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EDITORIAL

A Human rights approach to clinical nutrition: addressing the challenges of disease-related malnutrition in resource limited settings

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Abstract

A human rights-based approach can be the cornerstone in the field of clinical nutrition. By endorsing the five principles of the Vienna Declaration, the global clinical nutrition network is developing initiatives and strategies for implementing programmes for improving awareness, advocacy, education, research and collaboration. The prevalence of disease-related malnutrition in hospitalized patients is higher in Asian resource limited countries than in Europe with unacceptably high nutrition risks in cancer, tuberculosis and intestinal failure in Indonesia. The international human rights working group has recommended practical steps involving evaluation of the applicability of the current international guidelines, and development of new resource-stratified guidelines followed by promotion and implementation.

Introduction

In 2016, the United Nations General Assembly proclaimed the Decade of Action on Nutrition 2016–2025 (Nutrition Decade).[1] This was an opportunity to establish an international human rights working group (IHRWG) to globally promote a human rights-based approach (HRBA) to clinical nutrition (CN) by developing strategies to fight disease-related malnutrition (DRM). This initiative culminated in 2022, with the main international clinical nutrition societies (ASPEN, ESPEN, FELANPE, PENSA) in conjunction with >75 national societies/associations from across the globe who signed The Vienna Declaration (VD) advocating recognition of nutrition care as a human right.[2] The declaration was also endorsed by patient groups and representatives from the European Commission and World Health Organization (WHO). The VD, and other publications from the IHRWG[3,4] are designed to provide an international framework for programmes that aim to promote access to nutrition care for all patients who are at risk of DRM, based on a HRBA.

Following the landmark VD, the major signatories have responded to the calls for international action with plans for appealing to other scientific medical societies, public authorities, international governmental and non-governmental organizations (NGO) on the importance of the human right to optimal, nutrition care for all patients. For example, the parenteral and enteral nutrition society of Asia (PENSA)[5] recognizes that CN is a human right, and member countries advocate for policies and guidelines that support the provision of CN to patients, specifically endorsing the 5 principles of the VD:

- Awareness: by raising awareness about CN as a human right through public campaigns, social media, and other communication channels. PENSA works to inform the public about the importance of CN and the impact it has on patient health and well-being.
- Advocacy: by advocating for recognition of CN as a human right in national and regional policies and guidelines, PENSA is working

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closely with governments and other stakeholders to raise awareness and to ensure that patients have access to high-quality nutrition support.

- Education and Training: PENSA provides training programmes and educational workshops for healthcare professionals to improve their CN knowledge and skills.
- Research: CN researchers are encouraged by PENSA to develop evidence-based practices and guidelines for improving the provision of nutrition care to patients in Asia.
- Collaboration: PENSA collaborates with WHO and other professional societies to develop guidelines and policies that support the provision of CN to patients in need.

To further assist these initiatives, the IHRWG recently published guidance specifically designed for countries in resource-limited settings (RLS). This latest consensus paper and recommendations[6] for the basis for this editorial, with an added specific focus on Asia and Indonesia, in particular the urgent need to address DRM in the diseases of tuberculosis and intestinal failure.

It is now well documented, from clinical data generated primarily from Europe and the USA, that nutritional care for at-risk hospitalized medical and surgical inpatients improves clinical outcomes, including survival.[7,8] In contrast, DRM increases health care costs with prolonged hospital stays, comorbidities and delayed rehabilitation. However, data on the prevalence of DRM in RLS at both the national and international level[9,10] particularly in low-income countries (LIC) are scarce. Proposals for tackling DRM in RLS form the basis of the latest initiative of the IHRWG.[6]

Results of the IHRWG survey (in which PENSA members; Afghanistan, India and Sri Lanka participated) confirms that the prevalence of nutrition risk in hospitalized patients is higher in those Asian countries than in Europe (40% vs 30%).[11] Diseases most associated with DRM include cancer, non-communicable and gastrointestinal diseases, intestinal failure (IF), intensive care patients, tuberculosis (TB)and other infectious diseases. Indonesia did not participate in the original survey, but the members of the Indonesian Nutrition Society (INA) will be invited to answer a similar questionnaire during 2025. Meanwhile official government statistics confirm that, for example Cancer (1.2/million), obesity (23%) diabetes (11.7%) and wasting/ underweight (7.8%) are leading causes of DRM.[12]

More specifically the country recorded over 800,000 cases of TB in 2023, making Indonesia one of the countries with the highest TB burden in the world. According to WHO, malnutrition is the leading risk factor for TB infection.[13] Malnourished patients are twice as likely to die from TB compared with non-malnourished patients. Moreover, for every 25-30 cases of lung TB there is one case of enteroperitoneal (ETB) a life-threatening abdominal catastrophe with mortality up to 26%, that if diagnosed and treated properly can be successfully treated with a combination of nutrition support (NS) and multidrug therapies.[14] It is therefore important that policy and decision-makers should require nutritional screening and assessment at diagnosis and every 4 weeks during TB treatment. Guidelines for prevention and malnutrition management plans should focus on nutrition support with optimum protein, energy and micronutrient intake, key components of TB treatment.[15]

Intestinal failure (IF) has been a relatively under recognized organ failure that has a major contribution to DRM in hospitals. According to Jeppesen[16] the number of IF patients should not be less than 10% of the number of patients receiving dialysis for renal failure and patients should have the same rights regarding access to treatment and

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care as patients with other organ failures. Data on the prevalence of IF in Indonesia and other LIC is scarce, whereas in the EU, Denmark with a population of 6 million has approx 600 IF patients receiving Home Parenteral Support (100 per million), the highest prevalence in the world. It is therefore important to increase awareness that the cost of IF treatment is lower than cost of other organ failure treatments such as dialysis, survival of IF is better than other organ failures, and, with correct nutritional management, the quality of life of IF patients is better.

To tackle the lack of awareness of the important benefit of addressing DRM in the most common diseases, the IHRWG organized an expert panel from the 4 global societies to analyse and address the identified barriers to nutritional care access in RLS. The list of expert recommendations with mostly 100% consensus agreement[6], included:

- Malnourished patients should aspire to receive the best nutritional care possible, despite any economic barriers.
- To improve nutritional care in RLS it is recommended to establish a local nutritional care organization/CN society with guidelines, education and training of HPs and research to help strengthen the health care system
- CN societies, NGOs and International organizations must recognize that the delivery of safe, equitable and high-quality nutritional care in RLS is a priority and should provide potential solutions when resources are constrained.
- CN practice in RLS can benefit from literature generated by developed countries but guidelines should reflect local healthcare needs and available resources.
- Until local research generates RLS clinical guidelines, adaptation of existing guidelines is essential for safe, feasible and effective bedside practices
- Health care professionals from non-RLS have a duty to promote nutritional care for patients in RLS and help to adapt recommendations for the management of DRM.

Detailed analysis of RLS responses to the survey enabled the IHRWG to identify gaps in the following fields:

- *Epidemiological data and evidence for best practices*: Health professionals in RLS and LMIC can initially rely on best practice literature from high income countries (HIC) but these guidelines must be adapted to the specific local characteristics of the RLS before implementation.
- *Education and Capacity Building*: Training health care professionals must strike a balance between "best-known" standards of care and the "best available" standards in RLS.
- *Strengthening Health Systems*: strategies to tackle DRM in RLS should ensure availability of basic hospital resources witha reliable supply chain of essential equipment for optimum nutritional care, and a plan for human resource development.

Recommendations

The IHRWG, on behalf of the international nutrition societies, has recommended a three-step strategy for tackling DRM and promoting nutritional care access in RLS.[5]

1. Evaluation of the applicability of the current guidelines in RLS
2. Development of resource-stratified guidelines (RSG).
3. Promotion and implementation of RSG.

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Conclusions

Adopting a human-rights based approach to clinical nutrition in resource-limited settings is difficult, due to the higher-than-average prevalence of disease-related malnutrition, associated with diseases like tuberculosis and intestinal failure in Indonesia and other low-income Asian countries. Food security, and socioeconomic factors that contribute to the higher prevalence of nutritional risk, poor availability of medical nutrition therapy in hospitals with limited referrals and resources for nutritional screening/assessment are factors that the INA in Indonesia and other professional societies in Asia are working hard to address. Current guidelines may not be fully applicable due to various barriers to the provision of appropriate nutritional care which are gradually being addressed by national professional societies. The three-step strategy, recommended by the international working group, for consideration by national societies and governments, is designed to increase awareness, promote the development of resource-stratified guidelines to optimize access to nutrition care for all patients.

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CASE REPORT

Effects of probiotics supplementation on reducing inflammation in burn patients : Evidence based case report

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Abstract

Background: Burn injuries cause significant physical trauma and complex inflammatory responses, accounting for more than 300,000 deaths per year. Probiotics may help modulate inflammation in burn patients by improving biomarkers such as hs-CRP and IgA levels. This case report aims to investigate the effect of probiotics supplementation on reducing inflammation in burn patients.

Methods & Materials: A literature search was on three large databases: PubMed, Cochrane Library, and Google Scholar. MeSH terms, advanced search, and eligibility criteria were used for title and abstract screening after removing duplicates. Critical assessment tools and levels of evidence of the final articles are based on the Oxford Center for Evidence-Based Medicine.

Results: Two randomized controlled trials (RCTs) met the PICO and eligibility criteria. One RCT found that probiotics supplementation significantly reduced hs-CRP levels (21.38 ± 44.45 vs 36.36 ± 79.03; **p < 0.001**) and improved wound healing in burn patients. The other RCT found that single and mixed strain probiotic administration significantly increased IgA levels ($p < 0.001$ and $p = 0.025$, respectively) in burn patients.

Conclusions: Probiotics supplementation demonstrates significant benefits in reducing systemic inflammation and enhancing immune function. Further research is necessary to provide recommendations of probiotic use in burn care.

Keywords: probiotic, inflammation, burn patients

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Case Scenario

Mr. TM, a 58-year-old male, was admitted to the High Care Unit with burn injuries on his face, arms, and legs sustained two days prior due to a gas stove explosion at his home. The injury accounted for 35% total body surface area with superficial dermal to full-thickness burns. His initial treatment included fluid resuscitation, antibiotics, pain management, and albumin supplementation. His primary survey indicated stable vital signs and no respiratory distress. The patient was assessed as having a normal weight with a risk of malnutrition (NRS 3). Several important inflammation markers such as leukocyte count (initially 14,600/µL, peaking at 24,640/µL on day 13), procalcitonin (initially 2.06 ng/mL), and albumin levels (initially 2.4 g/dL, dropping to 2.2 g/dL on day 13) were closely monitored. The patient was referred by a plastic surgeon to a clinical nutrition specialist to provide nutrition therapy and education appropriate for the patient's condition and to inquire whether probiotics can help improve the patient's inflammation process.

Introduction

Burn injuries represent a significant global health challenge, particularly in low- and middle-income countries where resources for specialized burn care may be limited. These injuries often result in severe physical trauma and complex inflammatory responses, increasing the risk of infections and eventual death. According to the World Health Organization, burn injuries account for approximately 300,000 deaths globally each year.[1,2] An epidemiological study conducted at the Burn Unit (ULB) of Dr. Cipto Mangunkusumo National Central General Hospital (RSCM) recorded a burn-related mortality rate of 25.8%, with the primary cause of death being septic shock.[2]

Previously, skin and soft tissue infections were considered the primary cause of sepsis in burn patients. However, recent research indicates that bacterial translocation from the intestines to the bloodstream is the main cause of sepsis. In burn patients, there is a dramatic increase in intestinal permeability, leading to an imbalance in intestinal flora and the translocation of microorganisms and/or their products from the gastrointestinal tract to extra-intestinal sites, resulting in systemic sepsis and multiple organ failure.[3–5]

Various treatment modalities have been investigated to prevent bacterial translocation and enhance immune function after thermal injuries. Recent studies have shown that probiotics may be beneficial as a potential adjunct therapy for modulating inflammation in burn patients, especially its major strains which include *Lactobacillus* and *Bifidobacterium* species.[4] These bacteria can maintain gut equilibrium and prevent bacterial translocation through several mechanisms, including maintaining the gut barrier function and inhibiting the growth of pathogenic bacteria through the production of organic acids and bacteriocin-like substances.[4,6]

Oral probiotic administration has been advocated for the treatment and prevention of a diverse range of disorders, such as antibiotic-associated diarrhea, inflammatory bowel disease, or after major abdominal surgery.[4] However, the probiotic effect has not been thoroughly examined in the clinical burn setting. Study by Zha et al.[7] has shown augmentation of the gut barrier with the use of probiotics in burn rat models. Study by Masoumi et al.[3] found aligned results with significant reductions in high-sensitivity C-reactive protein (hs-CRP) levels and increases in immunoglobulin A (IgA) levels. On the contrary, study by Wang et al.[8] found no significant difference in infection rates or clinical outcomes with probiotic administration in critically ill patients, including those with severe burns. Therefore, this study was undertaken to evaluate the effect of probiotics supplementation on reducing inflammation in burn patients.

Clinical question

P : Adult burn patients
I : Probiotic supplementation
C : Placebo
O : Inflammation

Clinical question: Could probiotics

supplementation reduce inflammation in burn patients?

Methods

Literature search was performed using combination of MeSH terms and Title/Abstract on three large databases: Pubmed, Cochrane Library and Google Scholar. Search was conducted on May 29th, 2025. The keywords used were probiotic, inflammation, thermal injury, and burn patients. Critical appraisal tools and determination of the level of evidence were created based on Oxford Centre for Evidence-Based Medicine.

Eligibility criteria

Inclusion criteria includes subjects over 18 years of age with burn injury, burn surface area ≥ 20%, received oral probiotics supplementation, study design was randomized controlled trial (RCT), *systematic review* or meta-analysis, has inflammatory outcome, published between year 2020 to 2024, and was written in English. Exclusion criteria animal study and article not available in full text.

Results

The authors found nine articles in the Pubmed database, 134 articles in the Cochrane Library and 61 articles in Google Scholar **(Table 1)**. Duplicates removal was performed using *Covidence*. The articles were assessed for eligibility based on PICO and eligibility criteria (**Figure 1**), resulting in the selection of two articles. The study characteristics of these articles were listed in **Table 2.** The level of evidence for these articles is presented in **Table 3,** and all the articles were found to be relevant for answering the clinical question (**Table 4**).

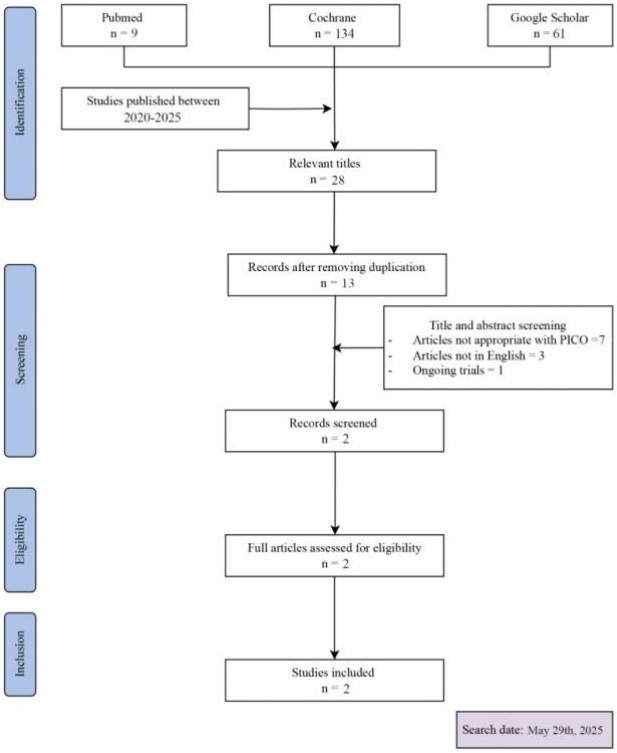

Figure 1. Prisma's Flow Chart

Table 1. Resources and search strategy

Database	Terminology	Hits	Eligible
PubMed	#1 ((probiotic[MeSH Terms]) OR (probiotics[MeSH Terms])) AND (probiotic[Title/Abstract]) #2 ((inflammation[MeSH Terms]) OR (inflammations[MeSH Terms])) OR (inflammation[Title/Abstract]) #3 (((burn[MeSH Terms]) OR (burns[MeSH Terms])) OR (thermal injury[MeSH Terms])) OR (burns[Title/Abstract]) #1 AND #2 AND #3	9	0
Cochrane	#1 MeSH descriptor: [Probiotic] explode all trees #2 (probiotic):ti,ab,kw (Word variations have been searched) #3 MeSH descriptor: [Inflammation] explode all trees #4 (inflammation)ti,ab,kw (Word variations have been searched) #5 MeSH descriptor: [Burn] explode all trees	13	2

	#6 (burn)ti,ab,kw (Word variations have been searched) #1 OR #2 #3 OR #4 #5 AND #6				
Google Scholar	allintitle: probiotic inflammation burn	73	2		

Table 2. Study characteristic

No	Author	Study design	Population characteristics	Number of subjects	Details of probiotic administration	Outcomes	Results
1	Masoumi *et al.* (2023)[3]	RCT, double blind	Adult participants with burn degree of 20-70% of total body surface area (TBSA), second degree with thermal burns, hospitalization within 24 hour post-burn, able to eat and drink through the mouth.	80	LactoCare® capsules containing *L. casei, L. acidophilus, L. rhamnosus, L. bulgaricus, B. breve, B. longum, S. thermophilus,* and prebiotic fructo-oligosaccharide. Given orally, twice daily for 14 days.	Level of inflammation status (hs-CRP and IgA)	Probiotic supplementation significantly mitigated inflammatory status. The hs-CRP reduced following probiotics (21.38 ± 44.45) consumption compared to placebo intake (36.36 ± 79.03) ($p < 0.001$). Also, the plasma level of IgA significantly increased in the intervention group (0.88 ±0.65) than in the control group (0.79 ± 0.18) ($p <0.001$).
2	Saputro *et al.* (2019)[5]	RCT, double blind	Adult participants with extensive burns ≥20% TBSA less than 24 hours after injury, could be fed orally and enterally during the study period.	17	Single strain: *L. acidophilus, B. longum, S. thermophilus.* Mixed train: *L. casei, L. rhamnosus, L. acidophilus, L. delbrueckii, B. breve, B. longum, S. thermophilus.* Given orally and enterally, once daily for 14 days.	Level of IgA and IL-6	Administration of probiotics significantly increased IgA levels from 1.01±0.67 to 1.89±0.98 mg/mL in the single strain group ($p<0.001$) and from 0.96±0.48 to 2.10±1.09 mg/mL in the mixed strain group ($p=0.025$). For IL-6, no significant changes were observed in the single strain probiotics group ($p=0.804$) or the mixed strain probiotics group ($p=0.683$).

CI, confidence interval; RCT, randomized controlled trial; TBSA, total body surface area; hs-CRP, high sensitive C-reactive protein; IL-6, interleukin-6; IgA, immunoglobulin A

Table 3. Validity criteria

	Study design	Number of patients	Randomization	Similarity treatment and control	Blinding comparable treatment	Domain	Determinant	Measurement of outcomes	Quality of evidence	Level of evidence
Masoumi *et al.* (2023)[3]	+	+	+	+	+	+	+	+	Moderate	1B
Saputro *et al.* (2019)[5]	+	+	+	+	+	+	+	+	Moderate	1B

* Quality of evidence according to GRADE guidelines, https://www.ncbi.nlm.nih.gov/pubmed/21208779
**Level of evidence according to Oxford Center of Evidence-based Medicine (CEBM), http://www.cebm.net.
+ clearly mentioned in the article; - not done; ? Not stated clearly
Systematic review and meta-analysis with troublesome heterogeneity

Table 4. Relevance criteria

Article	Similarity Population	Similarity determinant/intervention/indicators	Similarity outcome
Masoumi *et al.* (2022)[3]	+	+	+
Saputro *et al.* (2022)[5]	+	+	+

Discussion

In burn patients, a high level of pro-inflammatory cytokines stands as a critical component of the healing process.[9] The inflammatory process in burns is characterized by the immediate release of pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6). These cytokines are pivotal in orchestrating the inflammatory response, leading to vasodilation, increased vascular permeability, and the recruitment of immune cells like neutrophils and macrophages to the injury site.[10] This cytokine storm not only helps in containing the injury but can also cause systemic inflammatory response syndrome (SIRS) if excessive, contributing to complications such as multi-organ failure.[11]

The cascade of inflammatory responses triggered by burns is closely intertwined with disruptions in the gut barrier, which commonly manifest as increased intestinal permeability and bacterial translocation, thereby exacerbating systemic inflammation. The gut barrier plays a pivotal role in regulating homeostasis and preventing the translocation of harmful pathogens and toxins from the gut lumen into systemic circulation. Therefore, its impairment post-burn injury can significantly contribute to the systemic inflammatory burden experienced by burn patients.[3,5,6]

However, recent investigations have shed light on the potential therapeutic role of probiotics in ameliorating inflammation in burn patients. Probiotics, defined as live microorganisms conferring health benefits when administered in adequate amounts, have garnered attention for their ability to modulate the gut microbiota composition and enhance intestinal barrier function.[3,12] Notably, probiotics have been shown to exert anti-inflammatory effects by downregulating pro-inflammatory cytokines and reducing gut permeability in various clinical settings.[3,8]

The notable strains include *Lactobacillus fermentum*, *Lactobacillus delbrueckii*, *Lactobacillus acidophilus*, *Lactobacillus rhamnosus*, and *Lactobacillus casei*.[3,4] These probiotics help by maintaining the

gut barrier function, preventing bacterial translocation, and enhancing immune responses. Mechanisms include increasing intestinal acidity, motility, and mucin production, as well as inhibiting pathogenic bacteria through the production of organic acids and bacteriocin-like substances. They also stimulate cells of the innate immune system, boosting the activity of natural killer (NK) cells, macrophages, and lymphocytes.[5–8]

In an RCT by Masoumi et al.[3] involving 80 patients with 20-70% total body surface area burns, the use of probiotics significantly mitigated inflammation and improved wound healing. The study showed that patients receiving probiotics had a significant reduction in hs-CRP levels (21.38 ± 44.45 mg/L) compared to the placebo group (36.36 ± 79.03 mg/L, $p < 0.001$). Additionally, plasma levels of IgA significantly increased in the probiotic group (0.88 ± 0.65 g/L) compared to the control group (0.79 ± 0.18 g/L, $p < 0.001$). Although there was no significant difference in wound culture results between the groups, the incidence of bacterial colonization was slightly lower in the probiotic group ($p = 0.159$). Probiotics also accelerated wound healing, with a notable difference in the healed wound area by the end of the study period ($p < 0.001$).

Similarly, findings from an RCT by Saputro et al.[5] showed that the administration of single and mixed strain probiotics to severe burn patients (with more than 20% total body surface area burned) significantly increased serum levels of IgA. The study included 17 patients divided into two groups: one receiving a single strain probiotic and the other receiving mixed strains, both administered once daily for 14 days. IgA levels increased significantly from 1.01±0.67 to 1.89±0.98 mg/mL in the single strain group ($p<0.001$) and from 0.96±0.48 to 2.10±1.09 mg/mL in the mixed strain group ($p=0.025$).

Based on the critical review of the literature, the findings from both RCTs consistently demonstrate the potential benefits of probiotics in managing inflammation and improving outcomes in burn patients. The anti-inflammatory effects of probiotics are thought to occur via modulation of gut microbiota and the host immune response. Probiotics reduce intestinal permeability, decrease translocation of endotoxins, and suppress systemic inflammation by downregulating pro-inflammatory cytokines such as IL-6 and TNF-alpha. This results in decreased hepatic production of hs-CRP, an acutre-phase protein.[13-16] In addition, probiotics enhance mucosal immunity by stimulating the production of secretory IgA through activation of dendritic cells and B lymphocytes in gut-associated lypmnphoid tissue.[17-18]

Regarding the type of probiotics used, both single strain and mixed strain formulations showed significant increases in IgA levels in the study by Saputro et al.[5] However, the mixed strain group achieved a higher post-intervention IgA level (2.10 vs 1.89 mg/mL) and was more consistent with the findings of Masoumi et al.[3], who used a multistrain prodyct and demonstrated significant reductions in hs-CRP. There results suggest that mixed strain probiotics may offer broader immunomodulatory effects compared to single strain in burn patients.

It is also important to consider the role of nutritional status in modulating clinical outcomes among burn patients.[2,3,5] Although the patient in this case was categorized as “at risk” yet clinically well-nourished, nutritional adequacy, particularly energy and protein sufficiency, has been shown to support immune function, reduce catabolism, and facilitate wound healing. In the reviewed RCTs, while probiotic supplementation independently improved markers such as hs-CRP and IgA, these outcomes were likely optimized within the context of adequate nutritional intake.[3,5] Thus, the interplay between baseline nutritional status and probiotic efficacy cannot be overlooked, and future trials should better control for this variable.

The characteristics of patients included in these studies were similar to those of the case patient, suggesting that the research findings can be applied to the patient in this case as well. Probiotics supplementation demonstrated significant reductions in hs-CRP levels and increases in IgA levels.[3,5] These results support

the potential of probiotics in modulating inflammation and improving clinical outcomes in burn patients.

Conclusion

Probiotics supplementation emerges as a promising adjunctive therapy for burn patients, with evidence demonstrating its potential in reducing systemic inflammation and enhancing immune function. Based on the critical reviews of two RCTs included in this evidence-based case report, probiotics were effective in improving key inflammatory markers (hs-CRP and IgA) and promoting wound healing. While both single and mixed strain probiotics improve IgA levels, only mixed strains demonstrated consistent anti-inflammatory effects, suggesting a potential advantage in clinical use. Therefore, it is recommended to consider probiotics as part of the treatment strategy for the case patient and similar burn patients, with individualization based on inflammatory markers and gut health status. Nevertheless, the overall nutritional status of the patient may influence probiotic effectiveness, and its role should be considered in future protocols and research.

Limitations of this evidence-based case report include the small number of studies reviewed, variation in probiotic strains and dosages, and the lack of long-term outcome data. Further large-scale, placebo-controlled trials are needed to determine the optimal type, dose, and duration of probiotic therapy in burn care.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

The role of nutritional management in preventing stroke and improving clinical outcomes

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Abstract

Background: Stroke is a leading cause of global morbidity, mortality, and substantial economic burden. Modifiable stroke risk factors, including hypertension, dyslipidemia, obesity, and diabetes mellitus, can be effectively managed through targeted nutritional interventions. Nutritional management also supports neurological recovery and contributes to improved clinical outcomes in stroke survivors. **Methods:** A literature review was conducted using PubMed, MEDLINE, and EMBASE databases from the last ten years, focusing on nutritional management for stroke prevention, clinical outcomes, dietary patterns, and nutrient supplementation during post-stroke recovery. **Results:** Dietary strategies, including Dietary Approaches to Stop Hypertension (DASH), high intake of dietary fiber, and omega-3 fatty acids, significantly reduce stroke risk by improving cardiovascular health and decreasing inflammation. Supplementation with micronutrients such as B vitamins supports neurological and vascular function. Post-stroke nutritional issues such as dysphagia, malnutrition, sarcopenia, and pressure injuries commonly impair patient recovery. Targeted nutritional intervention, particularly adequate protein and branched-chain amino acid (BCAA) supplementation, help preserve muscle mass, enhance functional recovery, and optimize rehabilitation outcomes. **Conclusions:** Nutritional management plays a crucial role in both preventing stroke and improving clinical outcomes following stroke. Implementing effective nutritional strategies, together with patient education on healthy dietary practices, is fundamental for reducing stroke risk, accelerating recovery, and enhancing quality of life.

