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Dietary Intakes and Physical Fitness in Relation to Anaemia among Female Students Studying Nutrition at Universitas Negeri Surabaya, Indonesia

Hubungan Asupan Makan dan Kebugaran Fisik dengan Anemia pada Mahasiswi Gizi Universitas Negeri Surabaya, Indonesia

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ABSTRACT

Background: Anaemia affects approximately 31.2% of Indonesian women of reproductive age and has been linked to inadequate dietary intake and lifestyle behaviours.
Objectives: The present study aimed to determine the proportion of anaemia among female undergraduates in the Nutrition programme and to investigate its associations with dietary intake, anthropometric measures and physical activity levels.
Methods: In this cross-sectional study, 113 first- and second-year female Nutrition students completed three non-consecutive 24-hour food records to estimate daily intakes of energy, iron, folate, vitamin B_{12} and vitamin C. Dietary diversity was quantified using the Dietary Diversity Score (DDS). Physical fitness was assessed via the Harvard Step Test, and anthropometric measurements body mass index, mid-upper arm circumference and body-fat percentage were recorded. Capillary haemoglobin concentrations determined anaemia status. Independent t-tests or Mann-Whitney U tests compared anaemic and non-anaemic groups, and logistic regression models estimated odds ratios for associations with anaemia.
Results: 39% of participants were classified as anaemic. Fitness scores differed significantly between groups (anaemic: 43.7±2.1 vs non-anaemic: 51.4±2.5; p-value=0.03). In unadjusted analyses, higher folate intake corresponded to reduced odds of anaemia (p-value=0.02), but the association was no longer significant after adjustment for covariates.
Conclusions: A high proportion of female Nutrition undergraduates remain anaemic. Public health initiatives should promote diets rich in iron and folate, encourage greater dietary diversity, and support regular physical activity to mitigate anaemia risk. Further research should evaluate targeted nutritional interventions and fitness programmes for this demographic.

INTRODUCTION

Anaemia remains a global public health concern. In 2019, the World Health Organization (WHO) estimated that 29.9% of women aged 15-49 years approximately 570.8 million individuals were affected worldwide. In Indonesia, anaemia prevalence among women in this age bracket rose from 21.6% in 2018 to 31.2% in 2019[1]. Among undergraduates studying health-related subjects, reported rates range from 39% to 43%[2,3]. Anaemia has a multifactorial aetiology, with dietary factors significantly influencing its development and progression. Inadequate intake of essential micronutrients iron, folate, and vitamin B_{12} substantially increases anaemia risk. These nutrients are critical for erythropoiesis, the bone marrow process responsible for red blood cell production[4,5].

Ensuring a diverse diet is vital to meet daily nutrient requirements. Greater dietary variety is inversely related to anaemia prevalence[6]. The Food and Agriculture Organization of the United Nations (FAO-UN) has developed the Dietary Diversity Score (DDS) to facilitate dietary assessment among women of reproductive age. The DDS categorises food intake into ten groups: 1) grains, roots and tubers, 2) dark green leafy vegetables, 3) vitamin a-rich fruits and vegetables, 4) other fruits, 5) other vegetables, 6) meat, poultry and fish, 7) eggs, 8) pulses, 9) nuts and seeds, and 10) dairy products. Higher DDS values are associated with sufficient macro- and micronutrient consumption, pivotal in preventing and managing anaemia[7].

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In addition to dietary factors, physical fitness and exercise levels have also been associated with variations in anaemia prevalence. Impaired oxygen delivery to tissues and organs can compromise exercise capacity and overall fitness[8]. Conversely, individuals with higher fitness levels often demonstrate more efficient oxygen utilisation and circulation, which may lessen the likelihood or severity of anaemia through enhanced physiological adaptations to exercise[9].

