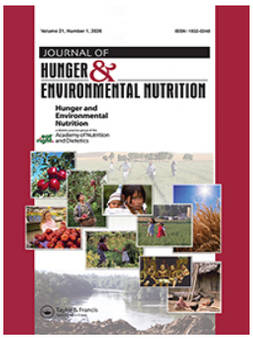

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ORIGINAL RESEARCH

Measuring food insecurity in Türkiye: validation of the four domain food insecurity scale (4D-FIS)

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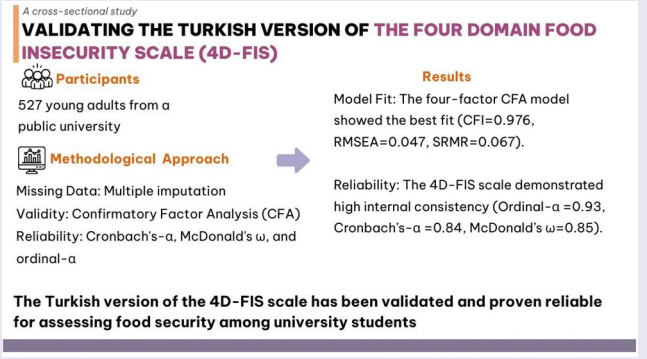
ABSTRACT

The aim was to conduct the Turkish validity and reliability study of the Four-Domain Food Insecurity Scale (4D-FIS). In this cross-sectional study, confirmatory factor analysis (CFA) was used to test the validity of the 4D-FIS scale. The 4D-FIS scale consists of four domains: quantitative, qualitative, psychological, and social. The Cronbach-α of the 4D-FIS scale was 0.84, indicating that the scale was reliable. CFA confirmed the four-factor structure of the 4D-FIS, with fit indices indicating good model fit. The Turkish 4D-FIS scale was found to be valid and reliable for evaluating food security in the quantitative, qualitative, psychological, and social domains.



KEYWORDS
Food insecurity; validity; confirmatory factor analysis

Introduction

According to the Food and Agriculture Organization of the United Nations, food insecurity is defined as the lack of regular access to sufficient, safe, and nutritious food to maintain an active and healthy life.[1] It is characterized by inadequate food consumption, limited food availability, and vulnerability to subsistence strategies that cannot withstand unexpected events.[2] The severity

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of food insecurity is generally classified as mild (marginal), moderate, and severe. Mild or marginal food insecurity reflects occasional concerns about food access and minor compromises in diet quality. Moderate food insecurity involves more frequent reductions in the quantity or quality of food consumed. Severe food insecurity is characterized by skipping meals or going without food for an entire day due to a lack of resources.[3]

Although some efforts are being made to address insufficient nutrition and hunger, food insecurity is still a major concern worldwide.[4,5] According to the 2022 reports of the Food and Agriculture Organization of the United Nations (FAO), the prevalence of moderate food insecurity has remained stable after significantly increasing in 2020.[6] However, severe food insecurity has continued to rise, with approximately 2.3 billion people worldwide facing moderate or severe food insecurity in 2021, or 11.7% of the global population.[7]

In recent years, food insecurity among university students has gained increasing attention. Food insecurity in this population is considered a significant public health issue, as it affects students' dietary quality, mental health, academic performance, and graduation rates.[8,9] Studies conducted among university students in Türkiye have reported food insecurity prevalence rates ranging from 35.5% to 68.2%.[10,11] Accurately identifying the scope and forms of food insecurity experienced by students is of critical importance, particularly given evidence indicating a rapid increase in these rates during the COVID-19 pandemic.[12] In addition to financial constraints specific to university students and rising housing and food costs,[13] broader socioeconomic factors in Türkiye, such as high food inflation, income inequalities, and structural vulnerabilities, further increase the risk of food insecurity among university students.[14–17]

