Food Insecurity, Energy Adequacy, and Direction-Specific Malnutrition Among University Students: A Cross-Sectional Study

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Abstract.
Food insecurity may influence nutritional status through pathways that are not fully captured by short-term energy intake, and associations may differ between underweight and excess weight. This cross-sectional study examined 99 Biology students at Universitas Negeri Makassar. Food insecurity was assessed using an adapted 10-item U.S. Adult Food Security Survey Module, dietary intake using one 24-hour food recall, and nutritional status using measured body mass index. Spearman correlation, Kruskal-Wallis tests, direction-specific logistic regression, and multinomial logistic regression as a sensitivity analysis were performed. Overall, 55.6% of students were food insecure, 81.8% had energy intake below 100% of the recommended allowance on the recall day, and 33.3% were underweight. Food insecurity score was not significantly correlated with energy intake, energy adequacy, or BMI. In the binary model comparing underweight with normal BMI, each one-point increase in food insecurity score was associated with 23% higher odds of underweight after adjustment for energy adequacy and sex (aOR=1.23; 95% CI 1.01-1.50; p=0.036). The multinomial estimate for underweight versus normal was similar but borderline significant (RRR=1.19; 95% CI 1.00-1.43; p=0.056). These direction-specific findings should be interpreted as exploratory and warrant confirmation in larger and more diverse samples.

Keywords: *Food Insecurity; Energy Adequacy; Underweight; Nutritional Status and University Students.*

I. INTRODUCTION

Food security refers to reliable access to sufficient, safe, and nutritious food for an active and healthy life. Recent global evidence shows that food-price inflation and pressures on household purchasing power continue to threaten access to healthy diets, particularly among economically vulnerable groups [1]. University students may be especially susceptible because the transition to greater independence often coincides with limited financial resources, competing academic expenses, and responsibility for managing daily food provision. A 2025 systematic review and meta-analysis reported a pooled food-insecurity prevalence above 40% among post-secondary students in high-income settings, although substantial heterogeneity was present across studies [2].

Food insecurity is also increasingly documented in Indonesian higher education. Khusun et al. reported that only 32.5% of Indonesian university students were food secure, while 46.1% experienced low food security and 21.4% very low food security [3]. A multicentre study of Indonesian undergraduates likewise identified food-affordability concerns alongside other health and wellbeing risks [4]. These findings indicate that food access is not only a household issue but also an important student-welfare and public-health concern.

The nutritional consequences of food insecurity are not necessarily expressed as a simple reduction in total energy intake. Students may reduce meal frequency or portion size, but they may also substitute less expensive, energy-dense foods for more nutrient-dense foods. Recent research among university students has linked food insecurity with lower fruit and vegetable consumption and broader diet-quality concerns [5,6]. Consequently, food insecurity and energy intake represent related but non-equivalent dimensions of nutritional vulnerability.

Associations between food insecurity and body weight may also differ by the direction of malnutrition. Recent studies have reported associations between food insecurity and higher BMI or obesity in some university populations [7,8], while student populations in low- and middle-income settings may simultaneously experience substantial underweight. In the same academic setting as the present study, dietary patterns and physical activity have previously been associated with nutritional status among students

[9]. However, evidence on whether food insecurity is differently associated with underweight and overweight/obesity remains limited in Indonesian university students. This study therefore aimed to describe food insecurity, energy intake and energy adequacy, and nutritional status; examine their associations; and evaluate food insecurity separately in relation to underweight and overweight/obesity.

II. METHODS

Study Design, Setting, and Participants

This analytical observational study used a cross-sectional design and was conducted from April to July 2026 among active students in the Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar. Participants were recruited purposively from students who agreed to complete the data-collection procedures. A total of 101 students provided initial data; two were excluded because their 24-hour food-recall records were insufficient for estimating energy intake. The final analytical sample comprised 99 students.

Food Insecurity Assessment

Food insecurity was assessed using an adapted 10-item U.S. Adult Food Security Survey Module with a 12-month reference period. Affirmative responses were summed to produce a score from 0 to 10, with higher scores indicating more severe food insecurity. Following the USDA scoring framework, scores were classified as high food security (0), marginal food security (1-2), low food security (3-5), and very low food security (6-10) [10]. For descriptive binary classification, high and marginal food security were grouped as food secure, whereas low and very low food security were grouped as food insecure. The continuous food-insecurity score was retained for association analyses to preserve severity information.