Keywords: clinical outcomes, nutritional management, nutritional supplementation, rehabilitation, stroke

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Introduction

Stroke remains a significant global health issue with high morbidity and mortality rates. Approximately 15 million new cases occur worldwide annually, making stroke one of the leading causes of disability and death. There are two main types of stroke: ischemic stroke, accounting for around 80–85% of global cases, and hemorrhagic stroke, comprising approximately 15–20%. This condition creates

substantial health and economic burdens for both individuals and healthcare systems.[1]

In Indonesia, stroke prevalence is also concerning. According to the Riset Kesehatan Dasar (RISKESDAS) 2018, the prevalence of stroke reached 10.9%, affecting approximately 713,783 individuals. Men have a higher risk of stroke than women, and individuals older than 75 years show the highest prevalence. Stroke incidence is also higher in urban areas than rural regions. Additionally, stroke ranks third in healthcare expenditures, following cardiovascular disease and cancer, emphasizing the urgent need for effective prevention and management strategies.[2]

Effective stroke prevention and management are essential to reduce incidence rates and long-term consequences.[3] Clinical nutrition interventions have emerged as an important approach for managing major risk factors such as hypertension, diabetes mellitus, and dyslipidemia. Appropriate nutrition not only lowers the risk but also significantly enhances clinical outcomes during post-stroke recovery.[4,5] Siotto et al.,[6] demonstrated that stroke patients with poor nutritional status and sarcopenia experienced worse functional recovery compared to well-nourished patients, highlighting the importance of early sarcopenia detection. Additionally, Sato et al.,[7] found that adequate energy and protein intake during the first week post-stroke was associated with higher discharge-to-home rates and improved activities of daily living (ADL) scores. Irisawa and Mizushima further noted that higher muscle mass and better nutritional status were linked to superior motor function recovery within the initial four weeks of rehabilitation.[8] Optimal nutritional management can minimize complications, such as malnutrition, infections, and inflammation, thereby supporting cognitive and motor recovery and enhancing patient quality of life.[3–5]

This review aims to evaluate the role of nutritional management in stroke prevention and in improving clinical outcomes for stroke patients by reducing complication risks and facilitating recovery. Through this analysis, a better understanding of the benefits of nutritional management in stroke care can be achieved, providing a basis for developing more effective clinical strategies.

Methods

A literature search was conducted in MEDLINE, PubMed, and EMBASE databases covering the last ten years. Keywords used included “medical nutrition in stroke,” “stroke management,” “micronutrient supplementation in stroke,” “nutrient supplementation in stroke,” “protein supplementation in stroke,” “sarcopenia,” “malnutrition,” and “stroke-related complications.” Reference lists from relevant articles were also reviewed to include studies not indexed in the initial search. Only English-language literature relevant to the main topic was included.

Literature Review

The Role of Nutrition in Stroke Prevention

Stroke is closely associated with various metabolic conditions, such as hypertension, diabetes mellitus, obesity, and dyslipidemia, most of which can be modified through dietary interventions. Nutritional management plays a critical role in stroke prevention by addressing these modifiable risk factors. Unhealthy dietary patterns characterized by high consumption of saturated fats, added sugar, and sodium, as well as low intake of dietary fiber and micronutrients, significantly increase stroke risk. Therefore, implementing evidence-based nutritional management, including diets rich in fiber, polyunsaturated fatty acids (PUFA), and micronutrients such as B vitamins is considered a key strategy for reducing stroke risk. [9–14]

DASH Diet

The Dietary Approaches to Stop Hypertension (DASH) diet is a well-established dietary pattern that emphasizes the consumption of fruits, vegetables, whole grains, low-fat or fat-free dairy

products, lean protein sources such as legumes and fish, and healthy plant oils. It is designed to lower blood pressure and reduce cardiovascular risk. The DASH diet, when combined with sodium restriction, typically with a target intake between 1,500 and 2,300 mg/day depending on individual characteristics, has been shown to produce greater reductions in blood pressure than either intervention alone. This effect is largely attributed to reduced sodium-induced fluid retention, improved vascular tone, and enhanced endothelial function.[15]

A systematic meta-analysis conducted by Chiavaroli et al.[14] evaluated nine randomized controlled trials (RCTs) assessing the blood pressure-lowering effects of the DASH diet with sodium restriction. Results indicated that interventions involving direct meal provision were most effective, achieving reductions in systolic blood pressure (SBP) ranging from 7.7 mmHg to 2.4 mmHg and diastolic blood pressure (DBP) ranging from 8.3 mmHg to 0.1 mmHg. For instance, one of the included studies reported that structured meal provision led to an SBP reduction of 7.7 mmHg and DBP reduction of 8.3 mmHg.[14]

Another meta-analysis by Xun et al.[13], which included data from ten RCTs involving 4,667 participants, demonstrated that behavioral interventions aimed at reducing salt consumption significantly lowered blood pressure. The interventions included education on cooking methods designed to reduce salt usage, resulting in an average systolic blood pressure (SBP) reduction of −1.17 mmHg (95% CI: −1.86 to −0.49 mmHg) and diastolic blood pressure (DBP) reduction of −0.58 mmHg (95% CI: −1.07 to −0.08 mmHg). This study highlighted behavioral approaches, especially salt-reduction education in schools and families, as effective strategies for managing blood pressure. Building upon previous research emphasizing the importance of healthy dietary patterns such as the DASH diet, these findings support dietary modification and salt management as essential preventive strategies for hypertension and cardiovascular complications. The authors recommended combining behavioral interventions with additional strategies, such as reformulating food products to contain lower salt levels, to further enhance the effectiveness of salt reduction programs.[13]

Omega-3 Fatty Acid

Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA), play a significant role in stroke prevention through multiple molecular pathways. Eicosapentaenoic acid is incorporated into membrane phospholipids, replacing arachidonic acid and modifying lipid raft composition, ion channel function, and membrane signaling. These alterations contribute to cardiac electrophysiological stability and reduce the risk of atrial arrhythmias associated with cardioembolic stroke. EPA also serves as a precursor for specialized pro-resolving mediators (SPMs), such as resolvins, which actively terminate vascular inflammation. In addition, EPA inhibits thromboxane A_2 production and platelet aggregation, providing antithrombotic effects important for ischemic stroke prevention.[16]

Furthermore, EPA has distinct membrane-stabilizing properties. It reduces membrane oxidative stress, prevents cholesterol crystal formation in atherosclerotic plaques, and preserves endothelial membrane integrity—mechanisms that lower inflammation and plaque vulnerability. These effects, which differ from those of docosahexaenoic acid (DHA), underline the unique vascular protective role of EPA.[17] Collectively, these findings demonstrate the multifaceted actions of EPA in modulating inflammation, thrombosis, and endothelial stability, all of which are crucial in the prevention of stroke.

O'Keefe et al.,[11] reported that individuals with the highest blood EPA levels experienced a 17% reduction in total stroke risk with hazard ratio (HR) 0.83 (95% CI: 0.76–0.91) and an 18% reduction in ischemic stroke risk. EPA, a marine-derived long-chain omega-3 polyunsaturated fatty acid, is primarily obtained from oily cold-water fish such as salmon, mackerel, sardines, and anchovies.[18] In line with these findings, Chen et al.[19] conducted a systematic review and meta-analysis demonstrating that high fish consumption was associated with a significantly

reduced risk of total stroke with relative risk (RR) 0.87 (95% CI: 0.79–0.96), with more pronounced effects observed for ischemic stroke. The greatest protective effect was observed among individuals consuming approximately 2−3 servings (100 g each) of fish per week.[19] This intake provides an average of 250–500 mg EPA and DHA per day, which is linked to a lower incidence of stroke, reinforcing their protective role in cerebrovascular health.[19,20]

Overall, evidence suggests that stroke prevention benefits are more consistently associated with regular fish consumption rather than isolated omega-3 supplementation, likely due to the synergistic interactions among various nutrients present in fish, such as vitamin D, B vitamins, and essential minerals.[19] Thus, increasing fish consumption as part of a balanced diet is recommended for stroke prevention, with the understanding that omega-3 supplementation alone might not yield comparable outcomes.

Dietary Fiber

In addition to omega-3 fatty acids, dietary fiber has been shown to play a significant role in stroke prevention through multiple mechanisms, including weight regulation, serum cholesterol reduction, and attenuation of vascular inflammation. Soluble fiber forms a gel-like substance in the stomach and small intestine, slowing nutrient absorption and delaying gastric emptying, which enhances satiety and facilitates weight control. In the colon, fermentation of fiber by gut microbiota produces short-chain fatty acids (SCFAs) such as acetate, propionate, and butyrate. These compounds inhibit hepatic cholesterol synthesis and subsequently lower serum cholesterol concentrations. SCFAs also stimulate the release of appetite-regulating hormones, including glucagon-like peptide-1 (GLP-1) and peptide YY, which contribute to improved insulin sensitivity and reduced systemic inflammation. Additionally, dietary fiber binds bile acids, reduces their reabsorption, and promotes the use of endogenous cholesterol for new bile acid synthesis, further contributing to decreased blood cholesterol levels.[21,22] The dietary fiber content of various food sources is summarized in **Table 1**.

Table 1. Dietary fiber content of various food items[23]

Source	Dietary fiber (g per 100 g of food item)		
	Total	Insoluble	Soluble
Oats	10.3	6.5	3.8
Rice (uncooked)	1.3	1.0	0.3
Rice (cooked)	0.7	0.7	0.0
Whole wheat	12.6	10.2	2.3
Almonds	11.2	10.1	1.1
Beets	7.8	5.4	2.4
Spinach (raw)	2.6	2.1	0.5
Radish	2.0	1.5	0.5
Tomato (raw)	1.2	0.8	0.4
Eggplant	6.6	5.3	1.3
Cucumber (peeled)	0.6	0.5	0.1
Cauliflower (raw)	1.8	1.1	0.7
Carrot (raw)	2.5	2.3	0.2
Broccoli (raw)	3.3	3.0	0.3
Apple (unpeeled)	2.0	1.8	0.2
Kiwi	3.4	2.6	0.8
Mango	1.8	1.1	0.7
Grapes	1.2	0.7	0.5
Orange	1.8	0.7	1.1
Strawberry	2.2	1.3	0.9
Banana	1.7	1.2	0.5
Pear	3.0	2.0	1.0

g: gram

A systematic review by Alahmari et al.,[22] found that individuals who consumed high-fiber diets, approximately 25 to 38 g per day or 14 g per 1,000 kilocalories, had a relative risk reduction for stroke ranging from 0.83 to 0.93. Greater protective effects were observed with fiber derived from fruits and cereals. Furthermore, Reynolds et al.[24] demonstrated in a meta-analysis of adults with established cardiovascular disease that higher fiber intake, with a median of 20 g/day (IQR 18–22 g/day), was associated with a 25%

reduction in all-cause mortality (RR 0.75; 95% CI: 0.58–0.97), equivalent to 60 fewer deaths per 1,000 individuals.[24]

These results support the recommendation to increase dietary fiber intake as part of a comprehensive nutritional strategy for stroke prevention, particularly ischemic stroke. Further research is needed to elucidate the effects of different fiber types and food sources on stroke risk reduction, which may contribute to more refined dietary guidelines for populations at elevated risk.

B Vitamins

Elevated plasma homocysteine levels are significant contributors to stroke risk, primarily via mechanisms involving vascular injury and chronic inflammation.[25] Mechanistically, hyperhomocysteinaemia impairs endothelial function by reducing nitric oxide (NO) bioavailability. This occurs through the uncoupling of endothelial nitric oxide synthase (eNOS) and increased levels of asymmetric dimethylarginine (ADMA), an endogenous inhibitor of NOS. These alterations promote vascular smooth muscle proliferation, oxidative stress, and disruption of the blood–brain barrier (BBB), contributing to the development of cerebral small vessel disease and lacunar infarction. Hyperhomocysteinaemia also activates proinflammatory signaling and endothelial apoptosis, while genetic variants, particularly the methylenetetrahydrofolate reductase (MTHFR) C677T polymorphism, further exacerbate homocysteine accumulation.[25,26]

The metabolism of homocysteine depends on several B vitamins, including folic acid, vitamin B6 (pyridoxine), and vitamin B12 (cobalamin)—each playing a distinct and complementary role in homocysteine regulation and stroke prevention. Folic acid acts as a methyl donor in the remethylation of homocysteine to methionine, vitamin B12 is an essential cofactor in this reaction, while vitamin B6 is required for the transsulfuration pathway, converting homocysteine to cysteine. Deficiencies in any of these vitamins may result in elevated homocysteine levels and increased vascular risk.[27,28]

Folic Acid

Recent meta-analyses confirm that higher dietary folic acid intake, particularly between 400–600 μg per day, is associated with a reduced risk of incident stroke, with optimal benefit at intakes of approximately 611 μg/day. Randomized controlled trials also demonstrate that folic acid supplementation at doses ranging from 0.4 to 0.8 mg/day is effective for primary stroke prevention in populations without mandatory food fortification. The protective effect of folic acid is primarily attributed to its ability to lower plasma homocysteine, thereby reducing endothelial dysfunction and vascular risk. Thus, folic acid is supported as a safe, cost-effective public health strategy for stroke prevention, especially in regions without food fortification.[28]

Vitamin B6

Vitamin B6 is integral to homocysteine metabolism via the transsulfuration pathway, acting as a cofactor for cystathionine β-synthase. However, evidence from RCTs consistently indicates that vitamin B6 supplementation alone does not significantly reduce the risk of stroke, myocardial infarction, or all-cause mortality, either for primary or secondary prevention. Large studies such as NORVIT have not demonstrated significant benefits for vitamin B6 monotherapy, and meta-analyses also report a lack of protective effect. Consequently, current evidence does not support vitamin B6 supplementation alone for primary stroke prevention in the general population.[29]

Vitamin B12

Vitamin B12 is a key cofactor in the remethylation of homocysteine to methionine and is essential for vascular health. Although clinical trials and meta-analyses have used supplementation doses of 0.4 to 1 mg/day for homocysteine lowering, RCTs show that vitamin B12 supplementation alone does not significantly reduce the incidence of stroke, myocardial infarction, or all-cause mortality, regardless of

whether it is used for primary or secondary prevention. Most observed benefit for stroke prevention has been limited to regimens combining vitamin B12 with folic acid and/or vitamin B6. Therefore, vitamin B12 monotherapy is not currently recommended for stroke prevention in the general population.[29,30]

The clinical significance of these mechanisms is supported by epidemiological and interventional data. A meta-analysis of 16 studies involving over 10,000 individuals found that elevated plasma homocysteine levels were associated with a markedly increased risk of ischemic stroke with Odds Ratio (OR) 2.51 (95% CI: 1.94–3.26), particularly in those with concentrations ≥15 μmol/L.[26] Intervention trials demonstrate that daily supplementation with folic acid 0.5 mg, vitamin B6 10 mg, and vitamin B12 0.4 mg for six weeks can reduce homocysteine concentrations by 25–30%.[27] In the HOPE-2 trial, a regimen of folic acid 2.5 mg, vitamin B6 50 mg, and vitamin B12 1 mg daily reduced stroke risk by 25% (RR 0.75; 95% CI 0.59–0.97) in populations without folic acid fortification.[27] Furthermore, a recent dose–response meta-analysis identified the most effective supplementation ranges as folic acid 0.8–2.5 mg/day, vitamin B6 20–50 mg/day, and vitamin B12 0.5–1 mg/day, associated with a 13–25% reduction in stroke risk.[30] Notably, doses below these ranges were less effective, and higher doses did not confer additional benefit.

Importantly, no clinical trials have shown that vitamin B6 or vitamin B12 supplementation alone—outside of combination with folic acid—significantly reduces stroke risk. The available evidence suggests that the stroke prevention benefits of B vitamins are most pronounced when used as part of a combined regimen, particularly in individuals with elevated homocysteine and low dietary folate intake.

Antioxidant

Antioxidants play a crucial role in stroke prevention by counteracting oxidative stress caused by reactive oxygen species (ROS), which are major contributors to vascular injury and the pathogenesis of stroke.[12] Based on this mechanistic pathway, numerous studies have explored the effects of various antioxidant vitamins, such as beta-carotene, vitamin C, and vitamin E, on stroke prevention. However, not all of these vitamins have demonstrated clear or consistent benefits in reducing stroke risk.

Vitamin E is a major antioxidant that has been extensively evaluated for its role in stroke prevention, primarily due to its ability to counteract oxidative stress caused by ROS—a central factor in vascular injury and stroke pathogenesis.[31,32] Two recent meta-analyses have looked at whether vitamin E can help prevent stroke. Loh et al.[31] analyzed 18 RCTs involving over 148,000 participants, with vitamin E dosages ranging from 50 IU to 800 IU per day, most commonly 400–600 IU daily. Their analysis found that vitamin E, at both low (<300 IU) and high (≥300 IU) doses, did not significantly reduce the overall risk of stroke (RR 0.98; 95% CI 0.93–1.04). There was a modest reduction in ischemic stroke risk (RR 0.92; 95% CI 0.86–0.98), but this was offset by a slight increase in hemorrhagic stroke risk (RR 1.17; 95% CI 1.02–1.34).[31]

Similarly, Maggio et al.[32] reviewed 16 RCTs with vitamin E supplementation doses ranging from 330 IU to 800 IU per day. Their meta-analysis confirmed that vitamin E alone, regardless of the dose, did not significantly reduce the risk of stroke. However, when vitamin E was combined with other antioxidants, such as vitamin C (100–1,000 mg/day), beta-carotene (20–50 mg/day), or selenium (up to 100 mg/day), there was a small but statistically significant reduction in ischemic stroke risk (RR 0.91; 95% CI 0.84–0.99). This benefit, however, was offset by a significant increase in the risk of hemorrhagic stroke (RR 1.22; 95% CI 1.00–1.48)[32]

Given the lack of benefit for total or fatal stroke at all tested doses, and the potential for increased risk of bleeding, routine supplementation with vitamin E, either alone or in combination with other antioxidants, cannot be recommended for stroke prevention. Current evidence supports a cautious approach, and further research is needed to determine if there are

specific patient subgroups who may derive net benefit from antioxidant therapy.

The Role of Nutrition in Improving Clinical Outcomes in Stroke Patients

Malnutrition represents a major clinical challenge in stroke patients and has a significant impact on clinical outcomes. The prevalence of malnutrition among hospitalized stroke patients is estimated at 26% upon admission and increases to 56–62% during hospital stays exceeding three weeks. This condition is often exacerbated by dysphagia which affects up to 60% of stroke patients, particularly during the acute phase. Dysphagia often causes inadequate oral intake and dehydration, thereby significantly increasing the risk of serious complications such as aspiration pneumonia. Additionally, social and psychological factors, including depression, anxiety, and social isolation, further contribute to the deterioration of nutritional status.[33]

Four major nutrition-related complications frequently observed in stroke patients include dysphagia, malnutrition, sarcopenia, and pressure injuries. Malnutrition, characterized by deficiencies in energy, protein, and micronutrients, is associated with increased morbidity, susceptibility to infections, prolonged hospital stays, and higher mortality rates. It also negatively affects neurological recovery and functional outcomes. Dysphagia, if inadequately managed, impairs oral intake, increases the risk of dehydration and aspiration pneumonia, leads to significant weight loss, and ultimately compromises quality of life and increases care burden.[33]

Sarcopenia, defined as the loss of skeletal muscle mass and strength due to prolonged immobility, further impedes rehabilitation, reduces functional capacity, increases the risk of falls, and extends dependency on care. Meanwhile, pressure injuries are often worsened by malnutrition, which delays wound healing, increases the risk of infection, and compromises skin integrity. Adequate nutritional intake—particularly of protein, arginine, vitamin C, and zinc—is essential for supporting wound healing and preventing the development of pressure injuries. Together, these complications underscore the critical importance of timely and sustained nutritional management in the overall management and recovery of stroke patients.[33]

Appropriate nutritional management is essential at all stages of stroke recovery to manage complications and support rehabilitation (**Figure 1**). In the acute phase (≤7 days), nutritional assessment should be conducted within the first 48 hours to prevent rapid nutritional deterioration. Enteral nutrition is recommended for patients with severe dysphagia to ensure adequate energy and protein intake. In the early subacute phase (7 days–3 months), oral intake can be resumed with texture-modified diets based on individual needs, supported by high-protein supplementation enriched with leucine and vitamin D to prevent sarcopenia. During the late subacute (3–6 months) and chronic phases (>6 months), nutritional management focuses on maintaining nutritional status, improving functional capacity, and preventing long-term complications such as pressure injuries.[33]

The role of nutrition in stroke rehabilitation lies in its capacity to support functional recovery and mitigate post-stroke complications. Stroke often leads to long-term neurological deficits, which elevate the risk of malnutrition, sarcopenia, anemia, diabetes mellitus, and osteoporosis. Appropriate nutritional management can improve nutritional status and facilitate the rehabilitation process, with the goal of accelerating recovery and preventing secondary complications. Several studies have demonstrated that targeted nutritional interventions significantly enhance post-stroke recovery. For instance, amino acid supplementation helps prevent post-stroke muscle protein hypercatabolism, increases muscle mass, and improves functional performance during early recovery. Supplementation with micronutrients such as vitamin D and vitamin B12 has been investigated in stroke patients, with some studies reporting improved outcomes. However, the evidence remains variable across different patient populations and study designs.[33,34]

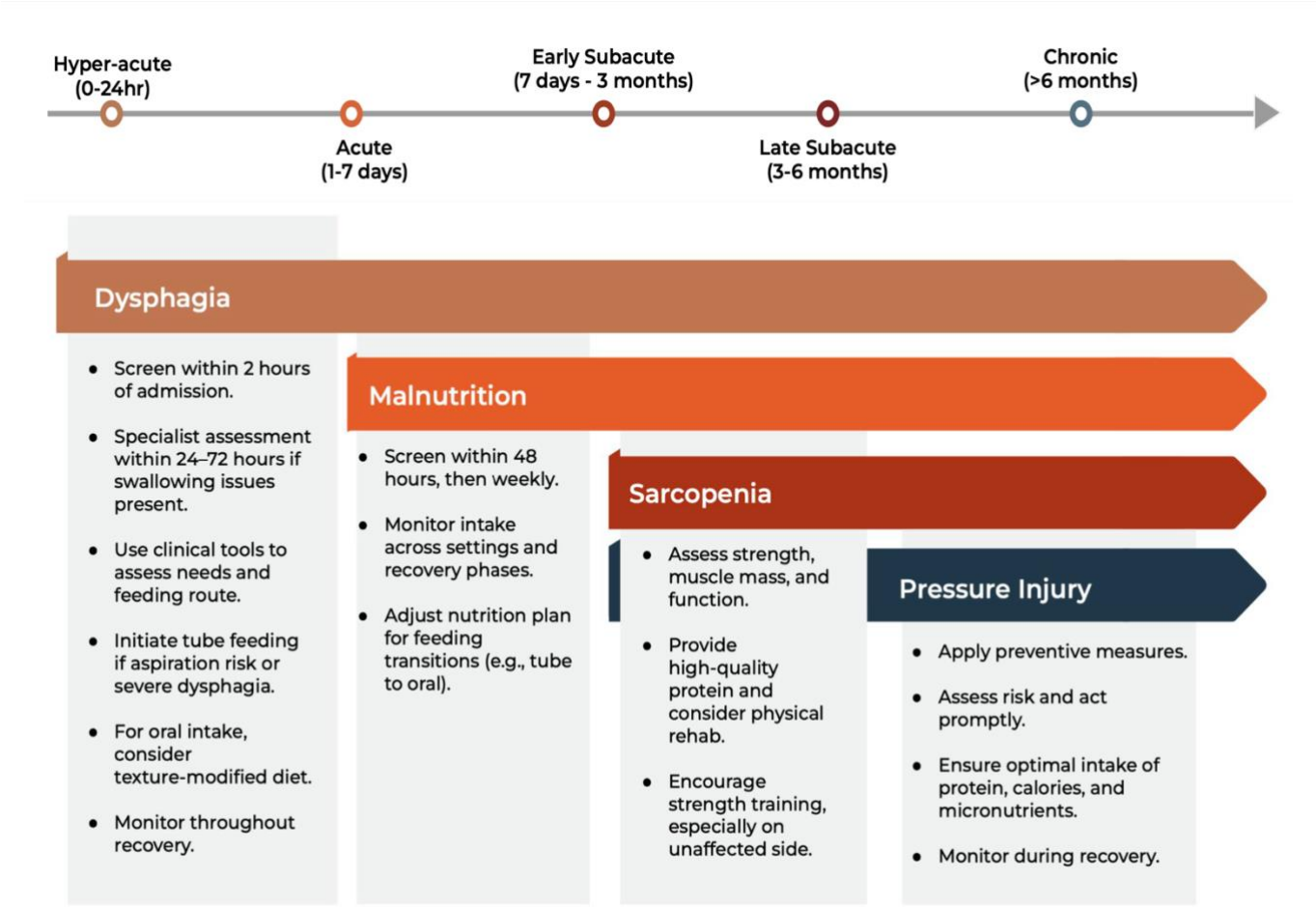

Figure 1. The role of nutrition management across stroke phase[33]

Protein Supplementation

Protein is essential for post-stroke recovery, as it supports the regeneration of neural and muscular tissues that are frequently damaged by stroke. Adequate protein intake promotes tissue repair and functional improvement. Branched-chain amino acids (BCAAs) play a central role in neural repair, modulation of inflammation, and the restoration of motor function. These amino acids serve as precursors for glutamate and stimulate muscle protein synthesis via activation of the mechanistic target of rapamycin (mTOR) pathway, thereby facilitating both neural and muscular recovery.[33–36]

Recent evidence from multiple interventional studies and RCTs, as reviewed by Chen et al.,[37] shows that supplementing 20–33 g of protein per day for 4 to 8 weeks improves neurological recovery, motor function, and physical performance, especially among post-stroke patients with poor nutritional status or sarcopenia. These studies, which included both subacute and chronic stroke populations, reported benefits such as greater reductions in National Institutes of Health Stroke Scale (NIHSS) scores, higher Functional Independence Measure (FIM) gains, improved balance, and increased discharge rates. However, effects on activities of daily living and cognitive outcomes were inconsistent, underscoring the need for personalized nutritional assessment and further high-quality research to determine long-term clinical efficacy.[37]

Branched-Chain Amino Acids

Branched-chain amino acids (BCAAs)—including leucine, isoleucine, and valine—are important for skeletal muscle recovery and may prevent muscle atrophy, a common complication

after stroke. Leucine, in particular, activates the mTOR pathway to stimulate muscle protein synthesis and inhibit degradation.[36] Supplementation with BCAAs can help preserve muscle mass and improve functional outcomes during rehabilitation. In a study by Park et al.,[35] post-stroke patients with sarcopenia who received 30 g of protein daily, including 6 g of BCAAs, for one month demonstrated significant improvements in both skeletal muscle index and handgrip strength compared to controls. Functional measures such as the Korean Mini-Mental Status Examination, Berg Balance Scale, and Functional Ambulation Categories also improved to a greater extent in the BCAA group, alongside a 35% lower incidence of infection. These results suggest that BCAA supplementation, combined with intensive rehabilitation, can help prevent muscle wasting and support recovery after stroke.[35]

Ko and Shin reviewed several RCTs and clinical studies involving adult and elderly post-stroke patients, particularly those who are malnourished or at risk of sarcopenia. Interventions typically included supplementation with 20–23 g of protein or whey protein per day, or 3–3.5 g per day of leucine-enriched essential amino acids, given for 4 to 12 weeks and resulted in significant improvements in muscle mass, handgrip strength, and functional outcomes such as Functional Independence Measure (FIM) and skeletal muscle index, especially in undernourished individuals.[38] These findings indicate that targeted BCAA supplementation may be particularly beneficial for post-stroke patients with sarcopenia or poor nutritional status to enhance rehabilitation outcomes.