The present study investigates the prevalence of anaemia among female undergraduates enrolled in the Nutrition programme at Universitas Negeri Surabaya. It explores associations between their dietary habits, physical fitness and anaemia status. The research seeks to identify the principal factors influencing anaemia in this cohort of young adult women by assessing dietary intake, anthropometric measurements and physical activity levels. The findings will inform targeted interventions designed to improve the nutritional status and overall health of female students at risk of anaemia.

METHODS

A cross-sectional study design was adopted, enrolling 113 female students from the Nutrition programme at Universitas Negeri Surabaya. Only those meeting predefined criteria for normal health were included. Participants were selected by cluster random sampling, with each class contributing an equal number of students to ensure representativeness. The required sample size was calculated to achieve a significance level of 0.05. Written informed consent was obtained from all participants before their involvement in the study.

Anaemia status was determined by capillary haemoglobin measurement using the EasyTouch GCHb metre (Taiwan). Participants with haemoglobin concentrations of ≥12 g/dL were classified as non-anaemic, and those recording <12 g/dL were classified as anaemic. Dietary intake data energy, iron, folate, vitamin B_{12} and vitamin C were collected via non-consecutive three-day 24-hour food records encompassing two weekdays and one weekend day. Nutritionist-researchers provided standardised training on completing the self-administered records. Energy, iron and vitamin C intakes were assessed against the Indonesian Recommended Dietary Allowances (RDA). Folate and vitamin B_{12} intakes, which exhibited a left-skewed distribution and generally low levels, were categorised as lower or adequate based on the sample mean. Physical fitness was evaluated using the Harvard Step Test (HST)[10,11].

Following completion of the HST, participants' pulse rates were recorded at rest and 1.5, 2.5, and 3.5 minutes post-exercise using a digital sphygmomanometer. The fitness score was calculated by multiplying the test duration (in seconds) by 100 and then dividing by twice the sum of the three post-test pulse counts. Participants were weighed on a digital scale, and their heights were measured with a stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in square meters and categorised according to WHO Asia-Pacific criteria. Dietary diversity was assessed using the Minimum Dietary Diversity for Women (MDD-W) protocol12, which classifies foods into ten groups: grains, roots and tubers; dark-green leafy vegetables; vitamin A-rich fruits and vegetables; other fruits; other vegetables; meat, poultry and fish; eggs; pulses; nuts and seeds; and dairy. Consumption of at least 15 g from any group scored one point, producing a total Dietary Diversity Score (DDS) ranging from 0 to 10[12].

Statistical analyses were conducted using IBM SPSS Statistics version 22.0 (IBM Corp., Chicago, IL, USA). Descriptive statistics are presented as frequencies and percentages. The student's t-test was used to compare dietary, physical-fitness and anthropometric variables across anaemia categories. The Mann-Whitney U test was applied when parametric assumptions were unmet. Logistic regression analysis was then performed to estimate odds ratios (ORs) for the association between anaemia status and each independent variable. Variables yielding a p-value below 0.25 in bivariate analyses were selected as candidates for the multivariate model. These were further evaluated using a change-in-estimate criterion: any variable whose inclusion or exclusion altered the primary exposure OR by more than 10 % was retained[13]. A backwards-elimination procedure was followed, with the successive removal of variables failing to meet this threshold. In the final model, p-values below 0.05 were considered statistically significant.

Ethics Approval and Consent to Participate

The Ethics Committee of the Polytechnic Health Ministry of Surabaya (No. EA/2209/KEPK-Poltekkes_Sby/V/2024) approved the study protocol on 2 April 2024. Participants received comprehensive information on the study objectives and procedures, and all provided written informed consent before any data were collected.

RESULTS AND DISCUSSIONS

Of the 113 female undergraduates enrolled in the Nutrition programme, 39% were classified as anaemic and 61% as non-anaemic (**Table 1**). Nearly half of the cohort (49%) had a body mass index (BMI) below the normal range; conversely, 21% were overweight and 10% were obese. Assessment of Middle Upper Arm Circumference (MUAC) indicated that 35% of participants met the Chronic Energy Deficiency (CED) criteria.