Food insecurity increases the risk of developing a wide range of health problems, including infectious diseases, poor oral health, injuries, depression, anxiety disorders, heart disease, hypertension, arthritis, back problems, and chronic pain.[18,19] Moreover, it has been reported to have negative effects not only on health outcomes but also on various other areas, such as access to health insurance, the availability of healthcare services, emergency department utilization, and financial burden.[20] Therefore, measuring food insecurity is highly important for understanding both its health-related and socio-economic consequences. The estimate of food insecurity has been based on the U.S. Department of Agriculture (USDA) Food Security Survey Module (FSSM) measure since 1995.[21] The purpose of these questions was to monitor changes in the prevalence and severity of food insecurity among U.S. households. For a long time, the prevalence of food insecurity has remained stable, ranging from about 10% to 15%, depending on economic fluctuations.[22] However, it has been argued that the FSSM is inadequate in measuring changes in food insecurity.[23] Maynard et al.[24]

argue that the FSSM is useful in providing standardized data but "may not accurately classify households and may not provide insights into the severity of food insecurity." Food insecurity includes four domains: quantitative (insufficient food), qualitative (insufficient food quality), psychological (uncertainty and anxiety about food), and social (social unacceptability).[21,25,26] However, FSSM does not pay much attention to social or psychological indicators such as deprivation, alienation, and shame.[23,24]

Although the FSSM has been used for years and has yielded comprehensive data, more comprehensive measurement methods are needed. Comprehensive measures of food insecurity are needed to understand how the severity of food insecurity impacts health, especially for vulnerable and marginalized communities at higher risk of food insecurity. Johnson et al. developed and tested a complementary tool, the Four Domain Food Insecurity Scale (4D-FIS), to more comprehensively assess the four domains of food insecurity (quantitative, qualitative, psychological, and social).[23] This study aimed to determine its validity and reliability in Turkish university students. In this context, accurately assessing food insecurity among university students is critically important for understanding its impact on both health and academic outcomes.

Materials and methods

Study population and data collection

The study data were collected from university students who agreed to participate in the study between July and September 2024. The inclusion criteria for the study were being aged 19–29 years, not having a chronic disease, and providing voluntary consent to participate in the study. Those who were pregnant/breastfeeding, those with a chronic disease, and those who did not sign the voluntary consent form were not included in the study. Ethics committee approval was received from Erzincan Binali Yıldırım University Rectorate for the study (No. 050.04-369107). Voluntary consent was obtained from all participants in the study, which was conducted in accordance with the Declaration of Helsinki. In calculating the sample size, Osborne and Costello stated that 5–10 times the number of items should be reached.[27] Therefore, it was aimed to reach at least 160 individuals for the 4D-FIS scale consisting of 16 items. Within the scope of the study, 547 individuals between the ages of 19–29 were reached, but 20 were excluded for various reasons (pregnant or breastfeeding, n = 4; having a chronic disease, n = 7; refusing to provide voluntary consent, n = 5; or with incomplete survey data, n = 4). As a result, 527 individuals meeting the inclusion criteria constituted the sample.

Measures

General information

In the general information section of the questionnaire, participants' characteristics such as sex, age, income, smoking, and alcohol consumption were questioned. To assess income status, participants were asked the question "How would you evaluate your income status?" with response options of low, medium, and high. Participants' body weight was measured using a calibrated scale with 0.1 kg sensitivity, while they wore light clothing and no shoes. Height was measured with a non-stretch measuring tape, with participants standing upright in the Frankfurt plane and ensuring that the head, hips, and heels were in contact with the wall.[28] BMI was calculated using body weight and height measurements (body weight (kg)/height $(m)^2$) and classified according to WHO criteria.[29]

Four-domain food insecurity scale

First, permission for the translation of the 4D-FIS was obtained via e-mail from Johnson et al. who developed the scale.[23] The English version of the 4D-FIS was translated into Turkish. The translation was done using the forward-backward translation method. For the forward translation method, a bilingual translator and a native Turkish bilingual academic translated the scale into Turkish without the knowledge of each other. The two versions were checked and discrepancies were edited collaboratively by the researchers. The scale was then translated back into English by a completely blind bilingual translator. Finally, a three-member expert panel (consisting of academic experts) evaluated both translations for inconsistencies between the two versions and developed a preliminary final version of the scale.