Omega-3 Fatty Acid

A systematic review and meta-analysis by Alvarez Campano et al.[39] examined 29 RCTs involving 3999 patients with stroke or transient ischemic attack (TIA), and found that supplementation with marine-derived omega-3 fatty acids (400–3300 mg/day, for 3 months to over 1 year) did not provide significant improvements in functional capacity, dependency, vascular mortality, recurrent stroke, quality of life, or mood compared to placebo.[39]

Consistent with these findings, a randomized controlled trial by Rist et al.[40] in 197 stroke survivors who received omega-3 supplementation (1 g/day of fish oil, containing 460 mg eicosapentaenoic acid [EPA] and 380 mg docosahexaenoic acid [DHA]) prior to stroke, with a median 1.4 years follow-up, showed no significant reduction in risk of post-stroke functional limitations or physical disability. The odds ratios for functional limitation and physical disability on the Nagi, Rosow-Breslau, and Katz ADL scales were 0.55 (95% CI 0.28 to 1.09), 0.56 (0.31 to 1.02), and 0.32 (0.08 to 1.24), respectively; none were statistically significant.[40] Taken together, current evidence does not support the clinical benefit of omega-3 fatty acid supplementation for improving post-stroke functional outcomes or reducing disability and mortality.

Vitamin B12 (Cobalamin)

Recent studies have explored the potential benefits of vitamin B12 supplementation in post-stroke patients. Yuan et al.,[42] investigated the effects of vitamin B12 supplementation in patients with ischemic stroke and H-type hypertension—a subtype of hypertension associated with elevated plasma homocysteine levels. Mecobalamin 500 μg three times daily led to significant reductions in homocysteine, hs-CRP, and carotid plaque thickness at 3 and 6 months (all $p < 0.05$). Functional recovery, assessed by the NIHSS, was also significantly greater in the mecobalamin group than in controls ($p < 0.05$).[42] These findings support the role of mecobalamin in improving neurological recovery and vascular health. When combined with evidence on the benefits of BCAA supplementation, the results reinforce the importance of nutritional management in optimizing post-stroke recovery and patient outcomes.

Vitamin D

Vitamin D supplementation in post-stroke patients has been studied using a wide range of

dosing regimens, including single intramuscular injections of 300,000–600,000 IU, daily oral doses of 600–2,000 IU, weekly doses of 50,000 IU, and monthly doses of 60,000 IU.[41] Several studies have reported statistically significant improvements in motor function (Brunnstrom Recovery Stage), balance (Berg Balance Scale), lower extremity function, mobility (Functional Ambulation Classification), and reductions in stroke impairment scores (Scandinavian Stroke Scale, NIH Stroke Scale). However, the effects on activities of daily living (Barthel Index, Functional Independence Measure) were inconsistent, and the clinical significance of these improvements remains uncertain due to small sample sizes, heterogeneity of study design, and the lack of clear evidence for minimal clinically important differences.[41] Therefore, despite its safety profile, current evidence does not support routine vitamin D supplementation specifically for improving clinical outcomes in stroke rehabilitation, and further large, high-quality trials are needed to determine its true benefit and optimal dosing strategy.

The Role of Nutritional Education in Stroke Management

Nutritional education is a critical component of comprehensive stroke care, particularly in promoting long-term dietary adherence and reducing the risk of recurrent cerebrovascular events. According to the latest American Heart Association (AHA) guidelines, effective dietary strategies should prioritize reducing sodium and saturated fat intake, emphasize the consumption of whole grains, fruits, vegetables, legumes, nuts, and non-tropical vegetable oils, and recommend lean protein sources such as fish and skinless poultry. Limiting sodium to less than 1,500–2,300 mg/day and saturated fat to less than 6% of total energy intake is essential for optimal blood pressure and lipid management.[1] Patient counselling should focus on practical approaches to selecting low-sodium foods, replacing saturated and trans fats with unsaturated fats, and increasing plant-based food consumption. Diets rich in dietary fiber, and micronutrients derived from plant-based foods support vascular endothelial function and overall cerebrovascular health.[43,44]

Family engagement is equally important in reinforcing dietary behavior change. Involving caregivers in nutritional education empowers them to support patients in adhering to therapeutic diets, thereby enhancing compliance, and promoting sustainable behavioral change. Such a family-centered approach has been associated with improved health literacy, self-efficacy, and preparedness for post-stroke care, contributing to secondary prevention and reducing the risk of recurrent stroke.

Conclusion

Nutritional intervention is fundamental to both the prevention and management of stroke. Diets that are rich in dietary fiber, unsaturated fats, and essential micronutrients such as folate, vitamin B6, and vitamin B12 help regulate major vascular risk factors including hypertension, abnormal blood lipids and excess body weight. Omega-3 fatty acids also offer anti-inflammatory and vascular-protective effects, thereby reducing the risk of blood clots and cerebrovascular disease.

After a stroke, nutritional support becomes critical. Adequate intake of calories, protein, and micronutrients helps the brain adapt, reduces systemic inflammation, and supports physical recovery. Common stroke complications such as difficulty swallowing, muscle wasting, and pressure injuries can delay rehabilitation and should be addressed with targeted nutrition interventions. Supplementation with branched-chain amino acids and vitamin B12 (mecobalamin), especially when combined with structured rehabilitation, has been shown to help preserve muscle mass and improve physical function.

In the long term, nutritional management should be integrated into every stage of stroke care. Ongoing nutrition education and the implementation of personalized, evidence-based nutrition plans can optimize recovery, support

daily functioning, and improve overall quality of life for stroke survivors.

Conflict of interest

The authors declare no competing interests.

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ORIGINAL PAPER

Association of food security and dietary diversity with stunting among toddlers in Gunungkidul regency, Indonesia

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Abstract

Background: Stunting is impaired child growth due to prolonged undernutrition. In 2022, Indonesia's stunting prevalence was 21.46% (SSGI), with Gunungkidul regency in Yogyakarta, Indonesia experiencing the highest rate at 23.5%. food security and dietary diversity can influence the occurrence of stunting in toddlers.

Objective: This study aims to determine the association of food security and dietary diversity with stunting among toddlers in Gunungkidul Regency.

Methods: This cross-sectional study was conducted in the Wonosari and Gedangsari District, Gunungkidul Regency. The sample of this study were 105 children from 6 *Posyandu* (integrated health care center), which were selected based on the stunting prevalence. The sample were selected using quota sampling techniques. Household food security was assessed using a questionnaire adapted from the 2012 USDA Household Food Security Survey Module, and dietary diversity was assessed using a questionnaire adapted from the 2011 Food and Agriculture Organization (FAO) guidelines. Data were analyzed using the Chi-Square test.

Results: More than 30% of the children were stunted (31.4%), 51.5% had dietary diversity in the low and medium categories, and 44.8% of respondents come from food insecure families. There was a significant relationship between dietary diversity and stunting ($p<0.05$), however the relationship with food security was not statistically significant ($p>0.05$).

Conclusion: Dietary diversity is significantly associated with stunting among toddler however food security is not related to stunting. Caregiver education promoting diverse toddler diets, especially local foods, is needed.

Keywords: food security, dietary diversity, stunting, toddlers, nutrient intake

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Introduction

Early childhood is a period for children under the age of 5, a period of growth with important developments to consider[1]. During early childhood, the formation of the basics of the senses, thinking, speaking, and mental growth occurs. In early childhood, there is a very rapid process of growth and development, making it very important

to pay attention[2]. The process of child growth and development is greatly influenced by nutritional status. Inadequate nutritional intake in children will result in children suffering from nutritional problems such as stunting[3].

Stunting is a condition of impaired growth and development in children caused by chronic undernutrition, resulting in short stature[4]. In addition to dietary intake, stunting can also be caused by infectious diseases. Infectious diseases in children can reduce appetite and increase nutritional needs, which, if left untreated, can contribute to stunting[5]. The long-term effects of stunting include decreased cognitive ability and learning achievement, a weakened immune system leading to frequent illnesses, and a high risk of developing diabetes, obesity, heart disease, cancer, stroke, and disabilities in old age. Additionally, stunting becomes a major nutritional problem that impacts social and economic life within communities[6].

Stunting remains a persistent health issue that needs to be continuously addressed. The national target for the prevalence of short and very short toddlers (stunting) in 2024 is 14%[7]. According to the SSGI data for the year 2022, the prevalence of short and very short toddlers (stunting) in Indonesia is 21.46%[8]. The highest prevalence of short and very short toddlers (stunting) is in the Special Region of Yogyakarta, specifically in Gunungkidul District with a prevalence of 23.5%[9].

Household food security is a global health issue. Food security is a prerequisite for the availability of sufficient food for everyone so that everyone always has physical and economic access to food. The focus of food security is not only on the provision of food at the local level, but also on the availability and consumption of food at the regional and household levels, as well as at the individual level in meeting nutritional needs[10]. Food security is closely related to household income and expenditure[11]. Low family income is the root of malnutrition problems, due to low purchasing power for food[12]. Stunting is closely linked to food insecurity and poverty. Factors such as household food expenditure and household food security are associated with the occurrence of stunting[13]. Household food security is a global health issue. Food security can be defined as an economic and social condition at the household level that has limited or uncertain access to an adequate amount of food[14]. According to a study conducted in the Sedayu District of Yogyakarta Special Region[15], Socioeconomic factors such as low household expenditure on food can affect the occurrence of stunting in children aged 6-23 months. Household food security is one of the main causes of nutritional deficiencies in children. Based on previous research conducted in N'Djamena on children aged 12-59 months, children from households experiencing severe food insecurity are at higher risk of stunting compared to children from food-secure households[16]. In addition, according to the research conducted in the Sedayu District of Yogyakarta Special Region on children aged 6-23 months[17], The research results indicate that household food security is related to the occurrence of stunting in infants aged 6-23 months.

Based on the report of the Agriculture and Food Office in 2023, Gunungkidul Regency faces unresolved issues in food security and dietary diversity. Stabilization of food prices and food supply remains suboptimal. Dietary diversity is still limited, with most varieties available only during harvest seasons. Several types of food, such as animal protein, vegetables, and fruits, are still under consumed by the people of Gunungkidul. The issue of dietary diversity in Gunungkidul Regency that still needs to be improved lies in fulfilling the diversity of animal-based food. The report indicates that the target score for animal-based food in Gunungkidul is 24.0, but the Achievement of Expected Food Pattern (Pola Pangan Harapan/PPH) score is only 18.9[18].

Nutrient intake can be concluded based on the quantity and quality. Quantitatively, nutrient intake can be seen in terms of its adequacy level, and qualitatively, it can be seen through dietary diversity[19]. Dietary diversity is the sufficiency of food consumption based on food groups. Sufficient consumption of a variety of foods is an indicator of achieving optimal nutritional status, thus reducing the risk of malnutrition[20]. It is very important to consume a variety of foods, as no single food contains all the nutrients needed to ensure growth and child health [21]. Diversity of food has an impact

on balancing children's food intake. Imbalance in children's food intake is one of the factors causing stunting[22]. According to previous research, children who consume a diverse range of foods are less likely to experience stunting compared to children who consume limited varieties of food[23].

Methods

Research design

This research was an observational study using cross-sectional design. Cross-sectional research was a study conducted by collecting data from a group of people at one specific point in time. This research was conducted from September to October 2024.

Research subjects

The subjects of this study were children aged 12-59 months in Gunungkidul Regency. The selected districts were Wonosari and Gedang Sari District, based on the prevalence of stunting. The sample of this study were 105 children from 6 *Posyandu* (integrated health care center), which were selected based on the stunting prevalence. The sample were selected using quota sampling techniques. Village selection was based on the top 3 highest prevalence of stunting among toddlers, while *posyandu* selection was based on the high prevalence of stunting and the *posyandu* implementation schedule. Each of the selected *posyandu* had an average of 25 toddlers participating. The sampling process is presented in **Figure 1**.

The sample selection followed the inclusion criteria: (1) children aged 12-59 months in Wonosari and Gedangsari District; (2) children who live with parents; and (3) mothers who agree to be respondents. The exclusion criteria were mothers or children who had incomplete data. Sampel size calculation using the Lemeshow formula with 95% confidence level indicated a minimum sample size of 96. To avoid potential dropouts, an additional 10% was added to the calculated sample size, resulting in a final sample of 107 respondents. After data cleaning, the final sample size was 105 respondents.

Data collection/materials and tools

This study had received ethical approval from Alma Ata University, Indonesia. Ethics approval number was KE/AA/VIII/10111999/EC/2024. The first data collection method in this research was to obtain secondary data in the form of a list of toddlers in the Wonosari and Gedangsari Districts. Next, primary data collection was carried out by measuring the height of the children, interviewing household food security, and assessing children's dietary diversity.

Anthropometric measurements were conducted directly to assess childhood stunting. Stunting was defined as a height for age ZScore <-2 SD below the 2020 Child Growth Standards median[24]. Household food security was assessed using a questionnaire adapted from the 2012 USDA Household Food Security Survey Module, which has been validated and tested for reliability in a previous study conducted in Panaguan Village, Proppo District, Pemekasan Regency[25]. Food security scores were categorized as food secure (scores 1-2) and food insecure (scores 3-18). Dietary diversity among 12-23-month-old children was assessed using a questionnaire adapted from the 2021 WHO and UNICEF indicators for assessing infant and young child feeding practices, based on eight food groups: breast milk, grains and tubers, legumes, milk and dairy products, fresh foods, eggs, vitamin A-rich fruits and vegetables, and other fruits and vegetables[26]. Meanwhile, dietary diversity among 24-59-month-old children was assessed using a questionnaire adapted from the 2011 Food and Agriculture Organization (FAO) guidelines, based on 12 food groups, including cereals and tubers, animal-source foods, milk and dairy products, eggs, legumes, vitamin A-rich fruits and vegetables, other fruits, other vegetables, and oils and fats[27]. Dietary diversity was assessed based on the food security score threshold, which was categorized as diverse (≥5 food groups) and not diverse (<5 food groups)[26].

Data analysis

The data analysis performed includes univariate analysis and bivariate analysis. Univariate analysis in this study describes the characteristics of children and parents as well as the variables related to independent and dependent variables. Bivariate analysis used Chi-Square test to examine the relationship between food security and dietary diversity with stunting status. P-values <0.05 were used to indicate statistical significance.

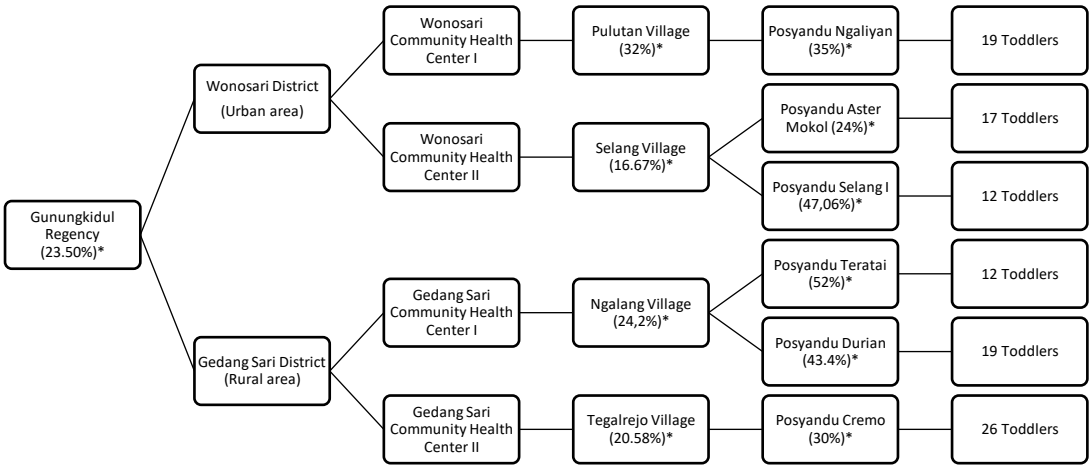

Figure 1. Sampling process
*) *stunting prevalence*

Results

The respondents in this study were children aged 12-59 months residing in Gunungkidul Regency. **Table 1** shows that the majority of respondents were aged 24-59 months, accounting for 78.1%. The majority of respondents were male, with a percentage of 58.1%. Based on residence data, 45.7% resided in Wonosari District and 54.3% resided in Gedang Sari District. Most fathers had an education level of junior high school/equivalent, with a percentage of 37.1%, while the majority of mothers had an education level of junior high school/equivalent and high school/equivalent, with a percentage of 37.1%. The majority of fathers worked as daily laborers, with a percentage of 38.1%, while the majority of mothers were housewives, with a percentage of 81.9%. In Gedang Sari District, the majority of families had an income below the Gunungkidul Minimum Wage, with a percentage of 63.8%. The majority of respondents did not receive any assistance, with a percentage of 38.1%. Most families had ≥4 dependents, with a percentage of 89.5%.

Based on primary data regarding the nutritional status of patients, 31.4% of children are classified as stunted, while 68.6% are not stunted. Household food security impacts the availability of food within the family. Stunting in children can result from an imbalance in food intake. The distribution of food security shows that 44.8% of families were categorized as food insecure, and 48.6% of children were categorized as having not diverse food intake; 51.4% were categorized as having diverse food intake.

The bivariate analysis of food security and stunting in **Table 2** shows that food security is not significantly associated with the occurrence of stunting. The p-value for the bivariate analysis between food security and stunting is 0.454. The percentage of stunting was slightly higher in the food secure category. Dietary diversity and stunting had significant relationship with the p-value was 0.012. The lowest percentage of stunting was found in the group with high dietary diversity.

Table 1. Characteristics of the respondents

Characteristics	n	%
Child's Age		
12-23 months	23	21.9
24-59 months	82	78.1
Gender		
Male	61	58.1
Female	44	41.9
Residence		
Wonosari District	48	45.7
Gedang Sari District	57	54.3
Father's Education		
Did not complete elementary school	3	2.9
Completed elementary school	22	21.0
Completed junior high school	35	33.3
Completed senior high school	39	37.1
Completed diploma/D3	3	2.9
Completed bachelor's degree or higher	3	2.9
Mother's Education		
Did not complete elementary school	1	1.0
Completed elementary school	16	15.2
Completed junior high school	39	37.1
Completed senior high school	39	37.1
Completed diploma/D3	4	3.8
Completed bachelor's degree or higher	6	5.7
Father's Occupation		
Farmer	3	2.9
Factory worker	6	5.7
Farm laborer	16	15.2
Private employee	17	16.2
Government employees/military/police	3	2.9
Entrepreneur	13	12.4
Daily laborer	40	38.1
Others	7	6.7
Mother's Occupation		
Farmer	1	1.0
Factory worker	1	1.0
Private employee	2	1.9
Government employees/military/police	3	2.9
Entrepreneur	3	2.9
Housewife/Unemployed	86	81.9
Daily laborer	1	1.0
Others	8	7.6
Family Income		
<Regional Minimum Wage of Gunungkidul (IDR 2,188,041,-)	67	63.8
≥Regional Minimum Wage of Gunungkidul (IDR 2,188,041,-)	38	36.2
Government Assistance		
Did not receive assistance	40	38.1
Receive assistance (PKH/BLT/BPNT)*	35	33.3
Receive more than one type of assistance	18	17.2
Others	12	11.4
Number of Family Dependents		
≥ 4 dependents	94	89.5
< 4 dependents	11	10.5

Characteristics	n	%
Distribution of Stunting		
Stunted	33	31.4
Normal	72	68.6
Food Security Status		
Food Insecure	47	44.8
Food Secure	58	55.2
Dietary Diversity Status		
Not Diverse (IDDS <5)	51	48.6
Diverse (IDDS ≥5)	54	51.4

*) *assistance program from the Indonesian Government in the form of subsidized money to help poor families*

Table 2. Association of food security and dietary diversity with stunting among toddlers

	Stunting Status				*p-value*	OR (95% CI)
	Stunted		Normal			
	N	%	N	%		
Food Security						
Food Insecure	13	27.7	34	72.3	0.454	0.73 (0.314-1.679)
Food Secure	20	34.5	38	65.5		
Dietary Diversity						
Not Diverse	22	43.1	29	56.9	0.012	2.97 (1.251-7.033)
Diverse	11	20.4	43	79.6		

Discussion

The results of this study showed that most of the 105 households in Gunungkidul Regency were categorized as food insecure. A majority of the food-insecure households were headed by daily laborers and had a lower socioeconomic status compared to food-secure households. According to UNICEF's conceptual framework of malnutrition, limited availability and control of resources influence household food access[28]. Regarding dietary diversity, the study found that most respondents had a moderate level of dietary diversity. Dietary diversity is a critical factor in determining the nutritional quality of a child's diet[29]. Children's dietary diversity can be influenced by family income[30]. Family income is closely linked to household food security, making household food security a key factor in achieving dietary diversity.

Household food insecurity is a condition where households have limited access to food, resulting in poor dietary quality[31]. Poor dietary quality is a nutritional health issue that needs attention[32]. This study also evaluated the relationship between household food security and stunting among children aged 12 to 59 months in Gunungkidul Regency. The results showed no significant association between food security and stunting in Gunungkidul. These findings are consistent with previous research conducted in Sekela District, Western Ethiopia, which also found no significant association between food security and stunting[33]. This study aligns with previous research in Maharashtra, India, which indicated no significant association between food security and stunting in both rural and urban areas[34]. Additionally, this study aligns with previous research conducted in East Siau and West Siau Subdistricts on Makalehi Island, indicating that there was no significant correlation between food security and stunting[35]. Stunting can be caused by various factors such as inadequate dietary intake, caregiving practices, and child health[28]. Previous research on food security conducted in areas with a low prevalence of stunting at the Dawe Community Health Center in Kudus Regency showed that most were food secure (74.4%) and food insecure (25.6%)[36]. While household food security is one factor contributing to stunting, there are numerous other factors involved, suggesting that stunting is not solely driven by food security.

Most of the children in this study were categorized as having high dietary diversity. However, most stunted children had a moderate level of dietary diversity. The results showed a significant negative correlation ($p<0.05$) between dietary diversity and stunting in Gunungkidul Regency. This indicates that higher dietary diversity scores were associated with better child height and a lower risk of stunting. Conversely, lower dietary diversity scores were linked to lower height-for-age. These findings align with previous research conducted in Dessie and Combolcha, Ethiopia, which demonstrated a significant association between dietary diversity and stunting[37]. Study in Semarang Regency, Indonesia, found a similar significant relationship between dietary diversity and stunting[38]. Additionally, this research aligns with a study in Bogor, indicating a significant correlation between dietary diversity and stunting[39]. Previous research on dietary diversity conducted in areas with a low prevalence of stunting in West Sumba Regency showed that most had adequate dietary diversity (98.31%) and inadequate dietary diversity (1.69%)[40]. Dietary diversity is crucial for child growth as consuming only one type of nutrient is insufficient to meet all the nutritional needs, especially during childhood[41]. The more varied the diet, the more nutritional needs are met[42]. A diverse diet can support the growth and development of children under five years of age[43].

This study has certain limitations that may have influenced the results. A deeper exploration of potential confounding variables was lacking. For instance, the duration of government assistance for food-insecure households was not thoroughly investigated and could be a confounding factor in the relationship between food security and stunting.

Conclusion

Dietary diversity is a factor that can cause stunting in children. However, food security is not the only factor determining the occurrence of stunting. The results of this study show that there was no significant relationship between food security and stunting in Gunungkidul Regency, but significant relationship was seen between dietary diversity and stunting. Based on the research findings, providing a diverse diet is crucial for child feeding. It is important for caregivers of toddlers to provide good parenting, including offering dietary diversity, especially those based on local ingredients.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

Understanding challenges and opportunity of data recording and reporting of malnutrition intervention programs: A qualitative study among healthcare workers in DKI Jakarta

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Abstract

Background: The number of stunting in Indonesia was reported to be 21.6% in 2022, still far from the 2024 target of 14%. The large-scale programs of nutrition-specific intervention have been done, including moderate-acute malnutrition (MAM) and severe-acute malnutrition (SAM) interventions. However, limited findings on the process of monitoring and evaluation of both interventions.

Objective: This paper aims to describe the implementation, challenges, and opportunities of malnutrition intervention data recording and reporting among healthcare workers in DKI Jakarta Province, Indonesia.

Methods: Qualitative data collection was taken with in-depth interview (IDI) and focus group discussion (FGD) in August-October 2024 towards healthcare workers in selected Puskesmas in DKI Jakarta who were involved with MAM and SAM interventions and data management. Data triangulation was done to health cadres and mothers of children under five (CU-5) as the beneficiaries.

Results: This study involved eight informants from South and Central Jakarta Puskesmas, and 16 cadres and 13 mothers who were involved in MAM and SAM interventions. The dissemination and adaptation of indicators has been done and digital data recording has been used, despite its lack of supporting resources and data integration which may affect its data quality. Leveraging resources and enabling data-sharing between facilities and maintaining communication between stakeholders are essential.

Conclusions: The process of data recording and reporting of malnutrition interventions required well-informed indicators, trained personnel, and streamlined information systems. Maintaining high quality data, collaboration between stakeholders and utilizing accessible technology are recommended for the healthcare worker to improve the process of data recording and reporting.

Keywords: MAM, SAM, malnutrition intervention, nutrition-spesific intervention, data recording, data reporting

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Introduction

As the third most populous country in the Asia (2020)[1], which accounted for 30 million (2%) of its population were children under-five (CU-5), Indonesia is currently facing the burden of stunting for these past years.[2] The prevalence of stunting in Indonesia was reported to be 21.6% in 2022, which is still far from the government's goals to reduce it to 14% by 2024.[3] By far, the Indonesian government has been focusing on the implementation of specific-nutrition intervention programs as a strategic way to reduce stunting, regulated in the Presidential Decree 2021 Number 72 about nine priority program.[4] There were six out of nine nutrition-specific intervention programs, that classified as on-track, while the other three programs still need acceleration.[5] Children under 5 years old (CU5) with severely acute malnutrition (SAM) receiving treatment and CU5 with moderately acute malnutrition (MAM) receiving additional nutrition intake, are two programs nutrition-specific intervention programs that are related with malnutrition intervention. Despite the current progress report in number and percentages, there was limited publications on exploration of factors that might foster or hinder the overall progress.

In the global setting, the sparse data on the large-scale nutrition-specific intervention outcomes on the reduction of stunting has occurred, remaining the intervention program's effectiveness being questionable.[6] There were some underlying reasons that lead to the lack of monitoring and evaluation data on intervention programs. First, the program indicator was not clearly disseminated, resulting in uneven understandings of the stakeholders, thus making the project unclear to be monitored and evaluated.[7,8] On the healthcare worker side, there are also some difficulties to undergo data recording and reporting in the digital setting. Some reports show that the healthcare workers in the primary health care were faced to the heavy burden of reporting data in 70 different applications which may be affecting the quality of the data.[9,10]

Using digital tools may also become a hindrance for the healthcare worker to perform data recording and reporting. Some researchers found that the knowledge and attitude of the healthcare workers toward the primary health care information system is low, especially in low-middle income countries, which may be due to shortage of workforce and low capacity to perform information system task.[11,12] Ideally, the healthcare workers are urged to possess the ability to effectively managing, analyzing, and interpreting data, to enhance the intervention progress.[13]

On the data infrastructure aspect, data integration between various intervention in different healthcare services is also important to capture thorough information of malnutrition intervention. Several systematic reviews on MAM and SAM interventions shows how comprehensive intervention approaches at the community-based screening and facility-based screening were beneficial to improve child's nutritional status, thus this highlights the need for data integration at both intervention end-points.[14,15] Mothers and the caregivers of the children also play vital role to ensure a continuum of care of malnourished children, which pose them to the potential socio-economic hindrance such as low education, limited access to healthcare facility, and even social stigma.[15] Involving the mothers and caregivers to actively participate in the intervention monitoring is critical, since that MAM and SAM interventions may require self-report on food consumption, resulting this type of data are prone to bias and loss of follow up.[16,17]

This qualitative study aims to explore the implementation, challenges, and opportunity of data recording and reporting of nutrition-specific intervention in several Puskesmas from DKI Jakarta Province. DKI Jakarta is accounted for 798,107 number of children, with the prevalence of stunting is 14.8%.[18] As the capital city of Indonesia, DKI Jakarta is more adaptive with the new guidelines or instructions from the MoH, thus this province is expected to have close gaps between the guidelines and the implementation process. Modification on WHO's framework of Using Nutrition Data for Decision Making[19] was used in this study, encompassing the whole process of MAM and SAM data recording and reporting business process.