Dietary Intake and Energy Adequacy

Dietary intake was collected using a single 24-hour food recall covering foods and beverages consumed by eating occasion, household portion size, and estimated gram weight. Reported portion sizes were checked for internal consistency. When gram weights were inconsistent with food type or household measures, estimates prioritized household measures and the Indonesian Food Photograph Book [11]. Energy content was calculated using the Indonesian Food Composition Table [12].

Energy adequacy was calculated as energy intake on the recall day divided by the sex- and age-specific recommended energy allowance and multiplied by 100. For participants aged 19-29 years, the Indonesian recommended energy allowances were 2,650 kcal/day for men and 2,250 kcal/day for women [13]. For descriptive presentation, energy adequacy was grouped into <70%, 70-<100%, and >=100%. A single 24-hour recall cannot precisely estimate an individual's habitual or long-term daily energy intake because of day-to-day variation [14]. In this study, the recall was therefore used to characterize intake on the measurement day and to support exploratory assessment of contemporaneous associations with food insecurity and nutritional status, rather than to estimate usual intake. Accordingly, the energy-adequacy categories were interpreted as recall-day intake rather than habitual adequacy.

Anthropometric Assessment

Body weight and height were measured directly by the research team using a digital scale and microtoise. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. Participants were classified as underweight (BMI <18.5 kg/m2), normal weight (18.5-24.9 kg/m2), overweight (25.0-29.9 kg/m2), or obese (>=30.0 kg/m2). Overweight and obesity were combined for direction-specific analysis because of the small number of participants in the two categories.

Statistical Analysis

Categorical variables are presented as frequencies and percentages, while numerical variables are summarized using mean and standard deviation and/or median and interquartile range as appropriate. Spearman correlation was used to assess associations among food-insecurity score, energy intake, energy adequacy, and BMI. Kruskal-Wallis tests compared food-insecurity score and energy adequacy across underweight, normal-weight, and overweight/obesity groups.

Direction-specific binary logistic regression compared underweight with normal weight and overweight/obesity with normal weight. Thus, participants in the opposite malnutrition category were not

included in each binary comparison. The underweight model was adjusted for energy adequacy and sex. Because the overweight/obesity group contained only 14 cases, the corresponding food-insecurity estimate is reported as an unadjusted association. Multinomial logistic regression with normal BMI as the reference category was used as a sensitivity analysis. Effect estimates are reported as odds ratios (OR), adjusted odds ratios (aOR), or relative risk ratios (RRR) with 95% confidence intervals (CI). Statistical significance was defined as $p<0.05$.

III. RESULT AND DISCUSSION

Participant Characteristics, Food Insecurity, Energy Intake, and Nutritional Status

Table 1. Participant characteristics, food insecurity, energy intake, and nutritional status

Indicator	n (%) / Value
Sex	
Female	86 (86.9)
Male	13 (13.1)
Semester	
Semester 4	25 (25.3)
Semester 6	74 (74.7)
Age, mean +/- SD (years)*	20.41 +/- 0.76
Food security status	
High food security	12 (12.1)
Marginal food security	32 (32.3)
Low food security	35 (35.4)
Very low food security	20 (20.2)
Food insecure (low + very low)	55 (55.6)
Food-insecurity score, mean +/- SD	3.38 +/- 2.52
Energy intake, mean +/- SD (kcal/day)	1,591.8 +/- 652.2
Energy adequacy, mean +/- SD (%)	69.14 +/- 28.13
Energy adequacy on recall day	
<70%	52 (52.5)
70-<100%	29 (29.3)
>=100%	18 (18.2)
Nutritional status	
Underweight	33 (33.3)
Normal	52 (52.5)
Overweight	6 (6.1)
Obesity	8 (8.1)

Source: primary study data.

The final analysis included 99 students; 86.9% were women and 74.7% were in semester 6. More than half (55.6%) were food insecure, and one third (33.3%) were underweight. Mean energy intake on the recall day was 1,591.8 kcal, corresponding to 69.14% of the recommended allowance; 81.8% consumed less than 100% of the recommended energy allowance on that day. The food-insecurity prevalence observed here is broadly consistent with the high burden reported in contemporary university populations. A recent meta-analysis estimated food insecurity in approximately two fifths of post-secondary students in high-income countries [2], while an Indonesian national student study reported 67.5% in low or very low food-security categories [3]. Differences in prevalence should be interpreted cautiously because sampling frames and food-security modules differ across studies.

The high proportion of underweight in this sample also suggests that student nutrition problems cannot be framed solely in terms of excess weight. Indonesian university-health research has documented multiple coexisting nutrition and lifestyle risks in young adults [4,9]. The present distribution therefore supports examining opposite directions of malnutrition separately rather than combining all non-normal BMI categories into a single outcome.