A pilot study was conducted with 10 participants selected from the same university as the main sample to evaluate the scale and test its comprehensibility. Participants completed a survey in which they were asked whether the items were understandable and meaningful, and were invited to provide feedback and suggest any necessary changes.

The 4D-FIS Scale is a Likert-type scale (Cronbach-$\alpha = 0.69–0.91$) consisting of 16 items developed by Johnson et al.[23] The scale consists of four domains: the quantitative domain includes 3 items, the qualitative domain includes 6 items, the psychological domain includes 3 items, and the social domain includes 4 items. Response options for quantitative, qualitative, and psychological items range from 4 categories: "Frequently," "Sometimes," "Rarely," and "Never"; for social items range from 5 categories: "Strongly agree" to "Strongly disagree." These responses were then converted to binary scoring. In calculating the first three subscale scores, the responses given to the items (often, sometimes) are scored as "1" and the others as "0." The scores obtained were added together to create the subscale scores.

Household food security survey module-short form (hfssm-Sf)

To determine the food security of the participants, the Household Food Security Survey Module-Short Form (HFSSM-SF), developed by the USDA, was used.[30] The reliability and validity of the Turkish version of the scale were established by Emiral et al.[31] The scale, consisting of six items, is Likert-type. Positive responses to the statements in the scale items ("yes," "sometimes true" and "mostly true") are worth 1 point. The scores obtained from the scale range between 0 and 6. Based on the total score obtained from the scale, the classification is as follows: a score of 0 indicates high food security, 1 indicates marginal food security, 2–4 indicates low food security and 5–6 indicates very low food security.[30] Food insecurity refers to the total number of households with low and very low food security. High food security indicates that all household members always have access to sufficient food. Marginal food security reflects concerns about having insufficient resources for food. Food insecurity involves a decrease in the quality and variety of food intake (low food security) or a reduction in both the quantity and quality of food consumed (very low food security).[30,31]

Statistical analyses

Missing data analysis showed that missing data in the scale items varied between 2.3% and 11.8%, and Little MCAR test showed that missing data were not completely randomly distributed (χ^2 (1830) = 2338.46, $p < .00$). As no distinct pattern was identified in the missing data, the Multiple Imputation (MI) method was employed to generate five different datasets. In the presence of item nonresponse, MI is widely recommended because it offers greater flexibility than deletion based methods and reduces missing data related bias while improving the accuracy of parameter estimates.[32–34] Continuous scores were calculated in these data sets and then converted into binary categories. All analyses were performed on five data sets and the average value was presented.

Confirmatory Factor Analysis (CFA) was conducted to test the validity of the scale. CFA is a technique that requires an a priori conceptual model and evaluates how well this predefined factor solution fits the data, which makes it particularly suitable to test for validity when the latent structure has already been established in prior research.[35,36] In this context, the four-factor structure in the original scale, the structure in which all items are collected under a single factor, and the second-level CFA were tested to examine whether there is a hierarchical structure between the items. The analyses were performed with Mplus 8.3 software and Weighted Least Squares Mean and Variance Adjusted (WLSMV) was used as the estimation method.[37] In assessing the model-data fit, the Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Standardized Root Mean Square Residual (SRMR) values were examined. An RMSEA value of ≤0.06

indicates a perfect fit, while a value of ≤0.08 signifies a good fit. As CFI values approach 1, the model fit improves; values greater than 0.90 indicate an acceptable fit, while values greater than 0.95 represent a good fit. An SRMR value of ≤0.08 represents a perfect fit, while a value of ≤0.10 indicates an acceptable fit.[38] Given that recommended cutoff values for fit indices are not absolute and may vary depending on model complexity and sample characteristics,[39] the evaluation of model fit also considered additional guidelines presented in the literature.[40] Other analyses were performed with SPSS 26.0 and R 4.4.[41,42]