Methods

This study employed a qualitative approach to explore the challenges and opportunities of data recording and reporting of MAM and SAM interventions among healthcare workers in DKI Jakarta. Data were collected by in-depth interview (IDI) to the main informant (healthcare worker in Puskesmas) and focus group discussions (FGD) to the key informants to facilitate data triangulation. This study purposely targeted DKI Jakarta Province, with the focus in Central Jakarta and South Jakarta Districts with the consideration of its CU-5 nutritional status landscape. Two Puskesmas were selected within each Central Jakarta and South Jakarta administration level to ensure a representative sample that captures the regional variations. To achieve maximum variety in participants, we involved main informants (healthcare workers) who worked in the sub-district and village level and had extensive experience in managing MAM and SAM interventions. We also performed data triangulation to manage bias, which was done to groups of health cadres who managed community-based intervention and mothers/caregivers of the CU-5 who received MAM or SAM intervention.

Data was then analysed by using thematic analysis methodology, focusing on specific themes: healthcare worker knowledge on program indicators, healthcare workers competencies and workload, facilities and resources, data quality, data integration, and health outcome evidence. We organized the data presentation by dividing the results into three sections: implementation, challenges, and opportunity sections, in which all of the specific themes were included in each section. The recording of FGD and IDI was transcripted into text, which then was coded into the specific themes by using Microsoft Excel.

This study had been accepted for ethical conduct, as issued by *Komite Etik Penelitian Kesehatan RSUP Nasional Dr. Cipto Mangunkusumo FKUI,* Number KET.999/UN2.F1/ETIK/PPM.00.02/2024.

Results

Characteristics of Informants

The main informants in this study consisted of eight participants with diverse demographic backgrounds from Puskesmas at the Sub-District and the Village levels (**Table 1**). There were four informants who came from Puskesmas in the District level, and four others from Puskesmas in the Village level. The healthcare workers that were gathered were all Puskesmas' Nutritionists.

To perform data triangulation, we gathered 16 health cadres who were responsible for MAM and SAM interventions in the community and mothers of the CU-5 who received the interventions. Towards the health cadres, we performed FGD in which 16 of the health cadres were divided into four groups. These cadres were responsible for distributing additional food for MAM CU-5. Another target of key informants were mothers of CU-5 with MAM and SAM condition, with a total of 13 people gathered for in-depth interviews.

Table 1. Characteristics of main informant

Characteristics	Total (n=8)
Age	
26-35	6
36-45	1
46-55	1
Education Level	
Diploma Degree	5
Bachelor Degree	3
Gender	
Male	1
Female	7
Role of The Occupation	
Intervention implementation	8
Data recording and reporting	8
Place of Working	
Sub-District Level Puskesmas	4
Village Level Puskesmas	4
Length of Working in Current Role Experience	
0-5 years	4
6-10 years	2
11-15 years	1
16-20 years	1

In the next section, the results are presented thematically according to the pre-determined theme (**Table 2**). For each main theme, there are some sub-theme mentioned to have a more organized presentation. To answer the specific objective of this research, the implementation, challenges, and opportunities are included in each sub-theme to present deeper analysis for each.

Implementation & Challenges

The general service flow of MAM and SAM interventions that were implemented in all study sites, began with the weight and height monthly measurement in Posyandu. After the nutritionist received the data, the Puskesmas' health worker validated all CU-5 with MAM and SAM nutrition status by repeating the weight and height measurement in Puskesmas. The data validation was done in Puskesmas, Posyandu, or home visit by the nutritionist.

> *"... we confirm it with the cadres, we ask the cadres to please ask the toddler to go back to the puskesmas, later at the puskesmas we will check again, whether the weight is in accordance with the measurements taken and or not"* #8 Main Informant, Village Puskesmas Nutritionist, 10-year experience

Table 2. Predetermined themes

Theme and Sub-Theme	Description
Program Indicator • Definition clarity • Fulfillment criteria	How the informants understand the current program indicator, including the fulfillment criteria or the definition of done of the indicators.
Competency and Workload • Competencies • Workload	How the informants are capable to perform data recording and reporting, able to operate the digital/manual tools. For the workload, it is how the informants manage the data recording and reporting tas on top of other daily workload.
Facilities and Resources • Facilities • Resources	How the facilities and resources in the Puskesmas or community-settings are available to support the data recording and reporting of MAM and SAM interventions.
Data Integration • Integration of Electronic Medical Record (EMR) • Integration of Health Information System (HIS)	The EMR and HIS were identified as the digital tools to store MAM and SAM data in Puskesmas, thus this theme explores how both systems interact with each other to capture comprehensive conditions of the intervention.
Data Quality • Accuracy • Timeliness • Completeness	How the informants perform the data recording and reporting with the consideration of the data quality aspects.
Health Outcome Evidence • Monitoring System • Feedback mechanisms	How the informants perform the overall monitoring in each end-point intervention settings, and how they provide and receive feedback of the intervention progress/outcome.

The healthcare worker in Puskesmas understood that all indicators refer to the guideline/SOP issued by the Provincial Health Office (PHO). However, there was a dispute among informants related to the indicator, recovered nutritional status (from malnutrition turning to normal), is also a program indicator that should be achieved.

> *"..but the indicators they (malnourished children) have to be normal, good nutrition, it doesn't exist yet..." #1 Main*

Informant, Sub-District Puskesmas Nutritionist, 6-year experience

In terms of training, the MoH had provided training, including guidebook socialization. On the other side, the DHO already accommodated a ToT training for the Puskesmas' team, which will be passed to the Village Level Puskesmas

"For training, it is usually accommodated by the district health office.. But after the training, we (Sub-District Puskesmas) did ToT with the Village Puskesmas team (Village Puskesmas)." #5 Main Informant, Sub-District Puskesmas Nutritionist, 11-year experience

For both the cadre and the Puskesmas' healthcare worker, they have been very busy working multiple roles. Thus, the burden of undergoing data recording and reporting for the MAM and SAM interventions were also affected. The cadre and the Puskesmas' healthcare worker should input the data in lots of forms.

"...So recording, the hassle of recording it means they (cadre) have to do quite a lot. Ehh, so they are the biggest burden, the workload (of the cadre) is already a lot so that's why we can't ask them to rush." #1 Main Informant, Sub-District Puskesmas Nutritionist, 6-year experience

For the data integration, all of the Puskesmas already use EMR in their own Puskesmas, including to record the SAM intervention. However, though the Puskesmas EMR records the overall services, the data was only localized in the Puskesmas. It does not share data with other health care facilities.

Researcher: Is the Puskesmas EMR bridging with the hospital EMR?
Nutritionist: Nope
#5 Main Informant, Sub-District Puskesmas Nutritionist, 11-year experience

After the data from Posyandu had been gathered, the Puskesmas' healthcare worker recorded the data into the specific HIS for nutrition system, which is the ePPGBM. This include all data of CU5 receiving MAM and SAM interventions. In ePPGBM, the DHO will monitor the data being submitted for each Puskesmas.

"But what is most focused on is EPPGBM, the District Health Office that looks at EPPGBM" #7 Main Informant, Sub-District Puskesmas Nutritionist, 7-year experience

As the Puskesmas' healthcare workers had already been equipped with several forms to report the MAM intervention progress, these forms were stand alone and not connected to each other. While if we look closer, the data that was recorded across these forms were related one to another. Therefore the Puskesmas' healthcare worker still needed to enter each form, with similar data components.

"... we also have to input it manually in a spreadsheet from the department, even though the data is actually the same, you can also take it from EPPGBM for case data... #1 Main Informant, Sub-District Puskesmas Nutritionist, 6-year experience

To ensure the data accuracy, especially the nutrition status of the children, the Puskesmas' healthcare worker used several ways to ensure that every child's weight and height measurements were plotted with the right nutritional status. But for the self-reporting data by the mothers of the consumed food of the children as proof of intervention, there was no validation mechanism to ensure that the food was truly consumed by the child.

"... To be honest, the food portion was too big so the child only finished half. Sometimes to be honest, there has been no verification" #1 Main Informant, Sub-District Puskesmas Nutritionist, 6-year experience

The data that was submitted by the cadre to the Puskesmas, regarding the intervention evaluation, was done through aggregated data. This included how many child had received the

PMT, how many has weight increase, and how many stayed the same.

> *"Then, when reporting to others, we usually just use aggregate data or numbers, for example, how much has increased, how much has remained the same." #1 Main Informant, Sub-District Puskesmas Nutritionist, 6-year experience*

For the SAM intervention, sometimes it was hard to ask the parent to have re-evaluation. This is due to the fact that parents tend to come to the health facility only if the children are ill. Therefore, the Puskesmas' healthcare worker asked for help from the cadre to urge the parent to come to the Puskesmas.

> *"Yes, so it's actually quite difficult for us to refer children under five to hospital because usually they feel healthy and so on. It must be because usually if the mother doesn't come, we call the cadre (to help reaching out to the mother)" #5 Main Informant, Sub-District Puskesmas Nutritionist, 11-year experience*

Opportunities

It was found that other Puskesmas had allocated incentives for cadres responsible for PMT distribution. The incentives were usually called the "transportation incentives" for the cadre, as they had to be mobile, distributing the food from the local community centre, to each house of the targeted child.

> *"There are incentives from the community health center". FGD Cadre in Puskesmas 3*
>
> *"Just transport money". FGD Cadre in Puskesmas 1*

For data integration, an initiative had been done between the Puskesmas' and Hospital Nutritionist to had Google Spreadsheet which could be filled by both sides, the hospital and Puskesmas, so that they could share the patient data. This way of data recording has helped the Puskesmas and Hospital Nutritionist on having broad picture of the ongoing intervention status for each individuals with SAM intervention from inter-healthcare facilities.

> *"There is spreadsheet link for reporting, the RSUD fills the form. It includes any clinical actions, medical prescription, food prescription, and of course patient attendance records …" #3 Main Informant, Sub-District Puskesmas Nutritionist, 20-year experience*

For data quality, certain Puskesmas used visual Comstock, representing the estimate pie chart of the remaining food. This helped the cadre to estimate the food being eaten by the child.

> *"This (the virtual Comstock) was given to us (cadre by the Puskesmas... This is how we can make the estimation of remaining portion because we can see from the photos whether it's finished, how much is left, half left, sometimes just a little bit left, we have that information..." #FGD Cadre from Puskesmas 1*

To support timely data submission, a collaboration between nutritionist and cadre had been done, immediately after the intervention being given.

> *"… usually we try to have a method of inputting together (with cadre), at least twice a month…." #1 Main Informant, Sub-District Puskesmas Nutritionist, 6-year experience*

To promote effective ways of monitoring, simple technology was involved, including the use of WhatsApp. Some Puskesmas created a WhatsApp group to communicate within this channel. The mother can use this group to ask for any assistance related with child health and nutrition. The healthcare worker from the Puskesmas attempted to respond to the chat timely.

> *"Yes, that's right. So later, if there is any information or anything, it's all through WA, through the same group as the midwife. Midwives also like quick*

responses" #2 IDI Mother from Puskesmas 3

To summarize the findings, we provide flowchart to visualize how the stakeholders are involved in the MAM and SAM interventions, including the detail process of data recording and reporting activities, and whom are the beneficiaries of the data (Appendix 1).

Discussion

The management of Moderate Acute Malnutrition (MAM) and Severe Acute Malnutrition (SAM) among children under five in Indonesia involves a structured process utilizing community health services and digital systems.[19] Posyandu conducts weight and height assessments and reports data to Puskesmas nutritionists, who upload the data to e-PPGBM, a specialized Health Information System (HIS) for monitoring nutritional status.[20] This data serves as the basis of targeted beneficiaries of malnutrition intervention.

National guidelines on supplementary food/*pemberian makanan tambahan* (2023) and malnutrition management (2020) guide implementation across all cities and districts, allowing local adaptations on its implementation.[21,22] Studies suggest that sufficient guideline dissemination, training for healthcare workers, and Ministry of Health (MoH) follow-up supervision are critical for success of program implementation in the region level.[23]

The dual roles of cadres and Puskesmas Nutritionists in managing Moderate Acute Malnutrition (MAM) and Severe Acute Malnutrition (SAM) interventions present significant challenges in terms of workload and data management. These healthcare workers are not only involved in direct service delivery but also in extensive data recording and reporting tasks. Similar finding in five LMI countries show that PHC facilities are responsible to use numerous registers and recording forms, resulting in burden to healthcare workers.[24] Studies have shown that excessive documentation requirements can detract from the quality of care provided and lead to fatigue and reduced motivation among healthcare workers.[25,26] These challenges emphasize the need for streamlined reporting processes and digital solutions that reduce duplication and ease the data entry process. Implementing digital solutions to unify reporting processes across governing bodies is needed for further streamline workflows, reduce redundancies, and enhance the timeliness and accuracy of data submission.[27]

The use of Electronic Medical Records (EMR) in Puskesmas can enhance the efficiency of patient data management, reduce errors, and improve healthcare delivery by providing real-time access to medical information.[28] Developed countries have already implemented EMRs in primary healthcare, leading to better data interoperability, improved patient care, and more efficient resource allocation.[29]

Integrating reporting processes in digital tools are essential to address the challenges faced by healthcare workers in managing administrative tasks like data entry.[30] Simplifying workflows through the integration of digital tools can significantly reduce duplication, save time, and improve the accuracy of health data.[31] The MoH has launched SATUSEHAT as centered platform to utilize all health data across healthcare. Integration and interoperability of medical record systems and data at healthcare facilities.[32] Assessing the feasibility and designing data workflow of malnutrition intervention across healthcare facilities to be interoperable and comply with SATUSEHAT standards are important to improve the data interoperability and enhance the intervention outcome.

For data quality, the accuracy aspect emerged for the self-reporting data. The MAM intervention requires the Cadre to report the remaining food being consumed by the child, by means of parent's self-reporting. Therefore, ensuring the validity of a parent's self-reporting is essential to ensure the intervention effectiveness. Study found that self-reporting caused biases.[33,34] In terms of timeliness, the data recording faces challenges when the number of children requiring evaluation is high, leading to potential delays. A study emphasized the importance of timely data collection and reporting in improving the

effectiveness of health and nutrition interventions.[35] These delays can hinder the effectiveness of interventions by limiting the ability to promptly address emerging needs on an individual basis.

To improve beneficiaries' feedback to support the comprehensiveness of the intervention, increasing mother's education on the importance of malnutrition condition is known to prevent the prevalence of malnutrition in developing countries.[16] To date, there has been numerous studies revealing the use of digital tools to improve treatment adherence, including the personalized interventions through mobile apps and telehealth services.[36] This can be done through SMS text messages, mobile app, calls, or WhatsApp, to improve treatment adherence.[37,38]

This study elaborates the topic that is still rarely discussed, related with the process of data recording and reporting of MAM and SAM interventions, which are part of the nutrition-specific interventions. This information is valuable to deeply analyze the current condition of MAM and SAM interventions monitoring and evaluation process, thus supporting basis data for shaping better monitoring and evaluation plan in the future.

However, this study was taken within the area of DKI Jakarta Province, limiting the diversity of geographical, socio-economic, political and other aspects that may affect the process of data recording and reporting in different areas. The findings of this study may not reflect the overall condition of other locations, encompassing all 34 provinces in Indonesia.

Conclusion

Both MAM and SAM interventions data recording and reporting processes in DKI Jakarta have been done according to the National MoH guidelines, with additional indicators to monitor the recovered malnourished children. Multiple roles of healthcare workers and cadres, redundancy in recording form, limited data integration, and resources were found as the challenges. To improve data quality and workload efficiency, data integration is required between systems being used in Puskesmas to report program indicators, supporting incentives, and intensive communication and collaboration between Puskesmas, cadres, mothers, and other stakeholders by using digital tools are essential to build a comprehensive monitoring intervention process. The healthcare worker in Puskesmas are urged to record intervention data in individual-based, to ensure the comprehensiveness of intervention monitoring reports. Maintaining collaboration with health cadres, caregivers, and even community leaders is beneficial to support the continuity of intervention monitoring. Using accessible technology is a potential tool to increase stakeholders' awareness in supporting intervention processes, thereby enhancing the quality of data recording and reporting.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this paper.

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Abbreviations

CU-5 : Children under 5
DHO : District Health Office

DKI	: *Daerah Khusus Ibukota*
EMR	: Electronic Medical Record
e-PPGBM	: *Aplikasi elektronik-Pencatatan dan Pelaporan Gizi Berbasis Masyarakat*
HAZ	: height-for-age z-score
HIS	: Health Information System
MAM	: Moderate-acute malnutrition
MoH	: Ministry of Health
PHO	: Provincial Health Office
Puskesmas	: Pusat Kesehatan Masyarakat
SAM	: Severe-acute malnutrition
WAZ	: weight-for-age z-score
WHZ	: weight-for-age height z-score

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Appendix 1

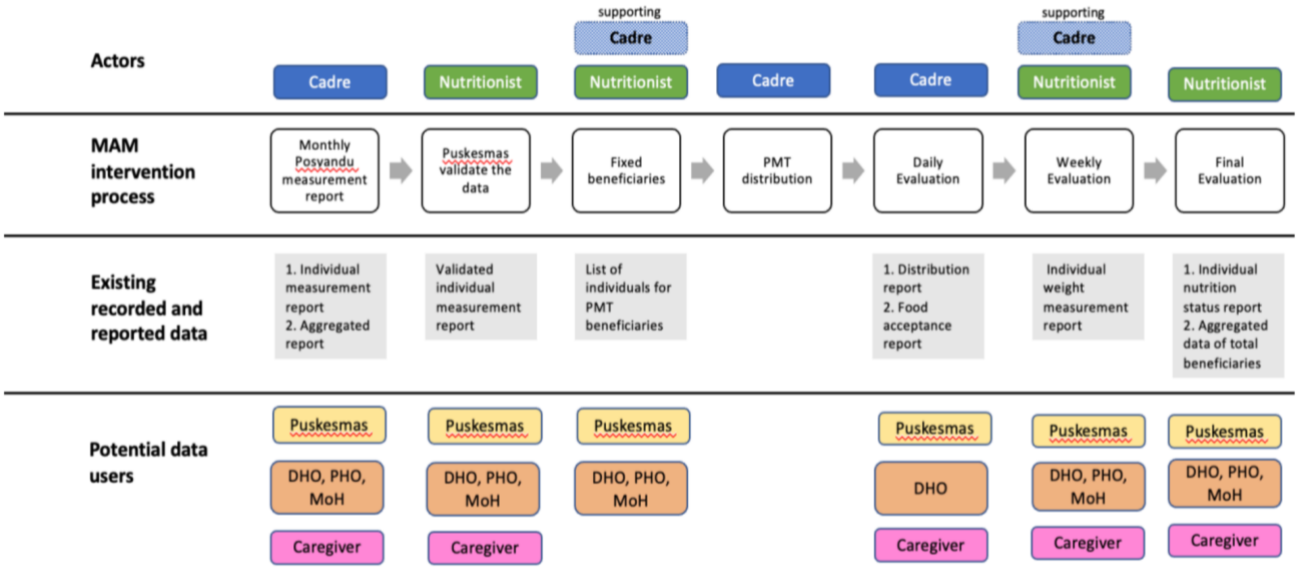

Figure 1. Flowchart of overall mechanism for MAM intervention data recording and reporting

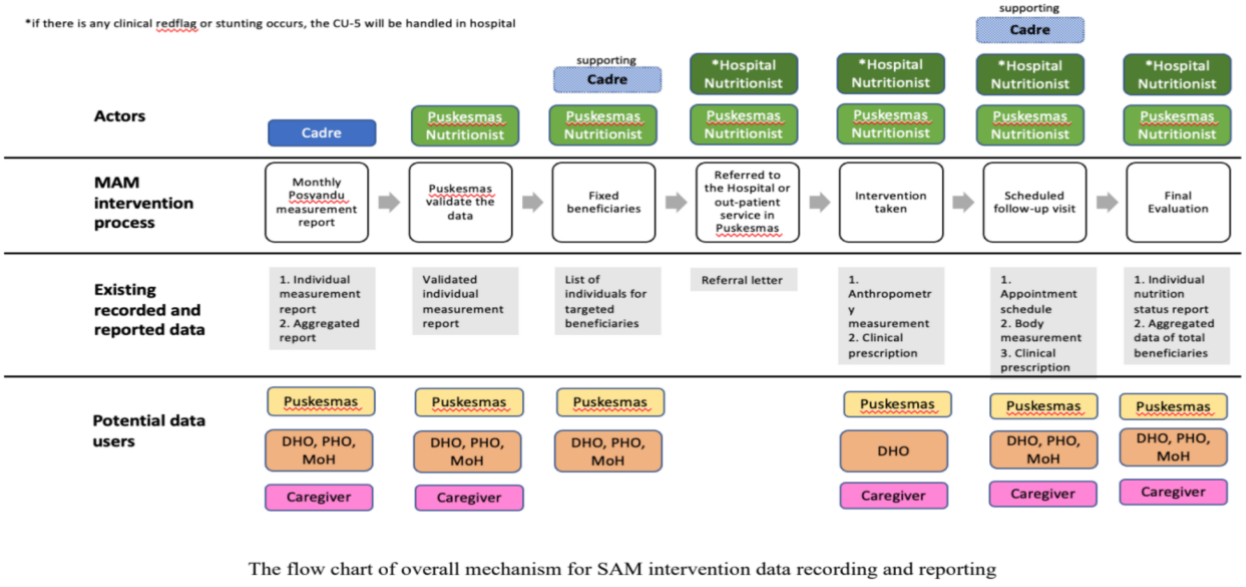

Figure 2. Flowchart of overall mechanism for SAM intervention data recording and reporting

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ORIGINAL PAPER

Association between muscle-to-visceral fat ratio and vascular elasticity in medical students

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Abstract

Background: Medical students often adopt lifestyles that contribute to decreased muscle mass and increased visceral fat accumulation, which can negatively impact vascular elasticity, a biomarker for the early detection of cardiovascular disease.

Objective: This study aims to evaluate the association between the muscle mass to visceral fat ratio and vascular elasticity in medical students at Universitas Pembangunan Nasional Veteran Jakarta (UPNVJ).

Methods: A cross-sectional design was conducted from November 2023 to January 2024 at UPNVJ. The sample consisted of 51 subjects who met the research criteria. The muscle-to-visceral fat (MVF) ratio was measured using Bioelectrical Impedance Analysis (BIA), while vascular elasticity was assessed using the Accelerated Photo plethysmograph Analyzer SA-3000P.

Results: The results revealed that 68.6% of the subjects had the lowest MVF ratio and 54.9% exhibited sub-optimal vascular elasticity. No differences were found in age, gender, physical activity, or eating habits between the vascular elasticity groups ($p > 0.05$). The Chi-square test revealed a significant association between the MVF ratio and vascular elasticity ($p = 0.009$; OR = 6.545; 95% CI = 1.7–24.9).

Conclusion: Students with the lowest MVF ratio were found to be 6.54 times more likely to have sub-optimal vascular elasticity, compared to those with low and high MVF ratios, indicating an increased risk of cardiovascular disease. These findings underscore the importance of early preventive intervention aimed at optimizing body composition through targeted wellness programs. The implementation of nutritional education and structured physical activity initiatives, particularly in young adults, may play a critical role in reducing the risk of cardiovascular disease.

Keywords: muscle mass, vascular elasticity, visceral fat

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Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide. In 2019, the World Health Organization estimated that 17.9 million people died from CVD, accounting for 32% of all global deaths.[1] Early identification of high-risk individuals can be facilitated using biomarkers.[2] Vascular elasticity is a novel biomarker for CVD.[3] Reduced vascular elasticity impedes blood flow and increases the left ventricle's workload, leading to elevated blood pressure. Consequently, decreased vascular elasticity heightens the risk of CVD.[4]

Physical inactivity is a recognized cardiovascular risk factor associated with changes in body composition. In Indonesia, the prevalence of physical inactivity increased from 26.1% in 2013 to 33.5% in 2018.[5] Lack of physical activity contributes to muscle mass loss and obesity.[6] The combined effects of muscle mass loss and visceral fat accumulation contribute to cardiometabolic diseases in young adults.[7] Studies show that obesity accelerates vascular aging from early adolescence.[8] Central obesity, characterized by visceral fat accumulation, is independently associated with metabolic disorders such as insulin resistance and cardiovascular conditions.[9] Additionally, reduced muscle mass is linked to insulin resistance, which contributes to endothelial dysfunction and vascular stiffness.[10] Moreover, muscle mass loss and visceral fat accumulation are interrelated through the synthesis of pro-inflammatory cytokines, which directly impact vascular elasticity.[11] Thus, the muscle-to-visceral fat (MVF) ratio serves as a stronger predictor of cardiometabolic diseases than muscle mass or visceral fat alone.[12]

A study at Universitas Pembangunan Nasional Veteran Jakarta (UPNVJ) in 2020 found that 47% of 150 medical students were obese, with most engaging in light physical activity.[13] This may be attributed to the demanding academic schedules of medical students, leading to increased food intake and neglect of physical activity, resulting in alterations to the MVF ratio. Such alterations are associated with metabolic disorders that may increase the risk of cardiovascular diseases.[11]

While physical activity remains important, dietary habits have been shown to exert an even greater influence on body mass index (BMI). Among medical students, common dietary habits include irregular meals, frequent meal skipping, inadequate consumption of fruits and vegetables, and high intake of candies, alcohol, fried foods, and fast food.[14] These poor dietary habits, in conjunction with a sedentary lifestyle, further contribute to adverse changes in the MVF ratio within this population. However, the impact of the MVF ratio on vascular elasticity in young adults, particularly among medical students, remains unexplored. Therefore, this study aims to evaluate the association between the MVF ratio and vascular elasticity in medical students at UPNVJ in 2023.

Methods

The study utilized an analytical cross-sectional design conducted in November 2023 - January 2024 at the Laboratory Unit of Physiology and Nutrition, Medical Education and Research Center of UPNVJ. The study population comprised 533 medical students from the Faculty of Medicine UPNVJ.

The research subjects were medical students from the 2023/2024 academic year who met the inclusion criteria, which included being at least 18 years old and engaging in light or moderate physical activity. Exclusion criteria included a history or diagnosis of diabetes mellitus or cardiovascular diseases (e.g., hypertension, chronic heart failure, myocardial infarction, and peripheral artery disease), as well as smoking or alcohol consumption.

The sample size was calculated using a two-proportion formula with $\alpha = 5\%$, $\beta = 80\%$, $P_1 = 0.76$, and $P_2 = 0.4$, based on studies by Liu et al. (2021)[15] and Xu et al. (2018)[11], resulting in a sample of 46 subjects. To account for a potential 10% dropout rate, the minimum required sample size was increased to 51 subjects. The subjects were selected using stratified random sampling according to their year of admission to the Faculty of Medicine.

Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ), which

measures activity in Metabolic Equivalent of Task (MET) units over the past month. The GPAQ demonstrated moderate to strong reliability for calculating total physical activity time (Spearman's rho: 0.68–0.79). Physical activity levels were categorized as vigorous (MET ≥ 3000), moderate (600 ≤ MET < 3000), and light (MET < 600).[16]

Eating habits were evaluated using the Adolescent Food Habits Checklist (AFHC), which was translated into Indonesian. AFHC scores were categorized into two groups: good eating habits (scores ≥ mean) and poor eating habits (scores ≤ mean). The validity and reliability of this tool were established, with a Cronbach's alpha of 0.86.[17]

Body composition was measured using the Body Composition Analyzer (Tanita MC-980MA Plus), which has 80% sensitivity and 90% specificity.[18] Subjects were instructed to remove all metal accessories, stand barefoot on the analyzer, and hold the electrodes for 30 seconds. The MVF ratio was categorized into four groups: lowest ratio (Q1): 2.62–15.3; low (Q2): 15.4 – 37.4; high (Q3): 37.5 – 42.7; and very high (Q4): 42.8 – 73.3.[12]

Vascular elasticity was measured using the Accelerated Photoplethysmography (APG) SA-3000P, which has 71.4% sensitivity and 90% specificity. Subjects were instructed to remove metal accessories and sit comfortably while the APG sensor was clipped onto the index fingertip for three minutes. Vascular elasticity results were categorized as sub-optimal (<30), normal (30-70), or optimal (>70).[19]

Univariate analysis was conducted to describe the subjects' characteristics, physical activity, eating habits, MVF ratio, and vascular elasticity. The Chi-square test was used to test the hypothesis of an association between MVF ratio and vascular elasticity. If the assumptions for the Chi-square test were not met, the exact Chi-square test was used as an alternative. The data were analyzed using SPSS software.