Dietary analysis showed that most participants failed to meet the Indonesian Recommended Dietary Allowance (RDA) for women aged 19-24 years. Specifically, 98% consumed less energy than recommended, while 83% and 69% fell short of the RDA for iron and vitamin C, respectively. Folate and vitamin B_{12} intakes were also below recommended levels; the cohort mean intakes 114 µg for folate and 2 µg for vitamin B_{12} served as cut-off values, revealing that 66% and 69% of participants, respectively, had intakes below these thresholds. Physical-fitness testing classified 90% of students as having low fitness levels, with the remaining 10% demonstrating adequate fitness.

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Table 1. Characteristics of respondents

Characteristics	Anaemia		Non-anaemia	
	n	%	n	%
Body Mass Index (BMI)				
Underweight	24	21	31	3
Normal	7	6	16	14
Overweight	9	8	15	13
Obesity	4	3	7	6
MUAC				
CED (MUAC <23.5 cm)	16	14	24	21
Non CED (MUAC ≥23.5 cm)	28	25	45	40
Energy Intake				
Less than RDA	28	25	67	59
According to RDA	16	14	2	2
Fe Intake				
Less than RDA	39	35	55	49
According to RDA	5	4	14	12
Folate Intake				
Less than mean (<114 μg)	30	27	39	35
More than Mean (≥114 μg)	14	12	30	27
Vitamin B12 Intake				
Less than mean (<2.09 μg)	75	66	45	40
Equal or more than mean (≥2.09 μg)	38	34	24	21
Vitamin C				
Less than RDA (<75 mg)	39	35	54	48
Equal or more than RDA (≥75 mg)	5	4	14	12
Physical Fitness				
Poor (scored <65)	22	19	62	55
Good (scored ≥65)	22	19	7	6
Total	44	39	69	41

BMI=Body Mass Index, MUAC=Middle Upper Arm Circumference, CED=Chronic Energy Deficiency, RDA=Recommended Daily Allowance.

Dietary intake, anthropometric measures, and physical-fitness scores were compared between anaemic and non-anaemic participants (**Table 2**). No statistically significant differences were observed in energy or micronutrient intakes or body composition indices. Although non-anaemic students recorded higher mean intakes of energy, iron, folate, vitamin B_{12}, and vitamin C than their anaemic counterparts, none of these gaps reached significance. The only variable showing a significant difference was the physical-fitness score, with non-anaemic participants achieving a mean of 51.4±2.5 compared with 43.7±2.1 in the anaemic cohort.

Table 2. Mean (SE) values of dietary intakes, anthropometric profiles, and physical fitness score according to anaemia status

Categories	M (SD)		p-value
	Anaemia	Non-Anaemia	
Dietary Intakes			
Energy (Kcal)	1,452 (65)	1,532 (42)	0.30
Fe (mg)	6.5 (0.5)	7.4 (0.3)	0.40
Folate (μg)	106.1 (11)	119.6 (6.3)	0.10
B12 (μg)	1.9 (1.2)	2.2 (1.9)	0.30
Vitamin C (mg)	34.1 (6.6)	44.34 (5.2)	0.10
Anthropometric Measurement and Fitness Score			
MUAC (cm)	25.4 (1.8)	24.4 (0.4)	0.40
BMI (kg/m^2)	21 (0.6)	21.5 (0.4)	0.50
Body fatness (%)	29.1 (0.7)	29.7 (0.5)	0.50
Fitness score	43.7 (2.1)	51.4 (2.5)	0.03

M=Mean, SE=Standard Error, MUAC=Middle Upper Arm Circumference, BMI=Body Mass Index, kcal=kilocalories. All p-values were obtained from a student's independent t-test.