The internal consistency analyses examined the reliability of 4D-FIS and its subscales, Ordinal alpha, and McDonald's-ω coefficient. While determining the internal consistency of the original scale, Cronbach-α values are also presented in this study to report Cronbach-α values and to ensure comparability with these values. Gadermann et al.[43] stated that the use of Ordinal-α is more appropriate than Cronbach alpha in structures consisting of items scored in ordinal categorical type. Nunnally and Bernstein[44,45] stated that values of 0.70 and above are moderate, values of 0.80 and above are appropriate, and values of 0.90 and above are desired values for internal consistency. Also according to Salvucci et al.[45] internal consistency values below 0.50 are considered as low, values between 0.50 and 0.80 as moderate, and values above 0.80 as highly reliable.

The Pearson correlation coefficient was used to determine the relationships between variables. The statistical significance level was determined as 0.05 in all analyses.

Results

General information about the individuals participating in the study is given in Table 1. 69.6% of the participants were female and the average age was 21.2 ± 2.0 years. Those with normal body weight constituted 67.6% of the sample (average BMI = 22.3 ± 3.6 kg/m2). 44.8% of the individuals participating in the study had low income and 91.1% did not have a chronic disease. The majority of the participants did not smoke (56.0%) and did not consume alcoholic beverages (56.2%). When the food security status was examined, it was determined that 13.1% of the participants had very low, 39.5% low, 22.0% marginal and 25.4% high food security.

Confirmatory factor analysis

The minimum value for item factor loading should be 0.30.[46] Confirmatory factor analyses showed that factor loadings for all items in all models were higher than 0.30. A comparison of the three models was made according to the model fit indices presented in Table 2. Model 1 (CFA), which shows the four-

Table 1. General information about the participants.

Variables	*n* (%) or X ± SD
Age (years)	21.2 ± 2.0
Sex	
Female	367 (69.6)
Male	160 (30.4)
BMI (kg/m^2)	22.3 ± 3.6
Underweight	67 (12.7)
Normal	356 (67.6)
Overweight	84 (15.9)
Obesity	20 (3.8)
Income	
Low	236 (44.8)
Medium	233 (44.2)
High	58 (11.0)
Chronic disease	
Yes	47 (8.9)
No	480 (91.1)
Smoking	
Yes	199 (37.8)
No	295 (56.0)
Give up	33 (6.3)
Alcohol consumption	
Yes	206 (39.1)
No	296 (56.2)
Give up	25 (4.7)
Food security status*	
Very low food security	69 (13.1)
Low food security	208 (39.5)
Marginal food security	116 (22.0)
High food security	134 (25.4)

*The Household Food Security Survey Module-Short Form (HFSSM-SF) was used. BMI = body mass index.

Table 2. Model-data fit indices of the models examined for 4D-FIS.

Model	χ^2	df	CFI	RMSEA	SRMR
CFA (Model 1)	193.77	98	0.976	0.047	0.067
Second Order CFA (Model 2)	212.87	101	0.972	0.046	0.071
Unidimensional (Model 3)	381.42	104	0.930	0.071	0.092

CFA = confirmatory factor analysis; CFI = comparative fit index; RMSEA = rootmean-square error of approximation; SRMR = standardized root mean square residual; df = degrees of freedom; 4D-FIS = Four-Domain Food Insecurity Scale.

factor CFA model, stands out as the model with the best-fit indices. The CFI (0.976) and RMSEA (0.047) values of this model show that the model fits the data very well. In addition, the SRMR value is quite low at 0.067, supporting that the model has a high fit. When the CFI (0.972) and RMSEA (0.046) values of Model 2 (Second Order CFA) are examined, it is seen that this model also provides a very good fit, but it has a lower fit compared to Model 1. The SRMR value is 0.071, slightly higher than Model 1, but still within acceptable limits. Model 3 (Unidimensional) is the model with the lowest fit indices. The χ^2 value is quite high with 381.42 and 104 degrees of freedom, which shows that the model fits the data poorly. In addition, the CFI (0.930), RMSEA (0.071)