This study received ethical clearance from the Health Research Ethics Committee of UPNVJ, with approval number 417/XI/2023/KEPK.

Results

The subjects of this study were first-, second-, and third-year medical students of UPNVJ, aged between 18 and 22 years. In the study, 84 out of 120 students who completed the questionnaire met the study's criteria. Stratified random sampling was used to select 51 subjects who met the criteria. The data on the subjects' characteristics reveal that the median age was 20 years. Most subjects were female, engaged in moderate physical activity, and exhibited poor eating habits. **Table 1** indicates no significant differences in age, gender, physical activity, and eating habits between the vascular elasticity groups (p > 0.05).

Table 1. Characteristics of subjects (N = 51)

No	Characteristics	Vascular Elasticity		p-value
		Sub-optimal N = 28	Normal+Optimal N = 23	
1.	Age, median (min-max)	20 (18-22)	20 (18-21)	0.984[a]
2.	Gender, n (%)			
	Male	10 (58.8)	7 (41.2)	0.921[b]
	Female	18 (52.9)	16 (47.1)	
3.	Physical Activity, n (%)			
	Light	14 (66.7)	7 (33.3)	0.260[b]
	Moderate	14 (46.7)	16 (53.3)	
4.	Eating Habits, n (%)			
	Good	13 (52)	12 (48)	0.899[b]
	Poor	15 (57.7)	11 (42.3)	

Note: [a]Mann-Whitney test, [b]Chi-square test

In this study, 35 subjects (68.6%) had an MVF ratio ranging from 2.62 to 15.3, categorized as Q1, indicating that most of the subjects had the lowest ratio of MVF. This was followed by 14 subjects (27.5%) in Q2 (MVF ratio: 15.4 – 37.4) and 2 subjects (3.9%) in Q3 (MVF ratio: 37.5 –

42.7). Notably, no subjects were categorized into Q4 (MVF ratio: 42.8–73.3) (**Figure 1**).

In this study, 28 subjects (54.9%) exhibited sub-optimal vascular elasticity (<30), 20 subjects (39.2%) had normal vascular elasticity (30-70), and 3 subjects (5.9%) had optimal vascular elasticity (>70) (**Figure 2**).

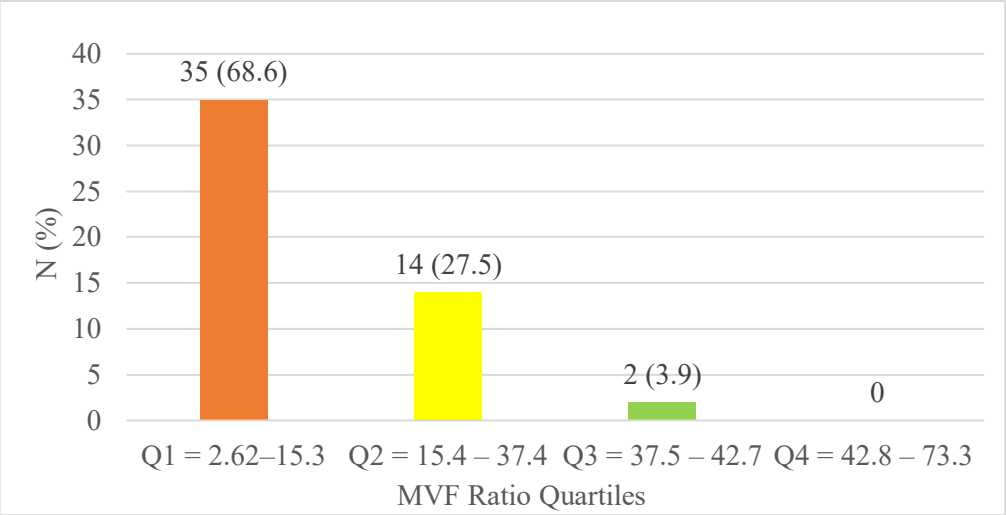

Figure 1. Muscle-to-visceral fat ratio of subjects

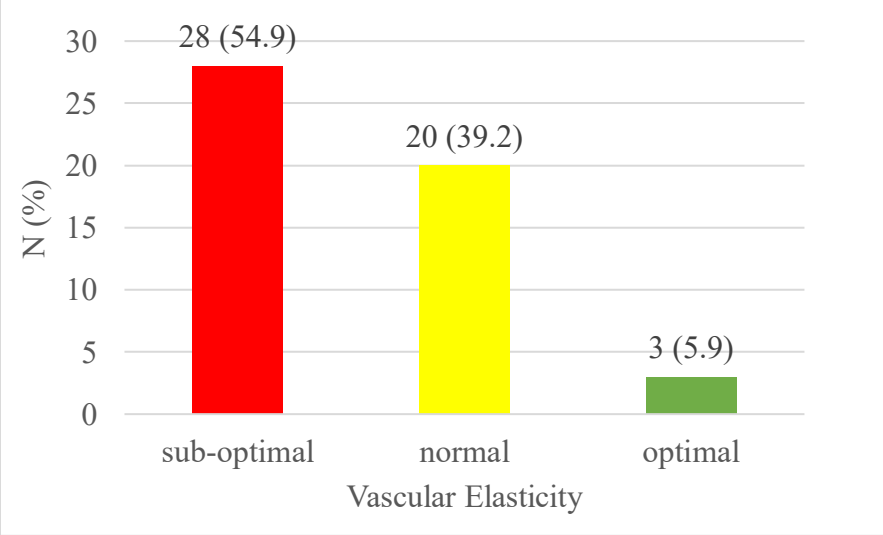

Figure 2. Vascular elasticity of subjects

The results of the Chi-square test revealed a significant association between the MVF ratio and vascular elasticity ($p = 0.009$; OR = 6.545; CI = 1.7 – 24.9) (Table 2), indicating that subjects with an MVF ratio of Q1 are 6.5 times more likely to have sub-optimal vascular elasticity compared to those in Q2 & Q3.

Table 2. The association between MVF ratio and vascular elasticity

MVF Ratio	Vascular Elasticity				Total		p-value	OR (95% CI)
	Sub-optimal		Normal+Optimal					
	N	%	N	%	N	%		
Q1	24	68.6	11	31.4	35	100	0.009	6.545
Q2 & Q3	4	25	12	75	16	100		(1.7 – 24.9)

Discussion

The results of this study indicate that most subjects had the lowest MVF ratio (Q1). This suggests that most subjects had low muscle mass and high visceral fat. This finding is consistent with a study conducted on university students in China, which found that 24.2% of participants experienced an increase in visceral fat percentage and a decrease in muscle mass percentage due to unhealthy lifestyles. The lack of leisure time and insufficient sleep among students reduces the time available for exercise, while increased reliance on internet use further detracts from physical activity.[20]

Another study reported that students expend only 1375.94 kcal daily due to sedentary lifestyles, which is 443 kcal less than the 1818 kcal required to maintain an ideal body composition. This contributes to 78% of subjects having high body fat and an imbalanced body composition.[21] A study conducted in 2022 among physiotherapy students at UPNVJ showed that students had high body fat percentages, with 76.5% of female subjects and 40.9% of male subjects exhibiting elevated fat levels. The increase in pro-inflammatory cytokine secretion from fat accumulation leads to protein catabolism and inhibition of muscle protein synthesis, causing students with higher fat levels to exhibit low muscle mass. Therefore, regular screening of body composition is essential to identify potential health problems.[22]

This study found that 28 subjects (54.9%) had sub-optimal vascular elasticity. This finding aligns with a study conducted in Sweden, which showed that 12% of young subjects exhibited vascular stiffness, thereby increasing their risk of cardiovascular disease. In that study, 24% of subjects consumed unhealthy foods, and 24% did not engage in recommended physical activity. Low physical activity and excessive nutritional intake in youth significantly contribute to vascular stiffness.[23] Additionally, a study indicated that vascular stiffness could begin as early as age 17. Measurements taken over seven years revealed that high body fat composition at the onset of puberty reduces elastin fiber thickness, increasing vascular wall tension and pressure. This leads to collagen accumulation and vascular stiffness.[24]

The data on subject characteristics revealed that the median age of the study participants was 20 years. Age influences vascular elasticity due to elastin fiber fragmentation and collagen deposition over time.[25] Age significantly impacts vascular stiffness in individuals over 60.[26] However, this study found no significant age difference between the vascular elasticity groups ($p = 0.286$) (Table 1), suggesting that age did not influence vascular elasticity in this study. This lack of significance may be attributed to the narrow age range of the study population, which is distinctly younger than the typical age group in which changes in vascular elasticity commonly begin to appear.

The research subjects included 34 females and 17 males, which reflects the higher number of female students at the Faculty of Medicine UPNVJ.[27] Sex hormones are known to play protective roles in vascular health. Differences in estrogen levels between females and males contribute to variations in vascular elasticity. High estrogen levels enhance nitric oxide (NO) bioavailability and reduce vascular stiffness.[28] Estrogen also protects vascular health by reducing reactive oxygen species (ROS) production. However, in young females with abundant lipid tissue, endothelial cell mineralocorticoid receptors play a critical role, stimulating sodium ion channel activation and oxidative stress, which can reduce vascular elasticity.[29] No significant gender differences were found between the vascular elasticity groups ($p = 0.921$) (Table 1), suggesting that gender did not influence vascular elasticity in this study.

Physical activity influences vascular elasticity by increasing blood flow and shear stress, which

triggers NO secretion. Increased NO availability causes smooth muscle relaxation in response to constant pressure from increased blood flow. Regular exercise induces endothelial adaptation, improving perfusion, reducing the risk of endothelial dysfunction, and improving vascular stiffness.[30] Another study highlighted that moderate-intensity physical activity for 150 minutes or high-intensity physical activity for 75 minutes per week positively impacts arterial stiffness.[31] This study categorized subjects' physical activity as light and moderate. However, no significant difference in physical activity was observed between the vascular elasticity groups ($p = 0.260$) (**Table 1**), suggesting that physical activity did not influence vascular elasticity differences in this study.

Eating habits scores revealed that most subjects with poor eating habits had sub-optimal vascular elasticity (57.7%). Eating habits are known to impact vascular elasticity, with studies indicating that unhealthy diets, such as increased fat and salt intake, are associated with increased vascular stiffness. Excessive fat intake leads to vascular remodelling, a process involved in atherosclerotic plaque formation. High salt intake also increases ROS production and reduces NO bioavailability.[32] However, this study found no significant difference in eating habits between the vascular elasticity groups ($p = 0.899$) (Table 1). This finding may be attributed to the limited sample size, which could have reduced the statistical power to detect meaningful differences. This finding aligns with a 2020 study that showed no association between eating habits and vascular stiffness in a cross-sectional design. However, eating habits significantly influence vascular elasticity in longitudinal studies over an average of seven years, as subclinical diseases like arterial stiffness tend to develop after prolonged exposure.[33]

The Chi-square test revealed a significant relationship between the MVF ratio and vascular elasticity ($p = 0.009$). An odds ratio (OR) of 6.54 indicates that individuals with the lowest MVF ratio are 6.5 times more likely to have sub-optimal vascular elasticity compared to those in Q2 & Q3 (Table 2). This finding is consistent with a study on type 2 diabetes mellitus patients in China, where the MVF ratio was measured using a dual bioelectrical impedance analyzer (dual-BIA), and vascular elasticity was assessed using brachial-ankle Pulse Wave Velocity (baPWV). This study found a significant association between the MVF ratio and vascular elasticity (OR = 4.33 for males, OR = 4.66 for females, $p < 0.01$). This relationship can be explained by the theory that a low MVF ratio induces insulin resistance. Muscles play a critical role in insulin-mediated glucose absorption, and reduced muscle mass decreases insulin receptor numbers, leading to insulin resistance. Increased visceral fat also correlates with heightened insulin resistance. Moreover, a low MVF ratio stimulates inflammatory cytokine secretion, contributing to vascular stiffness.[11] Another study demonstrated that a low MVF ratio was significantly associated with an increased 10-year cardiovascular disease risk ($p < 0.001$). The development of insulin resistance in subjects with a low MVF ratio negatively affects vascular elasticity, suggesting an elevated cardiovascular disease risk.[15] A study on Colombian students aged 18-30 found that the MVF ratio was significantly associated with metabolic syndrome ($p<0.001$). Metabolic syndrome is independently associated with vascular elasticity due to visceral fat accumulation, which triggers metabolic changes in adipose tissue, including free fatty acid flux dysregulation, oxidative stress, and increased inflammatory cytokines, leading to insulin resistance.[12]

This study categorized eating habits based on AFHC scores, but a more detailed nutritional assessment (e.g., macronutrient breakdown, specific micronutrient intake) would provide deeper insights into the relationship between diet and vascular elasticity.

This study has several limitations that should be considered when interpreting the findings. First, the study population consisted of a small sample of medical students from a single institution, which may limit the generalizability of the results to broader or more diverse populations. Second, several potential confounding variables, such as dietary patterns, stress levels, and sleep quality were not fully controlled or measured. The absence of multivariate analysis to adjust for these

confounders may have influenced the observed associations. Additionally, potential measurement biases, such as variations in hydration status that may affect the accuracy of bioelectrical impedance analysis (BIA), were not addressed in this study.

Conclusion

Based on the data and analysis of the research findings, it can be concluded that there is a significant association between the MVF ratio and vascular elasticity. Subjects with the lowest MVF ratio are 6.54 times more likely to have sub-optimal vascular elasticity. The finding matters because it highlights a significant association between a low muscle-to-visceral fat (MVF) ratio and sub-optimal vascular elasticity, indicating an elevated risk of early cardiovascular disease even in young adults, such as medical students. It underscores the importance of maintaining a healthy body composition early in life to mitigate long-term cardiovascular disease risk. Considering the limitation of this study, future research should involve a larger and more diverse population across multiple institutions, employ multivariate statistical approaches to control for confounders, and consider interventional study designs to evaluate whether improving the MVF ratio through dietary and exercise interventions can enhance vascular elasticity and reduce the risk of cardiovascular disease.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL PAPER

Association between animal protein adequacy and anemia among pregnant women in Palembang, Indonesia

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Abstract

Background: Palembang City has the highest prevalence of anemia in South Sumatra, Indonesia. Protein contributes to hemoglobin formation and insufficient protein intake increases the risk of anemia. However, Sumatera studies on protein intake based on protein sources in pregnant women are still limited.

Objective: This study aimed to examine the association between animal protein consumption and anemia prevalence in pregnant women.

Methods: A cross-sectional analytic study was conducted from July to October 2024 at six public health centers and seven private midwife clinics selected to represent Palembang's geographic diversity. A total of 62 pregnant women in their second or third trimester were recruited using consecutive sampling. Dietary intake was assessed via interviewer-administered 2×24-hour recalls on non-consecutive days. Protein intake was analyzed using modified NutriSurvey 2004 and categorized based on the Indonesian RDA. Hemoglobin levels were measured using venous blood samples and classified according to trimester-specific anemia thresholds. Bivariate analysis with Fisher's exact test was used to examine the association between animal protein intake and anemia prevalence.

Results: The Fisher Exact Test showed a statistically significant association between animal protein consumption levels and anemia in pregnant women in Palembang City ($p = 0.018$). The mean total protein intake was 80.40 ± 20.53 g/day, with animal and vegetable proteins contributing 40.22 ± 18.63 g/day and 40.91 ± 24.5 g/day, respectively. Mean hemoglobin level was 11.18 ± 1.17 g/dL.

Conclusion: Sufficient consumption of animal protein was found to be more protective against the occurrence of anemia.

Keywords: animal protein, pregnant woman, anemia, Palembang

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Introduction

The first thousand days of life are critical in shaping the child's ability to grow, develop, and learn throughout their lifetime. Pregnancy marks the beginning of this period, and any disruptions during this stage can significantly impact pregnancy outcomes.[1] Therefore, establishing an optimal nutritional foundation for pregnant women is crucial, including protein intake because this process is irreversible and will determine the long-term health of the mother and child in the future.[2,3]

Protein contributes for several physiological functions, including maintaining cell structure, facilitating biochemical reactions, and supporting tissue formation.[4] During pregnancy, the body's protein requirements increase to promote fetal growth and development.[5,6] Although there is no national data on protein adequacy among pregnant women, a 2022 study conducted in Malang City found that 82.8% of 64 pregnant women had insufficient protein intake.[7] Similarly, research by Dewi, Dery, and Tampubolon in 2021 reported that 80% of 50 pregnant women experienced protein deficiencies.[8] Protein is also crucial for hemoglobin synthesis and insufficient intake of protein may reduce hemoglobin production, thus increasing the risk of anemia during pregnancy.[9]

Anemia is a condition which a woman's hemoglobin level is below 11 g/dL during the first and third trimesters of pregnancy or below 10.5 g/dL in the second trimester.[10] It is estimated that anemia affects around 56–59 million pregnant women worldwide, accounting for 41.8%–43.8% of pregnancies. Indonesia is among the countries with a high prevalence of anemia in pregnant women, with an estimated 70% (7 out of 10) affected.[11]

Anemia during pregnancy is associated with adverse outcomes, including an increased risk of preterm birth, low birth weight, and miscarriage.[12] Additionally, it can contribute to long-term impairments in a child's growth and development. These risks highlight the critical need for anemia prevention through appropriate dietary interventions.

Dietary iron is classified into two main forms: heme and non-heme iron. Heme iron, primarily found in red meat and blood, is considered a promising source for iron supplementation and fortification due to its higher bioavailability and fewer side effects compared to non-heme iron.[13,14] Pregnant women are encouraged to consume animal protein, as it provides all essential amino acids necessary for fetal development.[4,15]

Palembang City, the capital of South Sumatra Province, Indonesia, is well known for its diverse traditional fish-based cuisine. The primary source of fish in the region comes from inland waters, and fish products are a major part of the daily protein intake for the local population. According to 2024 data from Statistics Indonesia (BPS), Palembang ranks among the cities with the highest average per capita fish consumption in South Sumatera. The population also consumes significant amounts of marine fish, including Indonesian wahoo fish (*tenggiri*), red snapper (*kakap merah*), and Spanish mackerel.[16]

Despite this high intake of fish and other animal protein sources, Palembang City has the highest reported prevalence of anemia in the province, reaching 34.8%, according to the South Sumatra Provincial Health Office in 2024. While several studies in Indonesia have examined the relationship between animal protein intake and anemia, none have specifically focused on the Sumatra region, particularly Palembang. Therefore, this study aims to investigate the association between animal protein consumption and the prevalence of anemia in pregnant women in Palembang city.

Methods

This study employed an analytic observational approach with a cross-sectional design using primary data. The Palembang region consists of 13 sub-districts in Ilir and 5 sub-districts in Ulu. The research was conducted at six randomly selected public health centers and seven independent midwives, representing the Palembang City Health Center work area. Those places were purposively selected to represent the city's diverse districts and populations. This ensured coverage of different geographic areas and service volumes within Palembang. We recognize that not all places were included, but by choosing places from various parts

of the city, the sample broadly reflects the target population.

The study was conducted from July to October 2024. The inclusion criteria for this study are women with singleton pregnancies who have been screened in the triple elimination program, in second or third trimester, and have agreed to participate by signing the informed consent form. Exclusion criteria included having chronic illnesses (such as diabetes mellitus, HIV/AIDS, tuberculosis, kidney disease, COPD, cancer, or cardiovascular conditions), being multigravida, following special dietary patterns, or opting not to complete the research procedures. Pregnant women in the first trimester were excluded because dietary intake patterns are often inconsistent in the first trimester due to nausea, vomiting, and food aversions, which may not reflect typical nutrient intake.[17,18] Ethical approval for this study was granted by the Medical and Health Research Ethics Committee of the Faculty of Medicine, Sriwijaya University, under protocol number 371-2024.

Minimum sample for this study is counted with P_1=0.545, P_2=0.258, $Z_{1-\alpha/2}$= 1,96, and $Z_{1-\beta/2}$= 1,28, thus 62 people were recruited.[19] Pregnant women meeting the inclusion criteria were recruited using consecutive sampling method. The respondents' characteristics were collected directly from respondents using questionnaires. Before completing the questionnaire, respondents were provided with detailed instructions on how to fill it out correctly and informed consent was obtained.

Data on pregnant women's food intake was gathered through a 2×24-hour food recall method, covering one weekday and one weekend day in non-consecutive day via interviewer-administered questionnaire. Trained enumerator conducted the interviews and guided participants through a 2x24-hour recall of their dietary intake. The study has shown that 2x24-hour recall was valid and feasible to estimate protein intakes.[20] Interviewers ensured that participants understood each question, and standardized food portion measurements were facilitated using food photo portionimetry, which was validated by the Indonesian Ministry of Health and supported by validated food pictures to improve accuracy. [21,22] The protein data from the 2 days will be averaged to determine the protein intake.

Modified Nutrisurvey 2004 software that has been synchronized to Indonesia Food Composition Table is used to calculate the protein content of the consumed foods.[23] If specific food items were not available in the portion references, the researcher utilized food databases from the US Department of Agriculture and the Energy and Nutrient Composition of Food, Health Promotion Board, Singapore, to estimate their nutritional content.[24,25] If food data remained unavailable, the ingredient and portion details were calculated as a new recipe.

According to the Indonesian RDA, the protein requirement for pregnant women is 75 grams per day during the second trimester and 95 grams per day during the third trimester.[26] The adequacy of total protein, vegetable protein, and animal protein intake was assessed by dividing the amount of total protein, vegetable protein, and animal protein consumed by the Indonesian RDA. Total protein intake levels were categorized as insufficient (<100% RDA) and sufficient (≥100% RDA).

Animal protein intake levels were categorized as insufficient (<20% RDA) and sufficient (≥20 RDA). This cut-off was determined by following prior study in Indonesia, this categorization helps identify women with substantially insufficient versus sufficient protein intake from animal sources.[27] Vegetable protein intake levels were categorized as insufficient (≥80% RDA) and sufficient (<80% RDA) based on on dietary modeling research showing that nutrient-sufficient diets require vegetable protein contribution between approximately 15–80% of total protein. Diets beyond 80% PP, predominantly plant-based with little animal protein give a risk insufficient intake of key nutrients unless supported by fortification or supplementation.[28]

The prevalence of anemia in this study was determined based on hemoglobin levels. Hemoglobin levels were measured through blood sample screening conducted by trained enumerators. Blood samples were collected intravenously, with 2 mL drawn per subject, and stored in EDTA tubes. The collected samples were analyzed at the Center for Health Laboratories to

measure hemoglobin levels using the Blood Cell Counter method.

Venous blood is preferred over capillary blood due to its more stable consistency and higher quality. In contrast, capillary blood obtained from a finger prick may lead to inaccurate hemoglobin measurements, as water loss from the capillaries can artificially lower hemoglobin concentrations. Previous studies have also recommended the use of venous blood samples to minimize pre-analytical bias associated with capillary blood collection.[29] Respondents were classified as anemic if their hemoglobin levels are below 11 g/dL during the third trimesters of pregnancy or below 10.5 g/dL in the second trimester.[10]

Data was processed using Microsoft Excel and SPSS 27th edition. The characteristics of respondents were analyzed using univariate analysis to obtain percentage values. Bivariate analysis was conducted using a 2×2 crosstab with Fisher's exact test to determine the association between participants' characteristics and protein intake with the prevalence of anemia.

Results

The majority of pregnant women were in their third trimester, aged between 20 and 35 years old, unemployed, multiparous, had a birth spacing of more than two years, had a secondary education, an income above the regional minimum wage, and with no supplementation (**Table 1**).

All participants consumed cereals, with high intake also observed for fruits (98.4%), eggs (96.8%), meat/poultry (95.2%), fish/shellfish (93.5%), and legumes (91.9%). Tubers were consumed by 62.9% of participants, while milk and dairy products had the lowest intake at 45.2%. Overall, most respondents consumed both plant- and animal-based protein sources, though dairy consumption was relatively low (**Table 2**).

The mean total protein intake was 80.40 ± 20.53 g/day, indicating that most participants were approaching the recommended daily intake for pregnancy. Animal protein contributed an average of 40.22 ± 18.63 g/day, while vegetable protein intake was slightly higher at 40.91 ± 24.5 g/day. This relatively balanced contribution suggests a mixed dietary pattern, with higher proportion of vegetable protein intake. The wide range in animal protein intake (14.40–112.80 g/day) also indicates that a substantial proportion of participants may have had insufficient intake of high-quality, heme-iron-rich protein sources. The mean hemoglobin level was 11.18 ± 1.17 g/dL, with values ranging from 8.80 to 13.40 g/dL **(Table 3)**.

The analysis revealed a statistically significant relationship between the level of animal protein consumption and the prevalence of anemia among pregnant women in Palembang City ($p = 0.023$). Pregnant women with insufficient animal protein intake had a 10.56-fold higher risk of developing anemia compared to those with sufficient or excessive protein consumption. Sufficient levels of animal protein intake were found to be protective against anemia. However, there is no statistically significant relationship between the level of total protein, vegetable protein, and iron consumption with the prevalence of anemia among pregnant women in Palembang city (**Table 4**).

There was significant association between pregnancy trimester and anemia status ($p = 0.009$), with a higher proportion of anemia observed in the third trimester (47.7%) compared to the second trimester (11.1%). No statistically significant associations were found for age, occupation, parity, birth spacing, education level, or household income ($p > 0.05$) **(Table 5).**

Regression Linear statistic was used for animal protein intake, pregnancy age, education level, and trimester with anemia prevalence ($p>0.25$). Education level showed a protective effect, with women having higher education significantly less likely to experience anemia ($p = 0.028$; OR = 0.045). Pregnancy age (trimester) was also a significant factor ($p = 0.014$), with those in the third trimester at greater risk of anemia (OR = 0.089). Adequate intake of animal protein was strongly associated with a reduced risk of anemia ($p = 0.022$), with an odds ratio of 30.255, indicating that women with sufficient animal protein intake had substantially lower odds of being anemic. In contrast, short birth spacing (<2 years) was associated with an increased risk of anemia ($p = 0.037$; OR = 7.136). These findings underscore the importance of maternal education, adequate animal

protein consumption, optimal pregnancy spacing, and consideration of gestational stage in preventing anemia during pregnancy (**Table 6**).