Analysis of dietary intake (**Table 2**) revealed an 80 kcal/day difference in energy consumption between groups: non-anaemic participants averaged 1,532 kcal/day, whereas those with anaemia consumed 1,452 kcal/day. Disparities in micronutrient intakes were even more pronounced, ranging from 13% to 30%. Mean iron intake among non-anaemic women was 7.4 mg/day compared with 6.5 mg/day in the anaemic cohort. Folate intake averaged 119.6 μg/day versus 106.9 μg/day, and vitamin B_{12} intake was 2.2 μg/day against 1.9 μg/day. Vitamin C consumption exhibited the largest relative gap, with non-anaemic students consuming 44.3 mg/day,

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approximately 30% more than the 34.1 mg/day recorded for those with anaemia. Anthropometric measures were similar across groups, including middle upper arm circumference (MUAC), body mass index (BMI), and body-fat percentage. Mean MUAC values were 24.4 cm for non-anaemic and 25.4 cm for anaemic participants, while both cohorts displayed a mean BMI of 21 kg/m² and a mean body-fat percentage of 29%.

Individual Dietary Diversity Scores (IDDS) and mean intakes across the ten FAO/UN food groups were calculated (**Table 3**). Mean IDDS values were comparable, 5.9 among non-anaemic participants and 5.5 among those with anaemia, and no significant differences emerged for any food-group intake. Dairy consumption averaged 32.9±5.9 g/day in the non-anaemic cohort and 52.5±10.7 g/day in the anaemic cohort; however, the difference did not reach statistical significance (p-value=0.09).

Table 3. Mean (SD) food groups consumption (in grams) and dietary diversity score (DDS) among anaemic and non-anaemic respondents

Parameters	Mean (SD)		p-value
	Anaemia	Non-Anaemia	
Grain, Roots, and Tubers	189.6 (8.5)	196.9 (9.6)	0.57
Dark Green Leafy Vegetables	14.8 (3.1)	17.7 (2.8)	0.53
Other Vitamin A Rich Vegetable and Fruit	35.4 (9.7)	41.1 (7.7)	0.65
Other Fruits	21.1 (6.5)	31.1 (6.8)	0.33
Other Vegetables	26.8 (5.1)	27.9 (3.8)	0.86
Meat, Poultry, and Fish	78.9 (6.5)	75.8 (4.6)	0.69
Legume and Pulses	49.2 (7.9)	44.8 (5.1)	0.95
Nut and Seed	2.9 (1.3)	3.1 (1.6)	0.92
Eggs	31.5 (3.7)	31.2 (2.9)	0.96
Dairy	52.5 (10.7)	32.9 (5.9)	0.09
Dietary Diversity Score (DDS)	5.5 (0.3)	5.9 (0.2)	0.21

SD=Standard Deviation, DDS=Dietary Diversity Score. All analysis is derived from an independent t-test.

Unadjusted and adjusted odds ratios (ORs and AORs) were calculated to evaluate differences in dietary intake, anthropometric measures and fitness scores between anaemic and non-anaemic groups (**Table 4**). The unadjusted analysis indicated that omitting dark-green leafy vegetables doubled the odds of anaemia (OR=2.1). At the same time, a folate intake of at least 114 µg/day was linked to an 80% lower risk (OR=0.2). After controlling for other covariates, neither association remained significant (AOR=0.9, p-value=0.8). Dairy consumption appeared to reduce anaemia risk (AOR =0.5), though this did not reach statistical significance (p-value=0.09).

Table 4. Logistic regression of parameters and anaemia status

Parameters	OR (95% CI)			
	Unadjusted	p-value	Adjusted[¥]	p-value
Dark Green Leafy Vegetables				
Yes	1.0	0.09*	1.0	0.22
No	2.1 (0.8-5.0)		0.6 (0.2-1.4)	
Vitamin A Rich Vegetable and Fruit				
Yes	1.0	0.41	-	-
No	1.4 (0.6-3.2)			
Other Fruit				
Yes	1.0	0.15	1.0	0.18
No	1.9 (0.8-4.5)		0.5 (0.2-1.3)	
Other Vegetables				
Yes	1.0	0.67	-	-
No	1.2 (0.5-2.7)			
Meat, Poultry, and Fish				
Yes	1.0	0.68	-	-
No	1.8 (0.1-2.9)			
Legume and Pulses				
Yes	1.0	0.66	-	-
No	1.2 (0.5-2.9)			
Nut and Seed				
Yes	1.0	0.89	-	-
No	1.1 (0.2-6.5)			
Eggs				
Yes	1.0	0.85	-	-