Correlations among Food Insecurity, Energy Intake, Energy Adequacy, and BMI

Table 2. Spearman correlations among food insecurity, energy intake, energy adequacy, and BMI

Variable pair	Spearman rho	p-value
Food-insecurity score - BMI	-0.170	0.093
Food-insecurity score - energy intake	0.065	0.523
Food-insecurity score - energy adequacy	0.062	0.544
Energy intake - BMI	0.005	0.965
Energy adequacy - BMI	-0.036	0.723

Food-insecurity score showed a weak negative correlation with BMI (rho=-0.170), but the association did not reach statistical significance (p=0.093). Food insecurity was not significantly correlated with energy intake or energy adequacy, and neither energy measure was significantly correlated with BMI. These findings indicate that the relationship between food access, short-term energy intake, and body size is not well represented by a simple linear pathway.

Recent student research similarly suggests that food insecurity is often more consistently reflected in food choice and diet quality than in a uniform change in total energy intake. Dharmayani et al. found that food insecurity was associated with lower fruit consumption and perceived constraints in food access and affordability [5], while methodological reviews emphasize that food insecurity is multidimensional and that health outcomes are measured heterogeneously across student studies [6,15]. The absence of an association between recall-day energy intake and BMI is also plausible because BMI reflects longer-term energy balance, whereas a single 24-hour recall captures only short-term intake and is sensitive to within-person day-to-day variation. Contemporary dietary-assessment guidance therefore cautions against interpreting one short-term recall as an individual's usual intake [14]. For the present exploratory analysis, the recall is most appropriately interpreted as a snapshot of intake on the measurement day, useful for examining whether short-term energy intake accompanied the observed food-insecurity and BMI patterns but not for drawing conclusions about habitual energy adequacy.

Food Insecurity and Energy Adequacy by Direction of Nutritional Status

Table 3. Food-insecurity score and energy adequacy by nutritional-status direction

Variable	Underweight (n=33)	Normal (n=52)	Overweight/obesity (n=14)	p-value
Food-insecurity score, median (IQR)	4.0 (2.0-5.0)	3.0 (1.0-4.0)	2.0 (1.0-5.75)	0.126
Energy adequacy, median (IQR), %	71.77 (51.02-87.60)	65.66 (47.60-92.60)	57.90 (38.02-75.08)	0.486

p-values are from Kruskal-Wallis tests. Source: primary study data.

Median food-insecurity score was highest in the underweight group, although the overall between-group difference was not statistically significant. Energy adequacy also did not differ significantly across BMI groups. These descriptive patterns were therefore followed by direction-specific regression to test whether severity of food insecurity was associated with underweight or overweight/obesity when each was compared with normal BMI.

Direction-Specific Regression Analysis

Table 4. Direction-specific regression analysis

Predictor/outcome	Effect estimate	95% CI	p-value
FI score -> underweight, crude OR per 1 point	1.21	1.00-1.47	0.048
FI score -> underweight, adjusted OR per 1 point*	1.23	1.01-1.50	0.036
Energy adequacy -> underweight, adjusted OR per +10%*	0.99	0.84-1.16	0.869
FI score -> overweight/obesity, crude OR per 1 point	1.09	0.87-1.37	0.460
Multinomial: FI -> underweight vs normal, RRR	1.19	1.00-1.43	0.056
Multinomial: FI -> overweight/obesity	1.12	0.88-1.44	0.356

vs normal, RRR	

**Adjusted for energy adequacy and sex. FI: food insecurity; OR: odds ratio; RRR: relative risk ratio; CI: confidence interval. Source: primary study data.*

In the binary comparison of underweight versus normal BMI, each one-point increase in food-insecurity score was associated with higher odds of underweight (crude OR=1.21; 95% CI 1.00-1.47; p=0.048). After adjustment for energy adequacy and sex, the association remained statistically significant (aOR=1.23; 95% CI 1.01-1.50; p=0.036). Energy adequacy itself was not associated with underweight. Food-insecurity score was not significantly associated with overweight/obesity in the crude binary model.

The multinomial sensitivity analysis produced a similar direction of association for underweight versus normal BMI (RRR=1.19), but the 95% CI included the null at the conventional threshold and the p-value was 0.056. No significant association was observed for overweight/obesity versus normal BMI. Taken together, the results suggest a possible direction-specific association rather than a general relationship between food insecurity and all forms of abnormal BMI.