Table 1. Respondents' characteristics (n = 62)

Variable	Total	Percentage (%)
Age		
<20 years	2	3.23
20–35 years	49	79.03
>35 years	11	17.74
Pregnancy age		
2nd trimester	18	29.03
3rd trimester	44	70.97
Occupation		
Employed	12	19.35
Unemployed	50	80.65
Parity		
Nuliparous	16	41.94
Primiparous	16	25.81
Multiparous	20	32.26
Birth spacing		
<2 years	12	20.35
≥2 years	50	80.65
Education level		
Primary[a]	9	14.52
Secondary[b]	43	69.35
Higher[c]	10	16.13
Household income[30]		
<Regional Minimum Wage[d]	18	29.03
≥Regional Minimum Wage	44	70.97
Iron supplementation consumption		
90 mg		
60 mg	2	3.22
30 mg	28	45.16
No Supplementation	14	22.59
	18	29.03

[a]Graduated from elementary school/junior high school
[b]Graduated from senior high school
[c]Graduated from diploma or bachelor's degree
[d]Regional minimum wage for South Sumatera= Rp.3.456.874/month (212.47 USD)

Table 2. Distribution of food source consumption among pregnant women (n = 62)

Food Sources	Total (n=62)	Percentage (%)
Cereals and their products		
Yes	62	100
No	0	0
Tubers and their products		
Yes	39	62.9
No	23	37.1
Nuts, seeds, beans, and their products		
Yes	57	91.9
No	5	8.1
Fruits and their products	61	98.4
Yes	1	1.6

Food Sources	Total (n=62)	Percentage (%)
No		
Meat, poultry, and their products		
Yes	59	95.2
No	3	4.8
Fish, shellfish, shrimp, and their products		
Yes	58	93.5
No	4	6.5
Eggs and their products		
Yes	60	96.8
No	2	3.2
Milk and dairy products		
Yes	28	45.2
No	34	54.8

Table 3. Hemoglobin and nutrient intake data

Variable	Mean ± SD	Median	Minimum	Maximum
Total protein intake (g)	80.40 ± 20.53	79.8	41.95	132.90
Total animal protein intake (g)	40.22 ± 18.63	36.13	14.40	112.80
Total vegetable protein intake (g)	40.91 ± 24.5	38.95	0.95	104.50
Total hemoglobin (g/dL)	11.18 ± 1.17	11.05	8.80	13.40

Table 4. Association between protein intake with anemia prevalence among pregnant women in Palembang

Variable	Anemia prevalence				OR	*p*
	Yes		No			
	n	%	n	%		
Total protein adequacy						
Insufficient	18	40	27	60	1.6	0.321
Sufficient	5	38.46	12	61.54	0.625	
Animal protein adequacy						
Insufficient	5	83.3	1	16.7	10.56	0.023
Sufficient	18	32.1	38	67.9	0.09	
Vegetable protein adequacy						
Insufficient	20	37.04	34	16.7	0.98	0.633
Sufficient	3	37.5	5	62.5	1.02	

Table 5. Association between participants' characteristic with anemia prevalence among pregnant women in Palembang

Variable	Anemia Prevalence				*p*
	Yes		No		
	n	%	n	%	
Age					
<20 years	0	0	2	100	0.538
20–35 years	19	39.8	30	61.2	
>35 years	4	36.4	7	63.6	
Pregnancy age					
2nd trimester	2	11.1	16	88.9	0.009
3rd trimester	21	47.7	23	52.3	
Occupation					
Employed	2	16.7	10	83.3	0.633
Unemployed	21	42	29	58	
Parity					
Nuliparous	4	25	12	75	0.376
Primiparous	12	47.2	14	53.8	
Multiparous	7	35	13	65	
Birth spacing					
<2 years	7	58.3	5	41.7	0.185
≥2 years	12	35.3	22	64.7	
Education level					
Primary	4	44.4	5	55.6	0.152
Secondary	18	41.9	25	58.1	
Higher	1	10	9	90	
Household income					
<Regional minimum wage	7	38.9	11	61.1	0.537
≥Regional minimum wage	16	36.4	28	63.6	
Iron supplementation					
Yes	5	14.7	29	85.3	
No	18	64.29	10	35.71	0.314

Table 6. Multivariate analysis between cofounding factors with anemia prevalence among pregnant women in Palembang

Variable	B	SE	Wald	Df	Sig	Exp(B)
Education level	-3.111	1.417	4.819	1	0.028	0.045
Pregnancy age	-2.424	0.991	5.977	1	0.014	0.089
Animal protein level	3.410	1.489	5.242	1	0.022	30.255
Birth spacing	1.965	0.944	4.334	1	0.037	7.136

Discussion

There was a statistically significant association between the amount of animal protein consumed and the prevalence of anemia in pregnant women in Palembang City (p=0.018). This outcome is consistent with earlier studies by Kusumawati, *et al.*, Fera, *et al.*, Soleha, Mayasari, *et. al.*[9,31–34]

Iron, which comes in two types, heme and non-heme, is one of the hemoglobin components. Plant protein contains non-heme iron, while animal protein has heme iron. In contrast to heme iron, non-heme iron cannot be utilized as a material that forms hemoglobin until it has been absorbed and processed by the duodenum's cytochrome B enzyme. While heme iron has a variable absorption rate, it is estimated that 10–20% of the heme in food is fully absorbed.[35] The body's heme iron also contributes to a higher rate of non-heme iron absorption.[14] Therefore, eating animal protein can raise the body's iron levels, which helps to prevent anemia.

Interestingly, neither total protein nor vegetable protein alone was associated with anemia prevalence in this study. This underscores the importance of protein quality over quantity. In Palembang, where plant-based dishes such as Indonesian sour vegetable soup (*sayur asem*),

vegetable in coconut milk soup (*lodeh*), and vegetable fritters (*bakwan*) are widely consumed, it is possible that non-heme iron absorption remains suboptimal despite seemingly adequate total intake. Non-heme iron from plant sources has lower absorption rates and may be inhibited by other dietary components.[14] Thus, high vegetable protein consumption does not necessarily mean high protein delivery to the body. Additionally, the relatively low intake of milk and dairy products (45.2% of respondents) reflects a gap in high-quality protein sources.

Palembang were also renowned with its traditional cuisine called "*pempek*", made from fish paste and tapioca flour, served with a sweet and tangy vinegar-based sauce. These dishes are rich in protein, particularly from fish and other seafood.[36] This helped to explain why nearly all respondents had an adequate intake of animal protein, which was linked to a lower risk of anemia.

This study demonstrated the need to promote the consumption of accessible and culturally accepted animal proteins, such as freshwater fish, eggs, and chicken among pregnant women. Traditional dishes can be nutritionally enhanced, for instance, by increasing the fish portion in *pempek* or adding eggs to Palembang fish ball soup (*tekwan*) or fish ball and tofu soup (*model*), to help pregnant women meet their nutritional needs without needing to drastically alter their dietary habits.

The utilization of primary data gathered using validated instruments, such as the 2×24-hour food recall and venous hemoglobin tests, which improved data accuracy, was one of this study's strengths. However, the small sample size (n = 62) limited generalizability, and the cross-sectional design restricted causal inference. Although trained enumerators were used and portionometry was applied in this study, there was still a risk of reporting bias and portion estimating mistakes that may have impacted the dietary recall data.

Conclusion

There is an association between the level of animal protein consumption and the prevalence of anemia among pregnant women in Palembang city. Sufficient level of animal protein consumption is protective against anemia. Furthermore, being in the third trimester of pregnancy is an independent risk factor for anemia. Therefore, further health promotion is needed so that pregnant women increase the level of animal protein consumption to prevent anemia. Future studies with larger sample sizes and longitudinal designs are recommended to confirm these findings and explore the impact of specific food sources and supplementation programs on maternal anemia outcomes.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL PAPER

Relation between body mass index, waist circumference, and a body shape index with VO_2 max among medical students in Jakarta, Indonesia

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Abstract

Background: Individuals with low VO_2 max have higher potential of chronic disease in later life. Body fat composition is a factor that affects VO_2 max. A sedentary lifestyle and poor diet in medical students can lead to excess body fat mass, which can be measured through BMI, WC, and ABSI.

Objective: The study aimed to determine the relation between BMI, WC, ABSI, and VO_2 max in medical students.

Methods: This study used an observational analytic method and a cross-sectional approach. It was conducted at the Medical Education and Research Center UPNVJ from January to December 2024. The sampling technique was simple random sampling with total sample size of 46 respondents. Data collection involved filling out a questionnaire and measuring BMI, WC, ABSI, and VO_2 max. Statistical analysis in this study was performed using the Mann-Whitney test.

Results: Most respondents had normal BMI, normal WC, and low ABSI. The results of bivariate analysis showed relation between WC and VO_2 max ($p = 0.000$), and there was no relation between VO_2 max with BMI ($p = 0.344$) and ABSI ($p = 0.956$).

Conclusion: The study's results conclude that WC and VO_2 max are related. However, there was no relation between BMI and ABSI and VO_2 max in medical students.

Keywords: body mass index, waist circumference, a body shape index, VO_2 max

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Introduction

Currently, Indonesia is experiencing a double burden of malnutrition, which includes high malnutrition and increasing prevalence of obesity.[1] According to Riskesdas data, the prevalence of obesity was 14.8% in 2013 and increased to 21.8% in 2018.[2,3] Based on the latest data from the 2023 Indonesian Health Survey, the prevalence of obesity in adults over 18 years old has reached 23.4%, consistently increasing compared to previous years.[4]

Obesity is a multifactorial problem. Apart from genetics, lifestyle, and environmental factors play a major role in the occurrence of obesity in most people.[5] Medical students tend to have a sedentary lifestyle due to long and busy lecture activities.[6] In addition, the busy lectures make students tend to consume fast food, which contains high calories and fat, which, if consumed excessively, can increase body fat.[7,8] If excessive energy intake is not balanced with adequate physical activity, it can sustainably lead to obesity.[9]

A common way to detect obesity is through anthropometric measurements, including body mass index (BMI) and waist circumference (WC).[10] Body mass index is a fairly effective measurement tool because it only uses a simple formula, inexpensive, and the results are relatively precise. However, it lacks the ability to distinguish between being overweight due to fat or due to muscle.[11] Waist circumference is used to measure central obesity and is known better to predict metabolic and cardiovascular disease risk than BMI.[12,13] In 2012, ABSI, or a body shape index, was developed to overcome the weaknesses of BMI by measuring abdominal adiposity based on WC adjusted for height and weight. The ABSI measurement is known to be superior in predicting the risk of premature mortality and quantifying the risks associated with central obesity.[14] High ABSI indicates higher concentration of visceral fat around the abdomen. The ventilatory function of the respiratory system becomes inefficient due to fat accumulation in the abdominal area, which increases pressure on the abdomen and restricts lung expansion.[15,16]

Obesity is a risk factor for non-communicable diseases such as diabetes mellitus, heart disease, cancer, hypertension, and other metabolic and non-metabolic diseases.[1] Some of these non-communicable diseases are a reminder of how important physical fitness is. Physical fitness is related to various aspects such as health, performance, productivity, and quality of life.[17] A person's physical fitness can be measured through cardiorespiratory fitness.

The indicator to assess cardiorespiratory fitness is VO_2 max, defined as the maximum amount of oxygen consumed per minute by a person when performing maximum effort.[18] VO_2 max reflects functional capacity and human performance. It is a strong, independent predictor of all-cause and disease-specific mortality, regardless of sex or race.[19] Higher VO_2 max enhances energy levels and human performance by lowering the metabolic strain on cardiac muscle, preventing the heart from excessive workload, and supporting increased cardiac output when needed.[20]

Individuals with low VO_2 max have a higher tendency to develop various chronic diseases.[21] Unhealthy lifestyles, such as sedentary lifestyles and poor diet, could result in excess body fat mass. Excess fat mass causes a decrease in VO_2 max because the presence of fat deposits disrupts oxygen intake to the lungs and oxygen perfusion from peripheral blood vessels to the muscles.[22] Gender, age, genetics, body composition, physical activity, cardiorespiratory diseases, and smoking habits are several variables that affect VO_2 max. This study only used female subjects, as male VO_2 max tends to be higher than females due to greater muscle mass, hemoglobin levels, and stroke volume in males.[23]

Methods

Study design and participants

This study used an observational analytic method and a cross-sectional approach. The research was conducted at the Medical Education and Research Center UPN "Veteran" Jakarta in January - December 2024. This study has received ethical approval from the UPNVJ Research Ethics

Committee with number 346/VII/2024/KEP. The population in this study were medical students of UPN "Veteran" Jakarta who met the inclusion and exclusion criteria. The sampling technique was carried out by the probability sampling method using simple random sampling with the number of samples obtained as many as 46 respondents. The inclusion criteria in this study include female gender, and aged 18-22 years. The exclusion criteria in this study were respondents who had a history of pulmonary disease, cardiovascular disease, musculoskeletal disease, chronic disease, were in a state of illness, were undergoing treatment, blood pressure more than 140/90 mmHg, smoking, and had heavy physical activity from the measurement results of the GPAQ (Global Physical Activity Questionnaire). The GPAQ questionnaire measures physical activity by classifying it according to MET (Metabolic Equivalent). It consists of three categories, heavy physical activity (MET>3000), moderate (3000>MET>600), and light (600<MET). Because physical activity can significantly influence VO_2 max, this study restricted participants to light and moderate activity levels.

Measurements

BMI measurements were done using digital scales and microtoise to obtain body weight and height data. Then, the IMT value is calculated by using the formula body weight in kilograms divided by height in square meters. Waist circumference was measured using a measuring tape. A body shape index (ABSI) was measured using digital scales, microtoise, and measuring tape to obtain data on body weight, height, and WC. Furthermore, the ABSI value was calculated using the following formula.

$$\text{ABSI} = \frac{\text{WC (cm)}}{\text{BMI}^{\frac{2}{3}}\left(\frac{\text{kg}}{\text{m}^2}\right) \text{ x Height}^{\frac{1}{2}}\text{ (m)}}$$

The protocol used for VO_2 max measurement was the Astrand-Rhyming Cycle Ergometer Test (ARCET) using a cycle ergometer (Monark Ergomedic 828E). The procedure began with setting the seat height on the cycle ergometer and warming up for 3 minutes at 50 rpm using a 1 kg leg load. This study set the initial power output at 300 kgm (kilogram-force meter/minute) or 50 Watts because all subjects were female. After the warm-up, a 6-minute test with a pedal speed of 50 rpm followed, aiming to produce a heart rate between 125-170 bpm. Heart rate was measured using a pulse oximeter during the last 30 seconds of the second to sixth minute. The test ended when the heart rate was within the target heart rate zone and differed by less than 10 beats per minute for two consecutive minutes (minutes five and six). If this criterion was not met, the test was extended by adjusting the power output until the heart rate was within 10 beats per minute for two consecutive minutes. The last two heart rate values were then averaged and used for calculation using the Astrand-Rhyming normogram and adjusted by a correction factor to obtain the VO_2 max value. Subjects cooled down after the test was finished.

Data analysis

The data obtained were then processed and analysed. Univariate analysis in this study is presented as frequency distributions and percentages because the data are ordinal categorical. Bivariate analysis was performed using the Mann-Whitney test.

Results

The majority of respondents in this study were 20 years old, which amounted to almost half of total respondents. Most respondents had a BMI <23, which was 1.5 times more than BMI >23. Most respondents had a normal WC, almost 3 times more than those with central obesity. Most respondents had low ABSI, almost 7 times more than those with high ABSI. Most respondents had high VO_2 max, 5 times more than low VO_2 max, and 1.5 times more than moderate VO_2 max (**Table 1**).

Table 1. Distribution of respondent characteristics

Characteristics	n	Percentage %
Age		
18	3	6.5
19	7	15.2
20	21	45.7
21	11	23.9
22	4	8.7
Body mass index		
BMI<23	28	60.9
BMI≥23	18	39.1
Waist circumference		
Normal	34	73.9
Central obesity	12	26.1
A body shape index		
Low	40	87
High	6	13
VO_2 Max		
Low	5	10.9
Moderate	16	34.8
High	25	54.3

Young adult women often pursue an ideal body shape by consciously reducing meal portions or skipping meals. Coupled with the demanding schedule of medical students, which frequently prevents them from eating three full meals a day. This reason may help them maintain normal body composition despite occasional consumption of unhealthy foods.

The results of this study showed that respondents with BMI<23 mostly had high VO_2 max (57.1%). Most respondents with BMI>23 (50%) have high VO_2 max. The statistical analysis showed no significant relation between BMI and VO_2 max, with p-value of 0.344 (p>0.05).

The data also showed that most respondents with normal WC had a high VO_2 max (67.6%), while respondents with central obesity had a low (41.7%) and moderate (41.7%) VO_2 max. The statistical analysis showed a significant relation between WC and VO_2 max, with p-value of 0.000 (p<0.05).

The results of this study also showed that respondents with low ABSI had a high VO_2 max (55%), while respondents with high ABSI had a VO_2 max with an equal amount in the moderate (50%) and high (50%) categories. The statistical analysis showed no significant relation between ABSI and VO_2 max, with p-value of 0.956 (p>0.05) **(Table 2)**.

Discussion

BMI and VO_2 max

The majority of both respondents, with IMT< 23 and IMT >23, have high VO_2 max. BMI measurements are used to determine the degree of obesity because it correlate with body fat.[24] The statistical analysis showed no significant relation between BMI and VO_2 max, with p-value of 0.344 (p>0.05).

Several previous studies revealed that the higher the BMI, the lower the value of VO_2 max.[25,26] Fat accumulation could build up in areas such as the chest and stomach. An increase in subcutaneous and visceral fat in these parts could press the diaphragm and limit lung expansion, ultimately reducing oxygen supply to the lungs.[27] Increased body fat could overburden the cardiorespiratory system, inhibiting the distribution and uptake of oxygen for intracellular metabolism in tissues. In addition, fat deposits in musculoskeletal tissue would make taking oxygen during exercise less effective.[28,29]

Table 2. Relationship between BMI, WC, and ABSI with VO2 max

Characteristics	*VO₂ Max*						*p-value*
	Low		Moderate		High		
	n	%	n	%	n	%	
BMI							
BMI < 23	1	3.6	11	39.3	16	57.1	0.344
IMT ≥ 23	4	22.2	5	27.8	9	50	
WC							
Normal	0	0	11	32.4	23	67.6	0.000
Central obesity	5	41.7	5	41.7	2	16.7	
ABSI							
Low	5	12.5	13	32.5	22	55	0.956
High	0	0	3	50	3	50	

Source: Primary Data, 2024

However, the results of this study showed that BMI and VO_2 max have no significant relation. Despite having a higher BMI, 50% of respondents with a BMI>23 have high VO_2 max. This difference in results can be caused by the fact that one of the weaknesses of BMI is that it cannot distinguish between fat and muscle mass. Apart from fat mass, being overweight can also occur due to a lot of muscle mass.[13,30]

The value of VO_2 max is determined by the respiratory system, cardiovascular circulation, and oxygen extraction/utilization by muscles.[16] Better maximum oxygen volume is related to better muscle extraction of peripheral oxygen. Maximum oxygen uptake during physical exercise depends on the maximum speed of oxygen transport toward the mitochondria in the working muscle tissue. Lack of muscle mass can lead to lack of metabolic oxygen utilization, and vice versa.[5,16]

WC and VO_2 max

The majority of respondents in this study had a normal WC and VO_2 max, which is high (67.6%). These findings can be caused by the fact that the subjects in this study are female students aged 18-22 years. The Indonesian Health Survey Report 2023 states that 24% of women aged 15-24 years in Indonesia have central obesity. The number has doubled in the next age group, 25-34 years, reaching 54.2%, and continues to increase in the subsequent age groups.[4] This could occur because the subjects in this study are also not married or pregnant. Pregnancy is associated with increased storage of abdominal visceral adipose tissue.[31] The study showed that most respondents with a normal WC had a high VO_2 max. Respondents with central obesity have a low and moderate VO_2 max. The statistical analysis showed a significant relation between WC and VO_2 max, with a p-value of 0.000 ($p<0.05$).

Waist circumference is used to identify central obesity and is considered more effective than BMI in predicting the risk of metabolic and cardiovascular diseases.[12,13] Obesity can be caused by low physical activity and high consumption of snacks, fried foods, and fast food.[32] Students with central obesity have a higher calorie intake, one of which is from eating fast food.[33] Medical students frequently experience high stress levels, resulting in increased consumption of unhealthy foods. Stress can trigger the release of cortisol, a hormone that increases appetite and can lead individuals to engage in overeating high-calories, high-fat, and high-sugar foods.[34,35]

Central obesity is characterized by a higher proportion of visceral fat. This visceral fat is more dangerous than subcutaneous fat because it releases a number of "bad" adipokines that can cause insulin resistance and chronic inflammation, potentially triggering the development of cardiovascular diseases such as atherosclerosis.[36] Fat accumulation in the body can trigger the release of pro-inflammatory cytokines that lead to endothelial dysfunction and reduced production nitric oxide (NO) as a vasodilator. This results in the narrowing of the arteries and increased peripheral resistance, leading to hypertension. As a result, less blood is pumped, and less oxygen is delivered to the muscles, which strains the cardiorespiratory

system. It can lead to a decrease in cardiovascular ability.[37,38]

Several previous studies have stated that the larger the WC, VO_2 max will continue to decline.[39,40] Each centimetre increase in WC decreases the value of VO_2 max by 0.48 ml/kg/min in men and 0.27 ml/kg/min in women.[40] Individuals with low VO_2 max have a greater tendency to develop various chronic diseases and premature death. In contrast, individuals with a high VO_2 max have a lower chance of developing chronic diseases.[21]

ABSI and VO_2 max

The majority of respondents have low ABSI and high VO2 max (55%). A body shape index (ABSI) is associated with visceral fat thickness and cardiovascular disease risk.[41] The statistical analysis showed no significant relation between ABSI and VO_2 max, with a p-value of 0.956 ($p > 0.05$).

A body shape index or ABSI is defined as central obesity if the value is $\geq$ 0.080.[42] ABSI values that exceed the normal range indicate a larger-than-expected increase in WC based on certain weight and height according to body volume. This indicates a higher concentration of visceral fat around the abdomen.[15]

The risk of cardiometabolic morbidity and mortality is related to the amount of excess fat and its distribution in the body. Visceral fat causes metabolic dysregulation, triggering inflammation, endothelial dysfunction, and insulin resistance. This is considered the main risk factor for the occurrence of various chronic diseases, such as hypertension, cardiovascular disease, and type 2 diabetes mellitus.[43]

Any heart disease that reduces maximum cardiac output will decrease the body's overall muscle power achievement due to reduced oxygen supply to muscle tissue.[5] In addition, the respiratory system's ventilation work becomes inefficient due to the accumulation of fat in the chest wall and stomach, which increases pressure in the abdomen, thereby inhibiting lung development. The physiological implication is that it is more difficult for obese individuals to do the same amount of work as people of normal weight due to the decrease in cardiorespiratory capacity.[16]

However, using ABSI to predict VO_2 max in this study did not show results consistent with Krakauer's findings when ABSI predicted a better risk of premature death than BMI and WC.[44] This result difference can be caused by the ABSI formula being developed based on data from the original study conducted in the United States. The body characteristics of Americans may differ from those of Indonesians, for example, average height, body fat distribution, and genetic factors that cause differences in results when the ABSI formula is applied to different populations.[45] Research on ABSI with VO_2 max is still lacking, so further research is needed to describe the causal relation between ABSI and VO_2 max.

This research still has some limitations. First, there are risk factors that can affect VO_2 max that have not been eliminated in this study, such as genetic and ethnic factors. Second, the determination of respondent's criteria regarding disease history is only based on interviews and filling out questionnaires, not original diagnoses taken from medical records.

Conclusion

Based on the study's results, most students have a normal BMI (52.2%), normal WC (73.9%), low ABSI (87%), and high VO_2 max (54.2%). The statistical analysis showed a relation between WC and VO_2 max, but there was no relation between BMI, ABSI, and VO_2 max. These results suggest that WC may be a more relevant predictor of cardiorespiratory fitness in this population compared to BMI or ABSI. Although ABSI did not show a significant association in this study, it remains a valuable anthropometric tool due to its ability to account for body shape and central adiposit factors that are strongly linked to cardiometabolic risk. Further research is needed to explore ABSI's role in early detection of metabolic and cardiovascular abnormalities.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL PAPER

Sleep quality and its association with waist circumference among undergraduate students

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Abstract

Background: Poor sleep quality has been associated with metabolic disturbances and behavioural changes that promote obesity, with growing evidence linking inadequate sleep to increased central adiposity. Waist circumference (WC), a key indicator of abdominal fat and cardiometabolic risk, has also been implicated in disrupted sleep through mechanisms such as hormonal imbalance and sleep-disordered breathing. Exploring the relationship between WC and sleep quality among undergraduate students is important to better understand early risk factors for obesity and related health outcomes.

Objective: This study aimed to examine sleep quality and its association with Body Mass Index (BMI) and Waist Circumference (WC) in an undergraduate population.

Methods: A total of 277 undergraduate students from Universiti Sultan Zainal Abidin (UniSZA), Gong Badak Campus, Malaysia, aged 18 to 25 years, were recruited for this cross-sectional study using non-probability proportionate stratified sampling. The students were weighed, and their BMI and WC were measured. The Pittsburgh Sleep Quality Index (PSQI) was completed to assess sleep quality.

Results: The results of the multiple linear regression analysis revealed that sleep quality did not significantly predict BMI (p>0.05). However, sleep quality significantly predicted WC (p=0.026), indicating a significant influence of sleep quality on WC.

Conclusion: While sleep quality was not significantly associated with body mass index, it was significantly associated with waist circumference. These findings highlight the potential importance of promoting a consistent sleep schedule as a preventative strategy to enhance sleep quality and mitigate weight-related risks in undergraduate students.

Keywords: sleep quality, body mass index, waist circumference, undergraduates

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Introduction

According to the World Obesity Atlas 2023 report, 38% of the population worldwide, presently are either overweight or obese,[1] having a body mass index (BMI) higher than 25kg/m^2. Regardless of social standing, Malaysia is currently seeing a geometric increase in the prevalence of obesity. The National Health and Morbidity Survey (NHMS) in 2019, reported that the prevalence of obesity has increased substantially from 15.1% in 2011 to 17.7% in 2015, and finally to 19.9%.[2]

Good sleep quality is described when one falls asleep during the night in 30 minutes or less with a sound sleep. On the other hand, poor sleep quality is when there is an issue of falling asleep and remaining asleep.[3] Sleep has recently been found to be an important modulator of cardiovascular activity, glucose regulation, and neuroendocrine function. The effects of deficiency in restorative sleep are severe, affecting the health, function and wellbeing of human.[4] Previous studies have reported that sleep problems caused by insufficient sleep are linked with a variety of adverse outcomes, including obesity,[5] cognitive dysfunction,[6] depression,[7] and heart disease.[8]

A study conducted among participants of the Early Life Exposure in Mexico to Environmental Toxicants study found that adolescents with consistently insufficient sleep exhibited higher levels of adiposity across all four measures - BMI-for-age Z score, triceps skinfold thickness, waist circumference, and body fat percentage - as well as a higher prevalence of obesity.[9] While, a study among Malaysian university students reported that overweight and obese (OW-OB) students exhibited poorer sleep quality, longer sleep latency, and more frequent sleep disruptions compared to their underweight and normal-weight (UW-NW) counterparts.[10] These findings emphasize the need for targeted wellness interventions that address both obesity prevention and the promotion of healthy sleep habits among university students. Waist circumference (WC) refers to the abdominal measurement taken at the midpoint between the lowest palpable rib and the upper border of the iliac crest.[11] It is a simple and convenient anthropometric measure that correlates well with body fat mass and serves as an indicator of intra-abdominal and total body fat,[12] particularly suitable for Asian populations. Abdominal obesity assessed by WC has been strongly associated with poor sleep quality, as excess central fat contributes to metabolic disturbances and sleep-disordered breathing, leading to reduced sleep duration and efficiency. This highlights a bidirectional relationship in which central adiposity impairs sleep quality, while inadequate sleep further promotes fat accumulation.[13] WC is strongly associated with higher risks of type 2 diabetes, heart disease, metabolic syndrome, and increased all-cause mortality, even among individuals with normal BMI.[14]

Research on the association between sleep quality, BMI, and WC in early adulthood is still limited, as most existing studies focus on children and adolescents. Examining both BMI and WC is important for understanding how sleep influences obesity risk, yet findings – especially on WC – have been inconsistent across populations and methods. In Malaysia, research in this area among early adulthood remains scarce. This study aims to fill that gap by assessing sleep quality and its relationship with BMI and WC among undergraduate students, providing evidence to guide health strategies and promote healthier lifestyles.