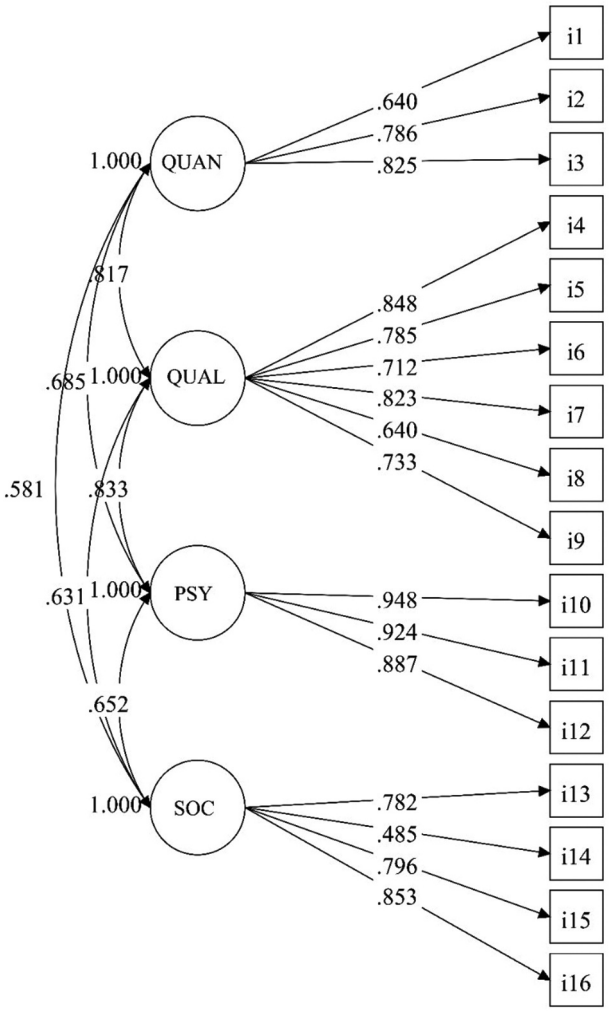

Figure 1. Factor loadings and inter-factor correlations of the CFA model (CFA – model 1). quan = quantitative; qual = qualitative; PSY = psychological; SOC = social.

and SRMR (0.092) values reveal that this model has lower fit indices than the other two models. In general, the analysis results showed that the Model 1 had best model fit indices ($\chi 2$ (98) = 193.77, RMSEA = 0.05, CFI = 0.98, SRMR = 0.07). Figure 1 demonstrates the model-fit indices of the 4D-FIS scale, for Model 1 (CFA). Model 2 (second-order CFA) and Model 3 (unidimensional CFA) are provided as supplementary materials.

Reliability

To determine the reliability of the 4D-FIS scores, internal consistency analysis using Ordinal alpha, Cronbach's alpha, and McDonald's omega coefficients were calculated (Table 3). As a result of the reliability analysis, Ordinal alpha,

Table 3. Reliability coefficient values of 4D-FIS and subscales.

	Number of items	Ordinal-α	McDonald's ω	Cronbach's-α
Quantitative	3	0.79	0.61	0.59
Qualitative	6	0.87	0.74	0.74
Psychological	3	0.94	0.80	0.80
Social	4	0.80	0.66	0.62
4D-FIS	16	0.93	0.85	0.84

4D-FIS = Four-Domain Food Insecurity Scale.

Table 4. Correlations between the 4D-FIS scale, its subscales, HFSSM-SF, BMI, age and sex.