The underweight direction differs from several recent studies in which food insecurity was associated with higher BMI or obesity [7,8]. This contrast is plausible because the nutritional expression of food insecurity depends on food prices, food environments, socioeconomic resources, coping strategies, and the severity of access constraints. The present sample also contained a high proportion of underweight students, creating a different nutritional context from populations in which overweight predominates. The finding should therefore not be interpreted as evidence that food insecurity universally leads to underweight.

Interpretation requires particular caution because the adjusted binary association was modest and the multinomial sensitivity estimate was only borderline significant. In addition, the overweight/obesity group included only 14 participants, substantially limiting statistical power and the stability and precision of estimates for that outcome. Accordingly, the absence of a statistically significant association in this subgroup should not be interpreted as evidence that no association exists. Recent methodological reviews of college food-insecurity research have similarly emphasized heterogeneity in measurement, sampling, and analytical approaches [15]. These direction-specific findings are therefore best considered exploratory and require confirmation in larger, multisite samples.

Strengths, Limitations, and Implications

A strength of this study is the integration of an experience-based food-insecurity measure, quantitative dietary recall, and direct anthropometric measurement, together with analyses that retained the food-insecurity score as a continuous severity measure. The direction-specific approach also avoided treating underweight and overweight/obesity as a homogeneous outcome.

Several limitations should be considered. The cross-sectional design prevents temporal or causal inference. Participants were recruited purposively from one academic department, the sample was relatively small, and women comprised 86.9% of participants. This marked gender imbalance substantially limits generalizability to male university students. It also warrants additional caution when interpreting energy-intake estimates because biological energy requirements differ by sex; although energy adequacy was calculated using sex-specific recommended allowances, the small number of men restricted meaningful sex-stratified assessment. Detailed socioeconomic variables such as living allowance, household income, accommodation, food expenditure, and other indicators of purchasing power were not available for the present analysis. Consequently, residual confounding by economic circumstances remains possible, and the adjusted model cannot be interpreted as fully accounting for socioeconomic differences that may jointly influence food insecurity and nutritional status. The single 24-hour recall should be regarded as a snapshot of intake on the measurement day rather than a measure of habitual intake; within-person day-to-day variation may therefore attenuate associations with BMI and limits inference about longer-term energy adequacy [14]. In addition, although the USDA module provides a structured framework for assessing food insecurity, the adapted version used in this study has not undergone rigorous local psychometric validation specifically among Indonesian university students. Cultural interpretation of items, response thresholds, and severity scoring may therefore have introduced misclassification or imprecision in ranking food-insecurity severity. Future research should include larger multisite samples with better gender balance, repeated dietary recalls,

detailed socioeconomic and expenditure measures, diet-quality indicators, and culturally adapted food-security instruments supported by local validity and reliability testing.

From a campus-health perspective, the coexistence of food insecurity and underweight indicates a need to address both nutrition knowledge and practical access to affordable nutritious foods. At Universitas Negeri Makassar, feasible responses could include subsidized nutrient-dense meal options or targeted meal vouchers in campus canteens, routine nutrition-risk screening and counselling linked to student health services, and focused nutrition-education programs for students identified as being at higher risk of food insecurity. Referral pathways for students with persistent food-access difficulties could also be incorporated into student-welfare support. These actions would extend beyond education alone by combining food-access support with nutrition and health services, consistent with contemporary evidence on institutional responses to student food insecurity [2,16].

IV. CONCLUSION

Food insecurity and underweight were prominent among the university students studied, while energy intake measured on a single recall day was not directly associated with BMI. Higher food-insecurity scores were associated with greater odds of underweight in the adjusted binary model, whereas the multinomial sensitivity analysis showed a similar but borderline association. No statistically significant association was observed with overweight/obesity; however, this null finding should be interpreted cautiously because only 14 participants were in that group. These direction-specific findings should be interpreted as exploratory and warrant confirmation in larger and more diverse student populations. For Universitas Negeri Makassar, practical follow-up could include improving access to affordable nutrient-dense foods through subsidized healthy meal options or targeted meal support, strengthening nutrition screening and counselling within student health services, and providing focused nutrition education and referral for students at higher risk of food insecurity. Such strategies should be evaluated prospectively before wider implementation.

V. ACKNOWLEDGMENTS

This study was conducted as part of the 2026 PNBP FMIPA Universitas Negeri Makassar research program.

REFERENCES

[1] FAO, IFAD, UNICEF, WFP, WHO, The State of Food Security and Nutrition in the World 2025: Addressing high food price inflation for food security and nutrition, Rome, 2025. doi:10.4060/cd6008en.