Methods

Design, location, and time

This study was conducted between January 2022 to February 2023 using cross-sectional study design. Participants were undergraduate students at Universiti Sultan Zainal Abidin (UniSZA), Gong Badak Campus, Terengganu, Malaysia. Prior to the study, ethical approval was obtained from the UniSZA Human Research and Ethics Committee (UHREC) (Ref. No. UniSZA/UHREC/2019/121), and informed consent was obtained from all students before data collection. The confidentiality of the students was ensured, as the data was used solely for the purpose of this research study and was not disclosed to the public. Students were selected from five faculties: *Fakulti Ekonomi dan*

Sains Pengurusan (FESP), *Fakulti Kontemporari Islam* (FKI), *Fakulti Sains Sosial Gunaan* (FSSG), *Fakulti Undang-Undang dan Hubungan Antarabangsa* (FUHA), *and Fakulti Bahasa dan Komunikasi* (FBK). The inclusion criteria encompassed healthy Malaysian early adults aged 18 to 25 years, enrolled in diploma or bachelor's degree programs at the UniSZA Gong Badak Campus, and literate in the Malay language. Exclusion criteria included individuals with severe psychopathological or medical conditions, pregnant or breastfeeding women, physically disabled students, those undergoing structured weight management or dietary control programs, athletes, and students from other UniSZA campuses.

Sampling

The sample size was calculated using G*Power version 3.1.9.7, and a total of 277 students were recruited. A non-probability proportionate stratified sampling method was employed, with students selected from each faculty based on their representation in the total population and according to predetermined eligibility criteria. Randomisation was not applied within each faculty.

Data collection

Students underwent anthropometric assessments (weight, height, and waist circumference) and completed a set of questionnaires that included sociodemographic information and sleep quality.

Sociodemographic information

This section consisted of questions on students' personal information such as gender, age, ethnicity, faculty, study program, and duration of study.

Anthropometric measurement

Anthropometric data, including weight and height, were measured for each student. Body weight was measured to the nearest 0.1 kg using a SECA digital weighing scale, while standing height was measured to the nearest 0.1 cm using a SECA stadiometer. Each measurement was taken twice, with a third measurement conducted if discrepancies were observed. Calibration was performed periodically following standard protocols to ensure accuracy. Body Mass Index (BMI) was then calculated based on World Health Organization (WHO) BMI classification chart. Waist Circumference (WC) was measured using a measuring tape at the narrowest point between the lowest rib and the iliac crest. Abdominal obesity was determined according to WC cut-off point as proposed by WHO.[11]

Pittsburgh Sleep Quality Index (PSQI)

The Malay version of the PSQI was used in this study to assess students' sleep quality.[15,16] The questionnaire consisted of 10 items, utilizing a 4-point frequency scale to evaluate sleep quality over the past month. The PSQI score was derived from seven components, each rated from 0 (no difficulty) to 3 (severe difficulty). These components included subjective sleep quality (C1), sleep latency (C2), sleep duration (C3), habitual sleep efficiency (C4), sleep disturbances (C5), use of sleep medications (C6), and daytime dysfunction (C7). The seven component scores were summed to generate a global score ranging from 0 to 21, with higher scores indicating poorer sleep quality. A total PSQI score greater than 5 was classified as "poor sleep quality," while a score of 5 or below was categorized as "good sleep quality." The results were then grouped accordingly into poor or good sleep quality categories.

Data analysis

Data analysis was performed using IBM SPSS for windows version 25. Descriptive statistics, including frequencies, percentage, mean and standard deviation, were used to summarize the students' socio-demographic characteristics, anthropometric measurements, and sleep quality. Simple linear regression was performed to examine the association between the independent and dependent variable. Multiple linear regression analysis was then used to assess the relationship

between sleep quality, BMI, and WC. Statistical significance was set at a $p<0.05$.

Results

Sociodemographic characteristics

A total of 277 students participated in the study, with 34.7% (n=96) being male and 65.3% (n=181) female (**Table 1**). 87.7% of the students were aged between 18 and 21 years, while 12.3% were between 21 and 25 years. The mean age of students was 21.53±2.22 years. In terms of ethnicity, 58.9% were Malays, 20.2% were Chinese, and 20.9% were Indian. Faculty distribution showed that 9.0% of students were from FBK, 22.4% from FKI, 24.9% from FESP, 20.6% from FUHA, and 23.1% from FSSG. The majority of students (63.5%) were enrolled in diploma programs, while 36.5% were pursuing a degree. Regarding the study period, most students were in their second year (63.9%), followed by third-year (19.1%) and first-year students (17.0%).

Table 1. General characteristics of the students

Characteristics	n (%)	Mean/SD
Gender		
Male	96 (34.7)	
Female	181 (65.3)	
Age (year)		21.53±2.22
18–21	243 (87.7)	
21–25	34 (12.3)	
Ethnicity		
Malay	163 (58.9)	
Chinese	56 (20.2)	
Indian	58 (20.9)	
Faculty		
FBK	25 (9.0)	
FKI	62 (22.4)	
FESP	69 (24.9)	
FUHA	57 (20.6)	
FSSG	64 (23.1)	
Study program		
Diploma	176 (63.5)	
Bachelor's degree	101 (36.5)	
Duration of study		
Year 1	47 (17.0)	
Year 2	177 (63.9)	
Year 3	53 (19.1)	
Weight (kg)		59.77±12.61
Height (m)		1.59±0.08
Body mass index (kg/m^2)		23.38±4.45
Underweight (<18.5)	34 (12.3)	
Normal (18.5–24.9)	157 (56.7)	
Overweight (25–29.9)	61 (22.0)	
Obese ≥30	25 (9.0)	
Waist circumference (cm)		
Male		73.78±10.29
Low risk (<94cm)	94 (97.9)	
High risk (≥94cm)	2 (2.1)	
Female		73.39±11.97
Low risk (<80cm)	141 (77.9)	
High risk (≥80cm)	40 (22.1)	

Anthropometric measurement

As shown in **Table 1**, the students' average weight was 59.77±12.61 kg and their average height was 1.59±0.08 m. The mean BMI of the students was 23.38±4.45 kg/m^2. A total of 56.7% of the students had a normal BMI (18.5–24.9 kg/m^2), while 12.3% (n=34) were classified as underweight, 22.0% (n=61) as overweight, and 9.0% (n=25) as obese. On the other hand, 2.1% (n=2) of the male students had a high central fat distribution and an elevated risk of co-morbidities, while 97.9% (n=94) had normal fat distribution and a low risk. Among female students, 22.1% (n=40) had a high central fat distribution and increased risk of co-morbidities, while 77.9% (n=141) had normal fat distribution and a low risk of co-morbidities.

Sleep quality characteristics

Results from the PSQI are presented in **Table 2.** The mean global PSQI score was 9.32±3.45 with 87.0% of the participants reporting extremely poor sleep quality (>5), and 13.0% experiencing good sleep quality (<5). However, when asked to subjectively rate their sleep quality, 22.4% described it as fairly bad, while 26.0% rated it as very bad. The key contributors to poor sleep quality included restricted sleep duration, prolonged sleep latency, low sleep efficiency, and daytime dysfunction. Overall, the majority of students reported insufficient sleep, with only 17.7% meeting the recommended seven or more hours of sleep per night. 42.6% slept for 6–7 hours per night, 21.3% for 5–6 hours, and 18.4% for less than 5 hours. Additionally, 16.2% of students took more than 60 minutes to fall asleep, and 72.2% had sleep efficiency below 85% (i.e., the percentage of time spent asleep from the moment they went to bed until they woke up). As a potential consequence of poor sleep quality, 25.6% of students reported experiencing daytime dysfunction at least once a week. Furthermore, 16.2% took sleep medication three or more times a week, while 19.1% used sleep medication at least once a week. Regarding sleep disturbances, 12.6% experienced disturbances three or more times a week, and 23.5% reported disturbances at least once a week.

Association between body mass index (BMI) and waist circumference (WC) with sleep quality among undergraduate students

Table 3 presents the results of the analysis examining the association between BMI and WC with sleep quality. Regression analysis was conducted to examine whether sleep quality predicts BMI and WC. For BMI, the regression model was not statistically significant (p>0.05), indicating that sleep quality does not have a significant influence on BMI. In contrast, the regression analysis for WC showed a significant association with sleep quality (p=0.026). However, the model explained only 1.9% of the variance in WC (R^2=0.019), suggesting that while the association is statistically significant, the effect size is small.

Table 2. Descriptive results of sleep quality

Characteristics	(n)%	Mean/SD
Sleep quality (Global score)		9.32±3.45
Good (<5)	36 (13.0)	
Poor (>5)	241 (87.0)	
Subjective sleep quality		
Very good	49 (17.7)	
Fairly good	94 (33.9)	
Fairly bad	62 (22.4)	
Very bad	72 (26.0)	

Characteristics	(n)%	Mean/SD
Sleep duration		
>7 hours	49 (17.7)	
6–7 hours	118 (42.6)	
5–6 hours	59 (21.3)	
<5 hours	51 (18.4)	
Sleep latency		
≤15 minutes / not during past month	60 (21.7)	
16–30 minutes / not during past month	75 (27.1)	
16–30 minutes / less than once a week	97 (35.0)	
>60 minutes / three or more times a week	45 (16.2)	
Sleep efficiency		
>85%	77 (27.8)	
75–84%	77 (27.8)	
65–74%	64 (23.1)	
<65 %	59 (21.3)	
Daytime dysfunction		
Not during past month	84 (30.3)	
Less than once a week	122 (44.1)	
Once or twice a week	43 (15.5)	
Three or more times a week	28 (10.1)	
Use of sleep medication		
Not during past month	70 (25.3)	
Less than once a week	109 (39.4)	
Once or twice a week	53 (19.1)	
Three or more times a week	45 (16.2)	
Sleep disturbances		
Not during the past week	82 (29.6)	
Less than once a week	95 (34.3)	
Once or twice a week	65 (23.5)	
Three or more times a week	35 (12.6)	

Table 3. Regression result of association between BMI and WC with sleep quality

	Sleep quality with BMI		Sleep quality with WC	
	Simple regression	Multiple regression	Simple regression	Multiple regression
β coefficients	0.155	0.145	0.059	0.067
p value	0.206	0.085	0.177	0.026*
R^2	-	0.019	-	0.019
F	(1,275) 2.42	(3,273) 2.54	(1,275) 0.46	(3,273) 0.92

Note: Independent variable included sleep quality; dependent variables included BMI and WC, *p<0.05 indicates statistically significant, BMI: Body Mass Index, WC: Waist Circumference. Multiple regression was adjusted for physical activity level.

Discussion

Our research identified a significant issue with the sleep quality of UniSZA undergraduate students, who experienced fragmented and poor sleep as measured by the PSQI. Referring to the hypothesis that sleep quality is associated with Body Mass Index (BMI) and Waist Circumference (WC), our findings indicated no significant association between sleep quality and BMI; however, sleep quality was significantly linked to WC.

While earlier research has demonstrated correlations between waist-to-hip ratio, BMI, and sleep duration in both children and adults,[17] our study specifically focused on the relationship between WC, BMI, and sleep quality in early adulthood. Consistent with our findings, a previous study has also reported no significant relationship between sleep quality and BMI. [18] One population-based study comparing adults with good and poor sleep quality found no differences in BMI or WC across groups.[19] Similarly, Öçal et al.[20] reported no significant variation in BMI when examining the effects of sleep quality on anthropometric measures.

In contrast, another study among students observed that those with poor sleep quality had lower mean BMI and WC,[21] suggesting that findings may differ depending on the population and study context.

In alignment with previous research, our study supports the notion that poor sleep quality is associated with increased central adiposity in early adults.[22,23] These findings underscore the importance of addressing sleep quality in young adults as part of comprehensive strategies to prevent obesity and related metabolic conditions.

Numerous studies have proposed an ideal sleep duration, noting that sleeping less than eight hours per day is associated with a higher risk of obesity and adiposity.[24] In addition, previous research has suggested that sleep disruption may contribute to the accumulation of body fat.[25] Specifically, the build-up of visceral fat in the abdominal region has been linked to the elevated release of adipokines and cytokines, which may further disrupt sleep patterns and reduce sleep quality.[26] Previous studies have also reported varying effects of sleep restriction on leptin levels. For instance, Spiegel et al.[27] reported an 18% reduction in daytime leptin following partial sleep deprivation compared to a rested state. In contrast, other studies have reported increased leptin levels following sleep restriction.[28]

A more recent study found that leptin secretion was higher in participants with poor sleep quality than in those with normal sleep quality, although further research is needed to clarify the directionality and mechanisms underlying this relationship.[29] The conflicting findings may be due to differences in study design, participant characteristics, and how sleep and leptin were measured. Factors like the duration of sleep restriction, timing of blood sampling, and individual variations in health and lifestyle can all influence leptin levels, making the relationship complex and not yet fully understood.

In addition to physiological mechanisms, psychosocial factors may also contribute to poor sleep quality and its relationship with adiposity.[30] Among university students, stress has been identified as one of the most frequent contributors to poor sleep quality. [31] Disrupted sleep alters circadian rhythms and may promote adiposity through various mechanisms, including changes in dietary habits and hormonal imbalances.[32] While some studies found no significant association between body composition parameters and subjective sleep quality as measured by the Pittsburgh Sleep Quality Index (PSQI),[33] others reported a negative association between lean BMI and sleep quality.[34] Subjective sleep quality has also been linked to psychological and cognitive functioning.[35] Additionally, a study among youth highlighted that PSQI and accelerometers may capture different dimensions of sleep, as accelerometers are limited in detecting wakefulness - leading to potential overestimation of sleep when individuals lie still but remain awake.[36] It is important to note that one limitation of the current study is the lack of control for psychosocial stress, which may have influenced both sleep quality and adiposity outcomes.

In addition to its impact on academic performance and daily activities, poor sleep quality places undergraduate students at risk for long-term health consequences, including excessive body

weight. In turn, excess body weight increases the likelihood of developing chronic conditions such as diabetes, cardiovascular diseases, and certain cancers. For instance, a recent meta-analysis identified 18 comorbidities associated with excess body weight, with type 2 diabetes posing the greatest burden, followed by cardiovascular diseases and various cancers, including oesophageal, colon, endometrial, gallbladder, and breast cancer.[37]

The interplay between poor sleep quality, adiposity, and nutritional behaviours highlights the need for a multidimensional health approach, as disrupted appetite-regulating hormones (ghrelin and leptin) may increase caloric intake and preference for unhealthy foods.[38] Irregular sleep further exacerbates central adiposity, compromises nutrient intake, and disrupts healthy eating patterns, thereby affecting overall diet quality and metabolic health.[39] The associations observed in this study highlight the importance of integrating sleep hygiene into public health strategies targeting obesity prevention, dietary behaviours, and chronic disease risk among young adults. Recognizing sleep as a modifiable lifestyle factor underscores its potential role in shaping long-term health outcomes beyond adiposity alone.

One of the strengths of our study is the use of validated and relevant questionnaires to assess sleep quality and its association with adiposity. However, this study has certain limitations, particularly the use of the Pittsburgh Sleep Quality Index (PSQI) instead of actigraphy, an objective measure of sleep quality. While the PSQI is widely validated and commonly applied in research, it remains a self-reported tool and is therefore subject to recall bias and individual perception differences, which may lead to underreporting or overreporting of sleep behaviours. To minimize these issues, validated instruments were employed and participants were assured of confidentiality to encourage accurate and honest responses.

Conclusion

This study concludes that sleep quality is not significantly associated with Body Mass Index (BMI); however, a significant association was found between sleep quality and Waist Circumference (WC) among UniSZA undergraduate students. By reviewing relevant studies, we identified both positive and negative influences on sleep quality, emphasizing the impact of lifestyle, mental health, social, and physical factors in university population. This study provides further evidence to clarify the key predisposing factors for poor sleep quality. The issue of poor sleep quality, which is a significant or first cause of disruption to normal physiological functioning, supports the conclusion that this disturbance merits serious consideration as a major public health concern.[40] Given the influence of lifestyle factors, future sleep quality intervention research should account for potential confounders. Furthermore, future studies with larger or stratified samples are recommended to explore subgroup-specific associations between sleep quality and anthropometric measures. In particular, further investigations into social jetlag that integrate the identified determinants are highly warranted among university students. Such efforts can inform targeted interventions to enhance sleep quality, which, in turn, may contribute to improved overall health and academic performance in university populations.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL PAPER

Association of eating behavior and diet quality among students in Taruna Nusantara Senior High School, Indonesia

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Abstract

Background: Poor adolescent diet quality is influenced by family eating habits, media promoting unhealthy foods, and body image pressures, leading to disordered eating, neglect of health considerations, and obesity. Even in controlled environments like boarding schools.

Objective: This study aims to assess association between eating behavior and dietary quality among students in Taruna Nusantara Senior High School (TN-SHS), Indonesia.

Methods: A cross-sectional study with 200 subjects aged 15-18 was conducted in January 2024. Participants were purposively sampled from TN-SHS boarding school. Data was collected using the Dutch Eating Behavior Questionnaire (DEBQ) and Diet Quality Index International (DQI-I), along with sociodemographic information, nutritional status, and physical activity. Analysis was performed using SPSS 29, employing multiple linear regression to examine the relationship between eating behaviors and diet quality.

Results: There was strong relationship between eating behavior and diet quality on different days, revealing that restrained eating correlates with better diet quality on average days (r=0.158, p=0.026), while external eating is linked to poorer diet quality. The association between eating behavior and diet quality on weekdays is weaker than on weekends. External eating consistently reduces diet quality across all periods (β=–1.380 to –1.854, p<0.01). Males exhibiting lower diet quality (β=–3.021 to –4.904, p≤0.002) and higher pocket money associated with improved diet quality, particularly on weekends (β=–3.633, p=0.021).

Conclusion: The study findings highlight the importance of managing external eating behaviors such as emotional eating, social eating, mindless eating, and binge eating, and suggest avenues for targeted interventions to promote healthier dietary habits.

Keywords: eating behavior, diet quality, adolescent, semi-military high school

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Introduction

According to the Indonesian Health Survey, the prevalence of obesity among adolescents aged 16-18 is 3.3% nationally, with Central Java reporting 2.9% for the same age group. Based on the Body Mass Index by Age, obesity rates for 15-18-year-olds in Indonesia are 3.5% for males and 3.1% for females.[1] This concerning trend is likely to have implications for both public health and the overall economic state of the country. The escalating prevalence of adolescent obesity in Indonesia poses a pressing concern.[2] Obesity increases the likelihood of non-communicable diseases such as high cholesterol level, hypertension high BMI, high blood sugar, and poor dietary also high in prevalence and increasing in Indonesia.[3,4] The surge in obesity in Indonesia is paralleled by a rise in diabetes, cerebrovascular disease, all of which are leading causes of mortality.[5,6]

Preventing obesity necessitates maintaining a healthy and balanced diet, which holds for adolescents as well. The quality of diet in high school adolescents significantly impacts their health and development during this critical period of rapid growth and maturation. Unfortunately, many teenagers tend to be affected by unhealthy eating habits, such as consuming fast food that is high in fat and sugar, as well as a lack of variety in their diet. Poor diet quality in teenagers can have a negative impact on their physical and mental health and can potentially cause long-term health problems. Therefore, it is important to understand the factors that influence the quality of their diet and take steps to improve them to ensure a healthy and fit adolescence.[7–9] Diet quality consists of four main categories: variety, adequacy, moderation, and overall balance of the diet.[10] High diet quality is related to the consumption of foods that meet macronutrient needs appropriately, both in terms of quantity and composition, as well as adequate micronutrient intake.[11] On the other hand, low diet quality is associated with high consumption of energy and fat, while low in fiber and micronutrients.[12]

Eating behavior is a critical factor that directly impacts the quality of an individual's diet. During adolescence, eating behavior exhibits crucial nutritional characteristics for growth. To ensure proper nutritional needs are met, adolescents must have good and regular eating habits.[13,14] Nonetheless, teenagers tend to engage in wrong eating behavior, namely consuming nutrients that are not following their needs or recommended dietary recommendations.[15,16] Wrong eating behavior like this can potentially cause nutritional problems that have a negative impact on their growth and health.[16] According to Agustina et al (2020) poor dietary quality and diversity, which is further reflected in their eating habits—many adolescents frequently skip meals, particularly by addressing meal frequency and reducing meal skipping, to help lower the risk of anemia and overweight-obesity among adolescent.[17] On the other hand, Setyowati et al. (2017) found that 69.2% of adolescents exhibit poor eating behavior in preventing anemia, with many having dietary restrictions by avoiding certain types of dishes.[18]

Adolescent eating behavior can be influenced by two factors: external and internal factors. External factors like family, peers, media, and food availability, along with internal factors such as physiological needs, body image, and personal beliefs, all influence eating behavior.[19] Children in boarding schools often consume excessive macronutrients like carbs, proteins, and fats, while lacking essential nutrients like iron, zinc, vitamin C, and calcium.[10,20] The diet quality of adolescents attending boarding schools can be meticulously monitored, allowing for targeted nutritional education and the inclusion of fresh fruits, vegetables, and lean proteins, encouraging informed dietary choices and promoting overall well-being. The essential to accurately assess eating habits to understand their impact on diet quality. To achieve this, the Dutch Eating Behavior Questionnaire (DEBQ) is used, which examines three key aspects of eating behavior: restrained eating, emotional eating, and external eating.[21] Assessing diet quality is imperative for identifying weaknesses and facilitating improvements, aiding individuals in understanding food composition and nutritional gaps. This knowledge promotes more effective efforts to enhance diet quality. To evaluate dietary quality and its impact on obesity, a reliable tool such as the Dietary Quality Index for

Adolescents (DQI-I) is essential, providing insights into the relationship between diet and associated problems. In the context of a semi-military boarding school like Taruna Nusantara Senior High School in Indonesia, which advocates healthy eating through balanced meals, portion control, and diverse food options, students' dietary quality may vary due to distinct eating behaviors, rendering it an ideal setting for this study. A comprehensive examination of the interactions between the two factors will offer a clearer perspective on their impact on an individual's health. Such research is scarce, particularly in school settings with a semi-military boarding system. These environments differ significantly from typical school contexts due to their unique characteristics, such as highly structured mealtimes, restricted food access, regulated daily routines, and heightened peer influence. These factors may have a substantial impact on students' dietary behaviors and overall nutrition, making this population an important yet underexplored group in dietary research. Researching to analyze the intricate relationship between diet quality, eating habits, and nutritional status is essential, intending to provide valuable insights for lifestyle improvements and enhanced nutritional guidance. This research aims to offer a new prospective on the evolving of eating behavior and diet quality among students in semi-military boarding school and focused on assessing the association between eating behavior and diet quality.

Methods

This cross-sectional study was conducted in January 2024 at Taruna Nusantara Senior High School, a semi-military boarding school in Central Java, Indonesia. A total of 200 students aged 15–18 years were selected through purposive sampling, with inclusion criteria requiring active enrolment and dormitory residence for at least three months. Students with metabolic disorders, prescribed diets, or incomplete responses were excluded.

Ethical approval was granted by the Ethics Committee of the Faculty of Medicine, Universitas Indonesia (KET-1819/UN2.FI/ETIK/PPM.00.02/2023).

Sociodemographic data, including age, sex, class, family structure, parental education and employment, household income, and pocket money, were collected using a structured questionnaire. Family size was categorized as small (≤3 members), medium (4–6), or large (≥7). Parental education was grouped into secondary (college/vocational or lower) and higher (bachelor's or above); employment status was recoded as both work or one work. Monthly household income was recoded into two categories: up to 3,500,000 IDR and above, while pocket money was grouped into amounts of 500,000 IDR or less and more than that.

Nutritional status was assessed using BMI-for-age Z-scores (BAZ) and classified into thinness, normal, overweight, and obese. Physical activity was measured using the PAQ-A, with scores above or below 2.75 used to categorize students as active or less active, respectively. Eating behaviors emotional, external, and restrained were measured using the Dutch Eating Behavior Questionnaire (DEBQ). Dietary intake was assessed using two non-consecutive 24-hour recalls (weekday and weekend) and analyzed using NutriSurvey software for nutrient intake and food group distribution. These data were used to calculate Diet Quality Index-International (DQI-I) scores (0–100), reflecting variety, adequacy, moderation, and balance. Data were analyzed using IBM SPSS Statistics version 29. Descriptive, bivariate, and multivariate analyses were conducted to examine the associations between eating behaviors, physical activity, sociodemographic factors, and diet quality.

Results

The sociodemographic characteristic of the subject is present in **Table 1** below. The median age of respondents was 16, with a majority being male (66%) and from medium-sized families (73.5%). Most parents had higher education (77%) and over half (53.5%) were dual earners. Additionally, 79% of families earned above 3.5 million IDR, and 74.5% of participants received up to 500,000 IDR

in pocket money. Regarding nutritional status, the majority, 152 people or 76%, have a normal weight. Those categorized as overweight account for 42 individuals or 21%, while a small number, 4 or 2%, are classified as obese. Underweight nutritional status is the least common with only 2 individuals or 1%. In terms of physical activity, 144 participants, or 72%, engage in high levels of activity, while the remaining 56, or 28%, have low levels of physical activity.

Table 1. Sociodemographic characteristics of the respondents (N = 200)

Characteristic	n	%
Gender		
Male	132	66
Female	68	34
Age		
15 years old	7	3.5
16 years old	126	63
17 years old	67	33.5
Family Member		
Small Family (≤ 3 Members)	44	22
Medium Family (4-5 Members)	147	73.5
Large Family (≥6 Members)	9	4.5
Parental Education*		
Secondary Education	55	23
Higher Education	154	77
Parental Employment Status		
Both Parent's Work	107	53.5
Only One Parent's Work	93	46.5
Parental Income Monthly		
≤ 3.5 Million (IDR)	42	21
> 3.5 Million (IDR)	158	79
Pocket Money Monthly		
≤ 500.000 (IDR)	149	74.5
>500.000 (IDR)	51	25.5
Nutritional Status**		
Underweight	2	1
Normal	152	76
Overweight	42	21
Obese	4	2
Physical Activity***		
High	144	72
Low	56	28

*Parental Education: Secondary Education including college or vocational and lower, Higher Education including bachelor's degree and higher **Nutritional status based on Permenkes no 2 of 2020 concerning anthropometric standards with the details: (-3SD to <-2SD) = Thinness, (-2SD to +1SD) = Normal, (+1SD to +2SD) = Overweight, and (>2SD) = Obese ***Physical Activity: Active adolescents (High) have a score (PAQ-A) more than 2.75, and if less than that can be describe about less active (Low).

Table 2 presents scores for both weekdays and weekends which enables comparison of dietary patterns on different days. The overall DQI-I scores are 53 for weekdays and 48 for weekends, indicating slightly better diet quality during weekdays. This table highlights the need for dietary improvements, particularly in fruit and vegetable intake, moderation of fats, sodium, and empty calorie foods, and achieving better nutrient balance.

Table 3 reveals that the median score for restrained eating, at 3.2, surpasses those of emotional eating and external eating, which range from 1.3 to 5. The mean scores similarly highlight that restrained eating, with an average of 3.2, is the dominant eating behavior, suggesting it is the most prevalent among the respondents. **Figures 1** show the dominant eating behavior of the respondent details among the study participants (N = 200),

displaying the count (n) and proportion (%) of each sub-scale.

The distribution of predominant eating behaviors among the study participants (N = 200), including the frequency (n) and percentage (%) for each subscale. Restrained Eating emerged as the most prevalent behavior, reported by 52.5% of respondents, followed by External Eating at 37.5%. Emotional Eating was comparatively less common, observed in only 5.5% of participants.