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Parameters	OR (95% CI)			
	Unadjusted	p-value	Adjusted¥	p-value
No	1.1 (0.4-2.9)			
Dairy				
Yes	1.0	0.10	1.0	0.09
No	0.5 (0.2-1.2)		0.5 (0.6-11.2)	
Dietary Diversity Score (DDS)				
<5 groups	1.0	0.39	-	-
≥5 groups	1.5 (0.6-3.9)			
BMI				
Not OW/OB	1.0	0.73		
OW/OB	1.2 (0.5-2.9)			
MUAC				
<23.5 cm	1.0	0.61	-	-
≥23.5 cm	0.8 (0.4-1.8)			
Fe Intake				
Less than RDA (<18 mg/d)	1.0	0.45	-	-
Not less than RDA (≥18 mg/d)	0.6 (0.6-0.7)			
Folate Intake				
Less than mean (<114 mcg/d)	1.0	0.02	1.0	0.8
Not less than mean (≥114 mcg/d)	0.2 (0.1-0.8)		0.9 (0.3-2.3)	
Vitamin B12 Intake				
Less than RDA (<4 mg/d)	1.0	0.22	1.0	0.2
Not less than RDA (≥4 mg/d)	0.4 (0.1-1.7)		0.4 (0.9-1.6)	
Vitamin C Intake				
Less than RDA (<4 mg/d)	1.0	0.43	-	-
Not less than RDA (≥4 mg/d)	0.7 (0.2-1.8)			
Fitness Score				
Poor (<65 mg/d)	1.0	0.53	-	-
Fit (≥65 mg/d)	0.6 (0.2-2.6)			

*p-value was obtained from Fisher's Exact Test. ¥OR is adjusted for dark green leafy vegetables, other fruit, dairy, and folate intakes. RDA=Recommended Daily Allowance, OR=Odds Ratio, CI=Confidence Interval, OW=Overweight, OB=Obese, BMI=Body Mass Index, MUAC=Middle Upper Arm Circumference, DDS=Dietary Diversity Score.

Figure 1 presents the proportion of students consuming at least 15 g/day from each of the ten FAO-UN food groups, alongside those achieving a Dietary Diversity Score above 5. A higher percentage of non-anaemic participants included dark-green leafy vegetables, vitamin A-rich fruits and vegetables, and other fruits in their diets than the anaemic group. Nuts and seeds were the least consumed in both groups, with only 5-6% of students reporting intake.