	1	2	3	4	5	6	7	8	9
1.4D-FIS total score	1	0.73*	0.87*	0.71*	0.71*	0.51*	0.05	0.02	−0.08*
2. Quantitative		1	0.54*	0.38*	0.35*	0.37*	0.01	−0.04	−0.01
3. Qualitative			1	0.54*	0.42*	0.43*	0.05	0.03	−0.07
4. Psychological				1	0.38*	0.27*	0.04	0.02	−0.06
5. Social					1	0.38*	0.05	0.03	−0.10*
6. HFSSM-SF						1	−0.02	0.00	−0.05
7. BMI							1	0.10*	−0.13*
8. Age								1	0.05
9. Sex									1

*p < .05, 4D-FIS = Four-Domain Food Insecurity Scale; HFSSM-SF = Household Food Security Survey Module-Short Form; BMI = body mass index.

Cronbach's alpha, and McDonald's ω values of 4D-FIS were found to be 0.93, 0.84, and 0.85, respectively. Ordinal alpha values for 4D-FIS subscales ranged between 0.79 and 0.94, Cronbach's alpha values ranged between 0.59 and 0.80 and McDonald's ω values ranged between 0.61 and 0.80. According to levels of ordinal alpha, 4D-FIS showed adequate internal consistency estimates for all subscales.

4d-Fis and its subscale relationships with hfssm-Sf, BMI, age and sex

Table 4 shows the correlations between the 4D-FIS scale total score and its domains (Quantitative, Qualitative, Psychological, Social), as well as HFSSM-SF, BMI, age, and sex. The 4D-FIS total score showed strong and significant relationships with the quantitative ($r = 0.73$, $p < .05$), qualitative ($r = 0.87$, $p < .05$), psychological ($r = 0.71$, $p < .05$) and social ($r = 0.71$, $p < .05$) domains. In addition, a moderate positive significant correlation ($r = 0.51$, $p < .05$) was found between the 4D-FIS scale total score and the HFSSM-SF scale total score. The correlations between the total 4D-FIS score and BMI ($r = 0.05$, $p > .05$) and age ($r = 0.02$, $p > .05$) were not significant. In addition, a point-biserial correlation showed that females had higher total 4D-FIS scores than males ($r = -0.08$, $p < .05$; sex coded as 0 = male, 1 = female).

Discussion

This study aimed to examine the psychometric properties of the Turkish version of the 4D-FIS scale in university students. This study was the first to

investigate the validity and reliability of the 4D-FIS scale in Türkiye. The results of the study reveal that the Turkish version of the 4D-FIS scale has strong psychometric properties.

Household Food Security Survey Module – Short Form (HFFSM-SF) is a scale used to assess food security at the household level and its Turkish validation was conducted by Emiral et al.[31] The Turkish validity and reliability study of the U.S. Adult Food Security Survey Module (AFSSM) was completed in 2024 to assess food security at the individual level.[47] However, this scale does not assess the psychological or social experiences of food insecurity.[48] In addition to determining food security at the individual level, the 4D-FIS scale has the ability to evaluate food security across four different domains: quantitative, qualitative, psychological, and social. Thus, the 4D-FIS scale provides a more comprehensive assessment of individual food security than HFFSM-SF. With the Covid-19 pandemic, food insecurity has increased significantly in the world and Türkiye. In addition, due to natural disasters such as earthquakes that have occurred in recent years[49] and hosting refugees,[11] a multidimensional assessment of food insecurity in Türkiye has become essential.

In the United States, food insecurity among university students increased from 11% to 15% between 2015 and 2019,[9] and in a study conducted in Australia, it was determined that more than half of the students (54%) experienced food insecurity.[50] In various studies conducted among university students in Türkiye, the prevalence of food insecurity was found to be between 33 and 68.2%.[10,11,51] In this study, 13.1% of the students were found to have very low and 39.5% low food security.

The analysis results showed that the 4D-FIS scale had sufficient internal reliability (Cronbach-α = 0.84, ω = 0.85). The Cronbach-α coefficient in the 4D-FIS scale developed by Johnson et al. was found to be 0.90. Similar results were obtained in other validity and reliability studies.[23] In validity and reliability studies conducted in different countries, the Cronbach-α coefficient was found to be 0.77,[47] .84,[52] and the omega coefficient was 0.72.[53] Although Cronbach-α is a widely used method to assess internal consistency, it may have some limitations when working with ordinal data.