Table 2. Component of diet quality between weekdays and weekend

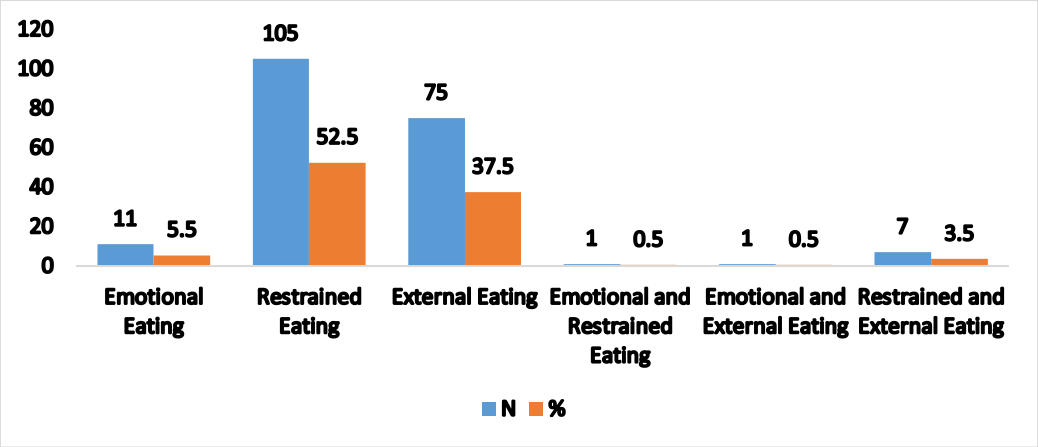
Variable	Score DQI-I	Diet Quality	
		Weekdays* Median (Min-Max)	Weekend** Median (Min-Max)
Variety	0-20	17(7-20)	17(9-20)
Food Group	0-15	12(6-15)	12(6-15)
Protein Source	0-5	5(1-5)	5(3-5)
Adequacy	0-40	12(5-24)	12(5-22)
Vegetable[a]	0-5	1(0-3)	0(0-1)
Fruit[a]	0-5	0(0-1)	0(0-5)
Grain[a]	0-5	1(0-5)	1(0-5)
Fiber[a]	0-5	1(1-5)	1(1-5)
Protein[a]	0-5	3(1-5)	3(1-5)
Iron[a]	0-5	3(1-5)	3(1-5)
Calcium[a]	0-5	1(1-3)	1(1-3)
Vitamin C[a]	0-5	1(1-3)	1(1-5)
Moderation	0-30	21(15-30)	21(0-30)
Total fat	0-6	0(0-6)	0(0-6)
Saturated fat	0-6	6(1-6)	6(0-6)
Cholesterol	0-6	6(6-6)	6(0-6)
Sodium	0-6	6(3-6)	6(0-6)
Empty calories foods	0-6	0(0-6)	0(0-6)
Overall balance	0-10	2(0-8)	0(0-8)
Macronutrient ratio[b]	0-6	0(0-6)	0(0-6)
Fatty acid ratio[b]	0-4	2(0-2)	0(0-4)
DQI-I Score	0-100	53(32-75)	48(32-67)

[a] data from Permenkes about *Angka Kecukupan Gizi* No 28 in 2019 [b] data from Permenkes about *Pedoman Gizi Seimbang* No 41 in 2014
*Weekdays: Sunday to Friday **Weekend: Saturday to Sunday

Table 3. Eating Behavior of the Respondent* (N = 200)

Sub-Scales	Median
Emotional Eating	1.7 (1.0 – 5.0)
Restrained Eating	3.2 (1.3 – 5.0)
External Eating	2.7 (1.0 – 4.7)

*Eating Behavior calculated using Dutch Eating Behavior Questionnaire



*The above percentages represent the proportion of the total population

Figure 1. Dominant eating behavior of the respondent (N = 200)

A minority of respondents exhibited mixed eating behavior patterns, with combinations such as Emotional and Restrained Eating, Emotional and External Eating, and Restrained and External Eating accounting for between 0.5% and 3.5% of the sample. **Table 4** show the associations between distinct eating behavior patterns and diet quality across different weekdays, and weekends. The findings indicate that on the overall average across both weekdays and weekends**,** restrained eating, characterized by conscious control over food intake, is positively associated with higher diet quality.

Table 4. Association between eating behavior and diet quality (N = 200)

Dependent variable	Independent variable	r value	p-value
Diet Quality	**Eating Behavior**		
DQI-I Score Weekdays	Emotional Eating	0.043	0.549
	Restrained Eating	0.087	0.220
	External Eating	0.218**	0.002
DQI-I Score Weekends	Emotional Eating	0.138	0.052
	Restrained Eating	0.199**	0.005
	External Eating	0.274**	0.001
DQI-I Score Average	Emotional Eating	0.110	0.122
	Restrained Eating	0.158*	0.026
	External Eating	0.305**	0.001

Statistical analysis used spearman correlation.
**. Correlation is significant at the 0.01 level (2-tailed) *. Correlation is significant at the 0.05 level (2-tailed)

In contrast, external eating—driven by environmental cues such as food visibility or social settings—is strongly linked to lower diet quality, while emotional eating shows minimal influence. During weekdays, the relationship between eating behaviors and diet quality appears attenuated, with neither emotional nor restrained eating showing a notable effect; however, external eating continues to negatively impact diet quality. On weekends, these associations become more pronounced: individuals engaging in restrained eating maintain better diet quality, while external eating remains a significant determinant of poorer dietary outcomes. These patterns underscore the heightened influence of social and environmental factors on eating behavior and diet quality during weekends, suggesting a context-dependent vulnerability to less healthy eating practices.

Table 5 presents a comparative analysis of the Diet Quality Index-International (DQI-I) across various demographic groups, detailing mean scores and ranges for weekdays, weekends, and overall daily averages. Statistically significant gender differences were identified, with males consistently exhibiting higher mean diet quality scores across all periods compared to females. Although age differences were not statistically significant, younger participants (≤15 years) tended to have higher mean DQI-I scores. Other demographic variables—including family size, parental education, employment status, and household income—did not significantly influence diet quality. However, pocket money showed a notable effect: participants with ≤500,000 IDR had significantly lower weekday diet quality compared to those with greater financial resources. While variations in nutritional status and physical activity levels were observed—with normal BMI and high activity levels generally linked to higher diet quality—these differences were not statistically significant.

Following this, **Table 6** provides results from a multivariate analysis examining factors influencing diet quality across different timeframes. The analysis highlights several key determinants: external eating consistently correlates with lower diet quality across weekdays, weekends, and average days; gender differences persist, with females demonstrating better diet quality than males; and higher pocket money is positively associated with improved diet quality, particularly on weekends.

Table 5. Association between Diet Quality Index International and sociodemographic characteristic (N=200)

Characteristic	Diet Quality Index International					
	Weekdays		Weekend		Average	
	Mean±SD Median (Min-max)	p-value	Mean±SD Median (Min-max)	p-value	Mean±SD Median (Min-max)	p-value
Gender						
Male	55 (32-75)	<0.001 [b]	49 (33-67)	0.003 [b]	52±5.63	<0.001 [a]
Female	48 (39-62		46 (32-64)		47.90±4.56	
Age						
15 years old	56 (47-69)	0.405 [c]	51 (42-56)	0.947 [c]	53.5 (44.5-60.5)	0.570 [c]
16 years old	53 (39–68)		48 (32-67)		49.75 (38-65)	
17 years old	52 (32-75)		48 (32-65)		50 (40-70)	
Family Member						
Small Family	53 (39-64)	0.733 [c]	48 (35-67)	0.168 [c]	49.5 (41.5-65)	0.253 [c]
Medium Family	52 (32-75)		48 (32-65)		50 (38-70)	
Large Family	56 (42-61)		53 (44-60		53 (48-59.5)	
Parental Education						
Secondary Education	51.76±6.36	0.448 [a]	47.50 (32-60)	0.573 [b]	49.25 (40-62.50)	0.420 [b]
Higher Education	52.68±7.49		48 (32-67)		50.75 (38-70)	
Parental Employment Status						
Both Work	52.26±7.10	0.656 [a]	48 (32-67)	0.526 [b]	49.50 (38-65)	0.641 [b]
One Work	52.72±7.44		48 (32-65)		50.50 (40-70)	
Parental Income						
≤ 3.5 Million	53.16±7.37	0.488 [a]	51 (32-61)	0.400 [b]	51 (40-61.50)	0.378 [b]
> 3.5 Million	52.29±7.22		48 (32-67)		49.75 (38-70)	
Pocket Money						
≤ 500000 (IDR)	48.82±6.91	0.030 [a]	51 (40-62)	0.076 [b]	50.14±5.37	0.675 [b]
>500000 (IDR)	52.81±7.20		48 (32-67)		50.74±5.66	
Nutritional Status						
Normal	53 (32-75)	0.025 [b]	48 (32-67)	0.076 [b]	50 (38-70)	0.548 [b]
Overweight	51.50 (47-56)		52 (46-58)		51.75 (46.50-57)	
Physical Activity						
High	54 (32-75)	0.221 [b]	48 (32-67)	0.131 [b]	51 (38-70)	0.066 [b]
Low	51 (39-69)		48 (33-64)		48.50 (40.50-61.50)	

[a] Statistic analysis used T-test for parametric mean comparison test, [b] Man Whitney U for non-parametric comparison test [c] Kruskal Walis for non-parametric comparison test

Table 6. Multiple linear regression analysis of diet quality (N = 200)

Parameter	Diet Quality											
	Weekdays[a]				Weekend[b]				Average[c]			
	Parameter Estimate	Standard Error	95% CI	p-value	Parameter Estimate	Standard Error	95% CI	p-value	Parameter Estimate	Standard Error	95% CI	p-value
Constant	46.989	10.27	26.73	<0.001**	61.908	9.955	42.274	<0.001**	51.526	2.632	46.335	<0.001**
Eating Behavior												
Emotional Eating	-	-	-	-	1.409	0.619	0.189	0.024*	1.252	0.502	0.263	0.013*
External Eating	-1.380	0.510	-2.385	0.007*	-1.854	0.490	-2.820	<0.001**	-1.651	0.397	-2.435	<0.001**
Restraint Eating	-	-	-	-	0.637	0.728	-0.799	0.383	0.212	0.592	-0.956	0.721
Gender	-4.904	1.000	-6.890	<0.001**	-3.021	0.951	-4.895	0.002*	-4.071	0.769	-5.588	<0.001**
Family Member	-	-	-	-	1.178	0.972	-0.739	0.227	-	-	-	-
Pocket Money	2.944	1.705	-0.418	0.086	-3.633	1.567	-6.723	0.021*				
Nutritional Status	2.693	4.476	-6.699	0.572	-3.483	4.394	-12.150	0.429				
Physical Activity	-	-	-	-	1.276	0.972	-0.641	0.191	1.133	0.788	-0.421	0.152

[a]Dependent variable: DQI-I Weekdays
*Significance level at p-value <0.05; **significance level at p-value <0.01
R Square = %, P-value = <0.01 analyzed with multiple linear regression using enter method.
[b]Dependent variable: DQI-I Weekend
Significance level at p-value <0.05; significance level at p-value <0.01
R Square = %, P-value = <0.01 analyzed with multiple linear regression using enter method.
[c]Dependent variable: DQI-I Average
Significance level at p-value <0.05; significance level at p-value <0.01
R Square = %, P-value = <0.01 analyzed with multiple linear regression using enter method.

Emotional eating was found to have a positive association with diet quality on weekends and average days, though nutritional status and physical activity were not significant predictors in the multivariate model. These findings underscore the multifaceted nature of dietary behaviors and suggest specific socio-demographic and behavioral factors that could inform targeted nutrition interventions.

Discussion

The study found that Most respondents are male, constituting 66% of the total sample, whereas females make up 34%. This skew towards male respondents might influence certain aspects of the study, such as perspectives or behaviors observed. The high proportion of male respondents in this study may influence the observed eating behavior patterns, particularly in the context of adherence to structured mealtimes, peer pressure, and the rigid daily routines typical of semi-military boarding schools such as Taruna Nusantara. In such environments, male students often engage in higher levels of physical activity compared to females, which can affect their daily energy needs and food preferences. This may lead to greater food intake in terms of quantity, but not necessarily in terms of dietary quality, as reflected in DQI-I scores. Additionally, external eating behavior may be more prominent among males in socially competitive and structured settings, while restrained eating could be more difficult to maintain consistently. Although emotional eating might be less pronounced in a highly disciplined environment, it remains relevant for understanding individual differences in response to stress or social pressure. Among the respondents, the highest proportion falls within the 16 years old category (63%). This concentration around the 16-17 age range suggests that the study largely targets adolescents, potentially influencing the interpretation of results, especially concerning behaviors typical of this age group such as irregular eating patterns, increased sensitivity to social norms, and a heightened responsiveness to environmental cues. These developmental characteristics may affect both the quality of diet and the expression of eating behaviors, including tendencies toward *external eating*, *emotional eating*, and inconsistent dietary restraint. This aligns with the Indonesian Ministry of Education and Culture Regulation (*Permendikbud*) No. 1 of 2021, which states that the minimum age for high school students is 15 years, and the maximum age is 21 years. This age range corresponds with the age range present in this study.[22] On the other hand, most respondents come from medium-sized families (73.5%) this distribution might indicate different dynamics in terms of family support, resources, and interactions that could impact various aspects of the respondents' lives, including their nutritional status and physical activity levels. In contrast, within the scope of this research, the mean family size reported among the respondents is slightly higher, amounting to 4 members per household. This slight discrepancy suggests that respondents may come from somewhat larger families than the national average, potentially affecting sociodemographic factors such as food availability, parental supervision, and sibling influence.[23] In larger households, dietary choices may be shaped by limited resources and older siblings, while parental control may be less direct.[24] These factors can influence adolescents' eating habits and diet quality scores. Additionally, students from larger families may be more familiar with group living, aiding their adjustment to structured environments like semi-military boarding schools.

A large proportion of parents in this study have attained a relatively high level of education and income, indicating an overall affluent and educated sample. This socioeconomic background may influence various lifestyle factors, including access to resources, dietary choices, and health-related behaviors among the respondents. The average pocket money per respondent is 500,000 IDR, with 66% of respondents falling within this range. This variable reflects individual financial autonomy and could influence spending habits, including dietary choices and participation in physical activities. Based on the findings elucidated in the study undertaken by Kurniawan (2017), there exists a significant correlation between the disbursement of pocket money and an

individual's consumption patterns, indicating that a surge in pocket money allocation is concurrent with heightened levels of energy sufficiency.[25] Therefore, higher income levels have an impact on the total consumption of students, affecting their nutritional status. Most respondents have a normal weight (76%), these findings provide an overview of the distribution of weight categories within the sample population, which is crucial for understanding health risks and intervention strategies. A significant portion of respondents (72%) engage in high levels of physical activity, while a smaller proportion (28%) have low levels of physical activity. This disparity in activity levels may have implications for overall health outcomes and could potentially correlate with nutritional status. In the context of a semi-military boarding school setting, such as Taruna Nusantara, this trend is not unexpected. Physical activity is embedded into the students' daily routine through a structured schedule that includes regular exercise, drills, and physical training, contributing to consistently high physical activity levels. Moreover, meeting a minimum standard of physical fitness is often part of the school's admission criteria, which may explain why most respondents have normal or healthier physical status. Research from Praditasari (2018), indicates that very light physical activity poses a risk factor 9.533 times greater for obesity compared to light physical activity (95% CI: 1.847-49.204).[26] This finding aligns with study Nisa et al (2021), which highlights a significant relationship between physical activity and the nutritional status of adolescents, and adolescents with insufficient physical activity are 1.937 times more likely to be overweight or obese than those who engage in adequate physical activity (95% CI: 1.06-3.53).[27] However, study from Nabawiyah et al (2021) suggests that there is no significant correlation between physical activity and adolescent nutritional status.[28] Adolescent nutrition is influenced by both dietary patterns and physical activity, where sufficient and balanced physical activity especially at moderate to high intensity combined with adequate energy intake supports healthy growth and helps reduce the risk of obesity, ultimately impacting their overall nutritional status.[29]

The individuals eating patterns and quality are thoroughly analyzed, with an emphasis on weekdays and weekends. Table 2 breaks down the dietary components into five categories: Variety, Protein Source, Adequacy, Moderation, and Overall Balance. According to the research, the weekend intake of a wide range of food groups is significantly lower than weekday consumption, according to the research. Several studies on diet quality, although the subjects are not the same, show that diet quality on weekdays and weekends, the amount of nutrient dense food consumed is less on weekends than weekdays.[30,31] Results from Danish studies on children aged 4 to 14 show that during the vacations, compared to school days, children consume fewer of the purportedly healthy food groups (vegetables and fruits).[32] Lunch and snack intake, as well as the amount of vegetables consumed, are far more sufficient on weekdays than on holidays. Additionally, according to Ruopeng (2015), there is a decrease in the consumption of fruits and vegetables, a rise in the consumption of fast food, a decrease in the Healthy Eating Index-2010 score, and an increase in caloric and total fat intake during the holidays.[33] Prior research indicated that as compared to school days, holidays are a time when people eat less healthfully. [31] The majority of participants showed consistent eating behavior on weekdays and weekends by consuming protein from three or more sources each day. Adequacy category revealed a noteworthy lack of consumption of fruits and vegetables, as a sizable portion of participants did not achieve the suggested serving sizes. Most of grains also consumed less than the suggested amounts, albeit at a somewhat higher percentage than fruits and vegetables. This is consistent with study by Esposito et al. that shows workday consumption of veggies, lunch, and snacks is substantially more adequate than it is on holidays.[34] This research also found that the consumption of iron, calcium, vitamin C is still relatively low compared to the recommendations, this is in line with research from Safitri et al in 2019 which stated that the intake of iron and vitamin C is still below the recommended adequacy of consumption, this food is by what is recommended, which means that the quality of school children's diets in Indonesia is

still relatively low.[35] On the other side for sub moderation results show that consumption of total fat, saturated fat, and empty calories is elevated, particularly on weekends. Throughout the week, consumption of sodium and cholesterol remained high. Activities that occur on unrestricted weekends in the school setting, where respondents have the freedom to eat out and consume food without the strict supervision and measurement that is typically applied in the school environment, can be a mediator in the increase in consumption of fat, saturated fat, and empty calories. For this overall balance the ratios of fatty acids and macronutrients indicated that a significant amount of the food was outside of the permitted range, particularly on weekends. Study from Triatmoko et al in 2024 found that high school students in semi-military schools had significantly lower diet quality on weekends compared to weekdays, indicating the negative impact of a less structured weekend environment on adolescents' eating habits.[36] Consistently low intake of fruits, vegetables, and grains—paired with excessive consumption of fats and empty calories—reflects a nutrient-poor, energy-dense diet that may elevate chronic disease risk, with nearly half of participants failing to meet recommended fruit and vegetable intake, posing a significant public health concern.[37] Despite various efforts to encourage adolescents to include vegetables and fruit in their daily diets, previous studies have reported a decline in their consumption.[38,39] This ongoing trend underscores the need for more effective public health initiatives and educational programs to promote healthier eating habits among young people and address the decreasing intake of these vital food groups. In another study, it was found that more than one-third of the sample scored less than 50% of the total score, indicating that a significant percentage of adolescents had low diet quality. This finding aligns with the results of the current study.[10,40–42] The causes of low diet quality among adolescents can be attributed to several factors, including poor nutritional knowledge, limited availability of healthy food options, high consumption of fast food and processed snacks, socio-economic constraints, and lack of parental guidance or supervision in dietary habits. Additionally, the influence of peer pressure and media on food choices also plays a critical role in shaping the dietary patterns of this age group. Enhancing the nutritional well-being of adolescents necessitates holistic initiatives tailored to their specific needs. These interventions should encompass multifaceted approaches, including educational campaigns aimed at bolstering nutritional awareness, initiatives to broaden access to affordable yet nutrient-rich food selections, advocacy for making healthy food options more readily available to students and members of the community, and empowerment programs for parents and caregivers to model and reinforce healthy eating behaviors. It is widely acknowledged that a healthy diet is often accompanied by other beneficial behaviors, such as increased levels of physical activity, which together contribute to an overall healthier lifestyle and enhance various aspects of physical and mental well-being.[43–45]

Data on the eating habits of the participants are shown in Table 3, where, in comparison to emotional and external eating, restricted eating has the greatest median and mean scores. In particular, the range for emotional and external eating is 1.3 to 5, but the median score for controlled eating is 3.2. With an average score of 3.2, the mean scores highlight the predominance of restrained eating even more, indicating that it is the respondents' preferred eating behavior. The study participants' most common eating behaviors are described in detail in Table 4, which also shows the count (n) and proportion (%) of each sub-scale. With 52.5% of respondents reporting restricted eating, it is the most common behavior, followed by external eating with 37.5%. Emotional eating is less common, as just 5.5% of participants reported experiencing it. Furthermore, a tiny percentage of participants engage in mixed eating behaviors, contributing between 0.5% and 3.5% of the total. These combinations include emotional and restrained eating, emotional and external eating, and restrained and external eating. According to a study conducted in China among adolescents aged 11 to 17 years, there are significant differences in eating behavior between genders as measured by the DEBQ, with a higher percentage of female

adolescents reporting emotional, restrained, and external eating behavior than male adolescents.[46] This study results show that respondents generally exhibit restrained eating behavior, pointing to a propensity for limiting food intake or following certain dietary recommendations. In Depboylu's study, it is mentioned that students with inadequate energy, carbohydrate, and protein intake scored higher in restrained eating compared to those with excessive energy, carbohydrate, and protein intake.[47] But it's important to think about how these eating habits might affect general health and wellbeing. In the study conducted by Nurdiani et al., it was observed that there is a positive and significant relationship between restrained eating behavior and BMI, showing that higher levels of restrained eating are associated with an increased BMI. This finding aligns with the restrained eating theory which posits that skipping meals can cause irregular eating patterns. This irregularity can lead to counter-regulatory eating, where individuals overcompensate by overeating after periods of restraint, ultimately resulting in weight gain. [48] This study also found results on the eating habits of respondents in more than one category, where the assessment results obtained the same number in the two categories of eating habits for each respondent. This means that the respondent has a complex and multifactorial eating pattern.

This research looks at the associations between different eating behavior and diet quality on weekdays and weekends. It shows that depending on the day of the week, there are different relationships between eating behavior and diet quality. People who practice restricted eating, which is defined as selecting foods carefully, typically have better-quality diets on average. On the other hand, poorer nutrition quality is associated with reliance on outside cues, such as food availability or social conditions, as observed in external eating. A prior study found a potential relationship between restricted eating and increased weight gain in adults,[49,50] as well as an increased risk of obesity in preadolescent and adolescent girls.[51,52] A study conducted in the United States of America revealed a positive correlation between the scores on the restriction scale and BMI (adjusted β = 0.39 kg/m2; 95% confidence interval (CI) = 0.34–0.44; $p < 0.001$) as well as weight gain (adjusted β = 0.33 pounds; 95% CI = 0.17–0.49; $p < 0.001$)[53]. On typical days, however, it seems that emotional eating has little effect on the quality of the diet. The impact of eating habits on diet quality is less noticeable during the week. While external eating continues to influence diet quality, it does so less than on ordinary days. Emotional and constrained eating are found to have minor relationships with diet quality. This finding contrasts with a study conducted by Sekarini on adolescents in Semarang, which demonstrated a significant relationship between emotional eating behaviors and diet quality. The results indicated a positive correlation with emotional eating ($p=0.005$; $r=0.236$) and a negative correlation with diet quality ($p=0.002$; $r=-0.261$), suggesting that as emotional eating increases, diet quality tends to decrease.[54] The impact of eating behavior on diet quality is especially noticeable on the weekends. Although students live in a structured semi-military boarding school environment, they still have the freedom to purchase food during weekends. This relative flexibility in food access may lead to greater expression of individual eating behaviors such as emotional or external eating which in turn can influence their overall diet quality during this period. The relevance of consistent eating behaviors is suggested by the tendency for those who follow restrained eating habits to retain improved diet quality. Furthermore, external eating continues to have a substantial impact on diet quality, suggesting the influence of environmental or social variables, which is especially noticeable on weekends. These observations are statistically supported by Table 3 findings, which show strong relationships between eating habits and diet quality on various kinds of days based on spearman correlation analyses. The significant differences in diet quality between men and women, with men scoring higher on weekdays and on average, and showing significant differences over the weekend. Although the study by Dewi et al. (2013), [55] was conducted in a regular public school setting, their finding that boys scored higher than girls on the DQI-I also appears in this semi-military boarding school context. This suggests that gender may

consistently influence diet quality among Indonesian adolescents, regardless of differences in school environment or structure. Scores on all components of the DQI-I (variety, adequacy, moderation, overall balance) were also higher in adolescent males than females. However, despite the values obtained for the adequacy, moderation, and overall balance components falling far from the point range, with only the adequacy of grains and protein not scoring too low, diet quality assesses food intake according to established dietary recommendations or nutritional guidelines, serving as a crucial determinant of an individual's nutritional status. [55,56]

In the present study, the relationship between age and diet quality was not statistically significant. All respondents were aged between 15 and 17 years, falling within the category of middle adolescence a developmental stage characterized by increasing autonomy, strong peer influence, and heightened media exposure, which may contribute to less consistent dietary patterns. While previous research suggests that younger adolescents (under 15 years old) tend to have higher diet quality scores particularly during weekdays and on average.[57] This pattern was not observed here, likely due to the absence of participants below 15 years of age in the sample. Particularly regarding dietary preferences, there's a strong sway towards food selections rich in fats and sugars, largely influenced by peer interactions and media exposure.

On this the study revealed that individuals with lower levels of pocket money exhibited decreased diet quality scores, particularly notable during weekdays, thus emphasizing the significant economic implications on the accessibility of nutritious food options**.** Interestingly, this pattern is also observed in a semi-military boarding school context. Despite the structured environment, students still have opportunities to purchase food whether at the school canteen on weekdays, albeit limited, or more freely during weekends. Teenagers who have a lot of pocket money frequently don't think about moral issues while deciding what to eat because they have more purchasing power and can choose what kind and how much to eat.[58] If teenagers have a lot of pocket money, they usually choose sugary snacks and fast meals, which are high-calorie foods with proven health risks.[59,60]

This implies that when making food decisions, teenagers with more discretionary cash can prioritize convenience and preference over ethical considerations about health, while the nutritional status in this study also influences diet quality on weekdays, as individuals with a normal nutritional status tend to score higher than those who are overweight. Also, in this study found that individuals with high physical activity have higher diet quality scores on weekdays, though not significantly, suggesting a potential relationship between physical activity and healthier food choices; similarly, adolescents with low diet quality and low physical activity are at a significantly increased risk, with 10.4 and 7.2 times greater likelihood respectively, of developing obesity.[61] However, in this study, no significant differences were found in diet quality based on family size, parental education, employment status, or parental income, suggesting that these sociodemographic factors may have a less direct impact on adolescents' dietary quality. This finding is particularly interesting in the context of a semi-military boarding school population, where students do not live at home on a daily basis. As a result, the direct influence of family dynamics or household environment on their eating behavior may be reduced. Daily meals are generally provided within the institution under structured schedules and limited food environments, which may diminish the role of parental socioeconomic status in shaping food choices. Nevertheless, future discussions may still consider how background factors subtly interact with individual autonomy, peer influence, and institutional food policies, and how tailored interventions can further support healthy eating behaviors in such unique settings.

A key strength of this study is its focus on students in a semi-military boarding school, a controlled environment that minimizes external influences like regional diets or socioeconomic factors. This allows for a clearer understanding of how structured school settings shape eating behaviors and diet quality, providing valuable insights for targeted nutrition programs and policies in similar educational contexts. However,

it is imperative to note potential biases introduce due to reliance on assessment of DQI-I, 24-hour recall is used to gather intake data, which may not accurately represent long-term eating patterns. There is a possibility that respondents may provide answers that are perceived as more socially acceptable or healthy, rather than what they consumed.

Conclusion

This study highlights that semi-military boardings school adolescent diet quality is influenced by several interrelated factors, especially on weekends. Males generally had higher diet quality scores than females, and younger adolescents showed slightly better, though not significant, scores. Lower pocket money was linked to poorer weekday diet quality, reflecting the impact of financial autonomy on food choices. Eating behaviors also mattered restrained eaters had better diet quality, while external eaters consumed less healthy diets, and emotional eating showed weaker, varying associations. Physical activity was positively linked to diet quality, though not significantly. Family size and parental socioeconomic factors showed no notable influence, indicating individual behaviors play a stronger role. These findings stress the need for structured eating, better nutrition knowledge, and targeted weekend interventions to improve adolescent diet quality.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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