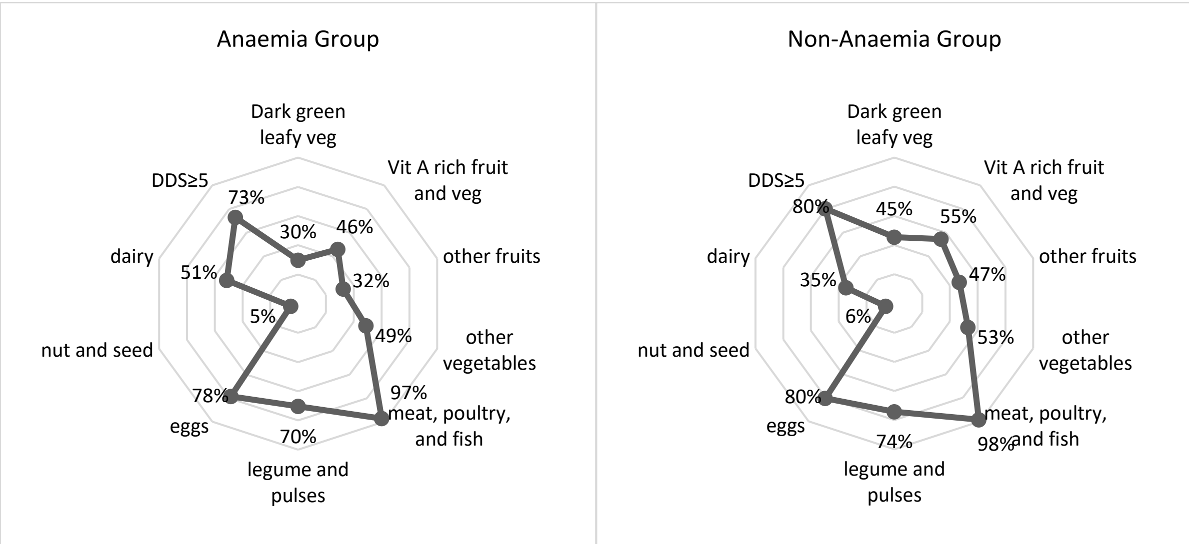

Figure 1. Proportion (%) of the respondents who are non-anaemic (left side) and anaemic (right side) consuming dark green leafy vegetables, vitamin A rich fruit and vegetables, other fruits, other vegetables, meat, poultry, and fish, legume and pulses, eggs, nut and seed, dairy, and whose Dietary Diversity Score (DDS) ≥5.

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The present study investigated the prevalence of anaemia among female undergraduates in the Nutrition programme at Universitas Negeri Surabaya. It explored its associations with dietary habits, anthropometric indices and physical activity levels. Results showed that 39% of participants were anaemic, indicating a considerable burden of haemoglobin deficiency in this cohort. Dietary intake patterns also appeared to influence anaemia status, suggesting that nutritional factors may be pivotal.

Young adult women are particularly vulnerable to undernutrition and micronutrient deficiencies[14]. Reflecting this susceptibility, our sample exhibited a 39% anaemia rate and a 49% underweight prevalence. The observed anaemia rate closely matches the national estimate for Indonesia (37.1% in 2013)[15]. According to the World Health Organization's 2024 global anaemia report, 29.9% of non-pregnant women aged 15-49 years were anaemic in 2019[1], a figure slightly below that recorded here. Moreover, the 49% underweight prevalence in our cohort exceeds rates reported for similar age groups (approximately 10-12%)[16-18].

The study cohort comprised female undergraduates enrolled in the Nutrition programme at Universitas Negeri Surabaya, which falls under the health-sciences cluster. Prior research reports elevated anaemia rates among students in health-related fields: 88% (n=158) of women aged 18-25 years at a Saudi Arabian medical university were anaemic[19]; in Pakistan, 39.8% (n=221) of female medical undergraduates exhibited anaemia[2]; and in India, 43% of medical students aged 18-25 years (n=149) were affected[3]. The World Health Organization classifies anaemia prevalence as 5-19.9% as a mild public health problem, 20-39.9% as moderate, and 40% or above as severe[20]. With a 39% rate in our cohort, anaemia constitutes a moderate public-health concern that demands multi-sectoral attention.

Our findings identify dietary habits and physical fitness as key determinants of anaemia among adolescent females. Physically, non-anaemic participants achieved significantly higher fitness scores (51.4±2.5) than their anaemic peers (43.7±2.1; p-value<0.05), confirming a robust association between fitness and haemoglobin status. This observation concurs with Risma et al. (2024) in Banggai, Indonesia, who reported a positive correlation between haemoglobin concentration and fitness level (r=0.28, p-value<0.01)[22]. Anaemia impairs the oxygen-transport capacity of haemoglobin to skeletal muscle, reducing exercise performance and often provoking fatigue in young women[23]. Sedentary lifestyles, academic time pressures, low exercise motivation and fear of injury have all been implicated in the low fitness levels observed among female health-science students[24-27].

