was filled out by caregivers without adolescents compared to the group of caregivers with adolescents, where caregivers were presumed unable to accurately report adolescent intake. This is consistent with research conducted by Vioque et al.[37] where weak validity was found with correlation coefficients of 0.14-0.48 with an explanation that caregivers might not report the complete food intake of children, especially foods consumed when children are away from home. Findings from this scoping review also suggest that SQ-FFQ completion whether done by adolescents[26,27,30] or with the guidance of nutritionists[29] showed a range of validity with better correlation coefficients compared to completion by caregivers.

The food list and duration of the SQ-FFQ are estimated to be factors influencing the validity and reproducibility of a method. Silvia et al.[26] and Yum J. & Seungmin L[29], who used shorter food lists and durations showed better correlation coefficients ranging from 0.32-0.50 and 0.22-0.54 compared to three articles using other SQ-FFQ methods[27,28,30]. The findings of this scoping study are supported by the research conducted by Cheng et al[38], indicating that a simplified-FFQ with 50 food items demonstrates better coefficient correlations for micronutrients, ranging from 0.29 to 0.71 in the adult population. The meta-analysis study targeting adolescent populations states that variables such as a high number of food items and a long time interval can affect the validity of FFQs by contributing to lower response rates because subjects may require extended time to answer and become fatigue and frustrated[39].

The test of relative validity in the FFQ method showed valid results with good correlation coefficients as indicated by riboflavin, vitamin C, calcium and acceptable correlation coefficients for retinol, thiamin, vitamin D, vitamin E and iron. The reproducibility test showed good results for all micronutrients including retinol, thiamin, riboflavin, vitamin C, vitamin D, iron and calcium. The validity of serum biomarkers showed a good correlation coefficient for iron (r: 0.78) and weak correlation for vitamin D and serum biomarkers (25(OH)D) (r: 0.00). Overby et al.[31] mentioned the low correlation coefficient for serum biomarkers (25(OH)D) because vitamin D is synthesized through sunlight exposure making it difficult to establish a strong correlation, especially when the study was conducted in October when adolescents tend to spend less time outdoors. These findings are supported by the research of Notario-Barandiaran et al.[27] conducted in winter, showing a weak correlation coefficient of r: 0.05 for serum biomarkers of vitamin D.

The validity test of the 24hDR method in this scoping review was only shown by Collese et al.[25] with an acceptable correlation coefficient (r: 0.28) between iron and serum iron biomarkers. This correlation value is lower compared to the correlation coefficient results using FFQ, which showed strong validity in the same study. The possible cause of the lower correlation in 24hDR is due to the fact that the 24hDR was completed by a nutritionist on the first day of data collection, while the following two days of data collection were done at home by parents/caregivers or the adolescents themselves. The low correlation coefficient is supported by the findings of Wark et al.[40] in adult samples, where self-completed 24hDR online showed 10-20% lower estimated intake compared to interview-based 24hDR.

The limitations of this scoping review are as follows; the majority (>86%) of studies included in the review originate from high-income countries, particularly in Europe, there is a shortage of articles from Asia especially Southeast Asia. Additionally, there is a lack of FFQ and 24hDR included in this scoping review thus preventing a comprehensive assessment of micronutrients validity and reliability. The strengths of this scoping review are that it focuses on adolescent population, a group particularly vulnerable to micronutrient deficiencies. This focus makes the review a sufficient basis for future researchers in selecting appropriate dietary assessment methods to measure micronutrient intake. Moreover, the review offers a comprehensive approach by comparing various dietary assessment methods, such as SQ-FFQ, FFQ, and 24hDR, providing broader insights into their validity and reproducibility in assessing micronutrient intake. It also provides concrete evidence that the SQ-FFQ and FFQ methods exhibit good validity in measuring multiple micronutrients, distinguishing this review from many previous studies that often focused on single method. The results of the scoping review can provide evidence that the SQ-FFQ method shows valid results in measuring intake of sodium, niacin, folate, thiamine, calcium, and phosphorus. The SQ-FFQ method also demonstrates good reproducibility in measuring intake of vitamin A, vitamin C, thiamine, riboflavin, niacin, iron, calcium, phosphorus, potassium, and β-carotene. The FFQ method

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shows valid results in measuring riboflavin, vitamin C, calcium, and good reproducibility across all micronutrients including retinol, thiamin, riboflavin, vitamin C, vitamin D, iron, and calcium. The 24hDR method shows acceptable validity for iron. Futher research is needed to conduct validity and reliability tests on the intake of micronutrients using other dietary assesment methods (such as 24hDR and FFQ) due to the lack of validity studies on several methods. Future research could also focus on adolescent populations in low and middle income countries.

CONCLUSIONS

The results of the scoping review indicate three dietary assessment methods for assessing micronutrient intake in adolescents. The SQ-FFQ method is the most widely used method for assessing food consumption quantity. SQ-FFQ methods with fewer food items, shorter time periods and completion by adolescents under the guidance of a nutritionist show better relative validity and reproducibility compared to SQ-FFQ methods with more food items, longer time periods, and completion by caregivers. The FFQ method shows better validity between iron and serum iron biomarkers compared to the alternative 3-day 24hDR method. The validity results with serum biomarker reference methods show weak results for serum biomarkers of vitamin D and E, both in SQ-FFQ and FFQ methods.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

All authors have no conflict of interest in this article. This research was funded independently by the researcher.

AUTHOR CONTRIBUTIONS

AMS: conceptualization, investigation, methodology, formal analysis, writing-original draft, writing-review and editing; YLRD: supervision, conceptualization, methodology, formal analysis, writing-review and editing, project administration; TRA: supervision, conceptualization, investigation, methodology, formal analysis, writing-review and editing.

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