[2] F.H. McKay, B.R. Olajide, L.J. Melleuish, P. Pitt, E.H.Y. Lau, M. Dunn, Food insecurity among post-secondary students in high income countries: systematic review and meta-analysis, Current Nutrition Reports 14 (2025) 58. doi:10.1007/s13668-025-00651-2.

[3] H. Khusun, I. Arumsari, I. Suraya, F. Badzlina, U. Fitri, Food security status of Indonesian university students and its sociodemographic factors, ***Malaysian Journal of Nutrition*** 32 (Supplement) (2026) 107-118. doi:10.31246/mjn-2025-0046.

[4] F.M. Ekawati, H. Kusnanto, P. Lestari, D. Vidiawati, D.A. Novitasari, I.S. Widyahening, L. Sanci, The health and wellbeing of undergraduate students in Indonesia: descriptive results of a survey in three public universities, Scientific Reports 15 (2025) 11731. doi:10.1038/s41598-025-90527-w.

[5] P.N.A. Dharmayani, M. Williams, C.V.A. Lopes, R. Ronto, J.Y. Chau, S.R. Partridge, S. Mihrshahi, Exploring reasons for high levels of food insecurity and low fruit and vegetable consumption among university students post-COVID-19, Appetite 200 (2024) 107534. doi:10.1016/j.appet.2024.107534.

[6] M.D. Radtke, F.M. Steinberg, R.E. Scherr, Methods for assessing health outcomes associated with food insecurity in the United States college student population: a narrative review, Advances in Nutrition 15 (2024) 100131. doi:10.1016/j.advnut.2023.10.004.

[7] Y.E. Cedillo, T. Kelly, E. Davis, L. Durham, D.L. Smith Jr., R.E. Kennedy, J.R. Fernandez, Evaluation of food security status, psychological well-being, and stress on BMI and diet-related behaviors among a sample of college students, Public Health 224 (2023) 32-40. doi:10.1016/j.puhe.2023.08.015.

[8] L. Garcia-Iruretagoyena, N. Martinez-Perez, L. Colen, M. Baeta, I. Olalde, L.E. Torheim, M. Arroyo-Izaga, Food insecurity, health, and socioeconomic status: results from the University of the Basque Country, Spain, Nutrients 17 (2025) 1314. doi:10.3390/nu17081314.

[9] A.M. Tayieb, A.A.A. Saru, The relationship between dietary patterns and physical activity and nutritional status among students of the Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, South Sulawesi, Indonesia, ***Jurnal Ilmu Gizi dan Dietetik*** 5 (2026) 379-384. doi:10.25182/jigd.2026.5.1.379-384.

[10] U.S. Department of Agriculture Economic Research Service, U.S. Adult Food Security Survey Module: Three-Stage Design, with Screeners, Washington, DC, 2012.

[11] Badan Penelitian dan Pengembangan Kesehatan, Buku Foto Makanan: Survei Konsumsi Makanan Individu 2014, Kementerian Kesehatan Republik Indonesia, Jakarta, 2014.

[12] Kementerian Kesehatan Republik Indonesia, Tabel Komposisi Pangan Indonesia 2017, Direktorat Jenderal Kesehatan Masyarakat, Jakarta, 2017.

[13] Kementerian Kesehatan Republik Indonesia, Peraturan Menteri Kesehatan Republik Indonesia Nomor 28 Tahun 2019 tentang Angka Kecukupan Gizi yang Dianjurkan untuk Masyarakat Indonesia, Jakarta, 2019.

[14] S.I. Kirkpatrick, P.M. Guenther, A.F. Subar, S.M. Krebs-Smith, K.A. Herrick, L.S. Freedman, K.W. Dodd, Using short-term dietary intake data to address research questions related to usual dietary intake among populations and subpopulations: assumptions, statistical techniques, and considerations, ***Journal of the Academy of Nutrition and Dietetics*** 122 (2022) 1246-1262. doi:10.1016/j.jand.2022.03.010.

[15] R. Fiagbor, O.N. Brown, Methods used to assess food insecurity among US college students: a systematic review, ***Journal of American College Health*** 74 (2026) 296-312. doi:10.1080/07448481.2025.2533914.

[16] P.M. Galseku, G.S. Keenan, L. Stevenson, R. Cousins, J. Lingwood, H. Dixon, L. Bourke, The association between food insecurity and academic performance among higher education students: a systematic review, Current Nutrition Reports 15 (2026) 17. doi:10.1007/s13668-026-00744-6.