Further analysis indicates that higher folate intake may protect adolescent females against anaemia. Mean folate consumption in the cohort was just 114 µg/day, fulfilling only 28% of the Indonesian RDA (400 µg/day) for this age group. Such inadequacy mirrors reports from other developing settings, including Myanmar and Indonesia[28]. To address this shortfall, weekly supplementation with 400 µg folate and 60 mg iron is recommended, alongside promoting dietary sources rich in folate, legumes, nuts, seeds, dark-green leafy vegetables and fruits[29].

Mean daily iron intakes did not differ significantly between anaemic and non-anaemic students, yet both groups fell well below the Indonesian RDA of 18 mg/day. The shortfall appears to result from insufficient consumption of iron-rich animal products, notably meat, poultry and fish. When organ meats were excluded, non-anaemic participants averaged 82 g/day of muscle meat and fish, compared with 60.9 g/day in the anaemic cohort (*data not shown*). These values closely mirror those reported by Agustina et al. (2020) among West Java adolescents, 75.7 g/day for non-anaemic and 68.2 g/day for anaemic individuals. Although Australian dietary guidelines recommend 65 g/day of lean meat for adults[30], total meat intake became comparable once organ meats and poultry were included in the calculation.

Dark-green leafy vegetables supply non-haem iron and folate. For example, fresh spinach contains approximately 15 mg of iron per 100 g[31]; however, non-haem iron from these plant sources is poorly absorbed. Phytates, dietary fibre and polyphenols inhibit intestinal uptake[32], resulting in a bioavailability of only 7-9% from leafy greens and 2% from legumes. In regions reliant on plant-based diets, under 10% of non-haem iron intake is actually absorbed[33].

Ascorbic acid (vitamin C) enhances non-haem iron absorption by reducing ferric iron (Fe^{3+}) to the more soluble ferrous form (Fe^{2+})[33]. In this study, non-anaemic students recorded higher vitamin C intakes than their anaemic peers. However, the relative timing of vitamin C and iron consumption, which is crucial for optimal absorption, was not documented. Experimental trials have demonstrated that increasing vitamin C intake through fruits such as beetroot, dragon fruit and strawberries can raise haemoglobin concentrations in adolescent girls[34,35].

Key strengths of the present investigation include the integration of diet-quality metrics into the analytical framework, enabling a nuanced appraisal of nutritional determinants of anaemia among female undergraduates. The homogeneity of participants' anthropometric profiles allowed us to isolate the influence of dietary factors on anaemia status, with BMI and obesity effectively ruled out as confounders[36]. Moreover, implementing a three-day food record spanning both weekdays and a weekend day enhanced the accuracy of habitual dietary assessment.

Nevertheless, several limitations must be acknowledged. The cross-sectional design precludes any inference of causality between dietary patterns, physical fitness and anaemia status. Restricting the sample to female students at Universitas Negeri Surabaya may limit the generalisability of our findings to other cohorts, including male students. Finally, applying mean nutrient intakes as the threshold for adequacy, rather than established Recommended Dietary Allowances for folate and vitamin B_{12}, could affect the interpretation of dietary sufficiency.

CONCLUSIONS

The present study demonstrates that anaemia remains a significant public-health concern among female undergraduates in the Nutrition programme at Universitas Negeri Surabaya, with a 39% prevalence corresponding to a moderate public-health classification by WHO standards. Despite their health-science training, participants showed suboptimal dietary quality specifically inadequate folate, iron and vitamin C intakes and low physical-fitness levels. While dietary intake and anthropometric indices did not differ significantly between anaemic and non-anaemic students, clear gaps in nutrient consumption were evident, and fitness scores were significantly lower among those with anaemia. These results underline the need for targeted health-promotion initiatives emphasising dietary diversity, increased iron- and folate-rich foods intake, and regular physical activity. Educational interventions tailored to female students in nutrition and allied health fields are crucial to improving nutritional status and reducing anaemia risk.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

LAS: conceived and designed the study, analysed and interpreted the data, drafted the manuscript and oversaw revisions; NRM and NAS: contributed to the study design and conducted data collection. All authors reviewed and approved the final version of the manuscript.

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