Cronbach-α may misleadingly underestimate reliability values, especially in scales based on ordinal categorical data such as Likert-type scales. Ordinal alpha is a method designed to suit the nature of ordinal data and provides more accurate modeling of the data set. Therefore, ordinal alpha provides a more reliable measure of internal consistency in ordinal data.[43,54] Since the 4D-FIS scale validated in our study is a Likert-type scale, ordinal alpha values were also examined. It was determined that ordinal alpha showed better internal consistency than Cronbach-α in both the overall scale and domains.

In this study, 3 different models were tested for the construct validity of the 4D-FIS scale. It was observed that the four-factor model (Model 1) and the second-order CFA model (Model 2) best reflected the construct validity

of the scale. However, similar to the results of Johnson and colleagues,[23] the four-factor structure was confirmed and the fit indices were found to be well-fitting. It was observed that the fit indices of the single-factor model were lower. In this study, the convergent validity of the 4D-FIS scale was evaluated by examining its correlation with HFFSM-SF, the only scale validated in Turkish for determining food insecurity in our country. Our findings showed that the 4D-FIS scale had a moderately significant positive correlation with HFFSM-SF. Johnson et al.[23] reported that the agreement between the two scales was moderate in the triple and binary categorization comparisons between 4D-FIS and USDA FSSM. HFFSM-SF is an effective tool for measuring the access dimension of food insecurity, particularly the quantitative and qualitative domains, but it does not assess the psychological or social experiences of food insecurity.

In this study, the relationship between HFSSM-SF and the social and psychological scores of the 4D-FIS domains was weaker than that of the other domains. In this context, it can be said that 4D-FIS scale offers a broader perspective in assessing food security compared to HFFSM-SF. Since this scale has not been validated in different countries, the validity results could not be compared.

Many studies have shown that various demographic factors are associated with food insecurity.[55,56] In this study, while age and BMI were not found to be associated with food insecurity (4D-FIS score), it was determined that the 4D-FIS score was higher in female participants. Although some studies reported that food insecurity increases the risk of obesity,[57,58] some studies did not find any association.[10,59] In a meta-analysis by Jung et al, it was determined that female participants were 1.4 times more likely to report food insecurity than male participants.[60] (Jung et al.[60]). On the contrary, some studies reported that the frequency of food insecurity was higher in male participants.[10,55] Esin and Ayyıldız[11] reported that food insecurity was not associated with demographic factors. Inconsistencies across studies may be related to differences in sample characteristics, measurement tools, and cultural norms that influence how individuals experience and report food insecurity. This suggests that sex- and demography-related differences in food insecurity are complex, and highlights the importance of interpreting findings within the socioeconomic and cultural context of the study population.

This study has some limitations. First, the evaluation of all scales is based on self-reporting. Self-reported measures may be affected by recall or social desirability bias. Second, the sample is limited by some demographic characteristics. Although it was aimed to include equal numbers of male and female participants in this study, the majority of the individuals who agreed to participate in the study were female. Third limitation of this study is that the relationship between 4D-FIS scores and BMI was examined only with correlation analysis. Regression models were not employed, which restricts the

evaluation of predictive validity. Additionally, the non-significant relationship may be partly due to the relatively homogeneous BMI distribution in our sample. Future studies should consider applying regression models or other predictive analyses and examine more diverse populations to better assess potential associations. Finally, participation was voluntary within a single university setting, which may limit the representativeness of the broader university student population. It is recommended that the 4D-FIS scale be examined in larger samples, age groups, various disease groups, and different education levels in future studies.

Conclusion

The results of this study showed that the 4D-FIS scale is a valid and reliable tool in Turkish university students. In addition to determining food security at the individual level, this scale has the ability to evaluate it in four different domains: quantitative, qualitative, psychological and social. Therefore, it is considered to be a more comprehensive and effective tool in determining food security. This scale can be used as an effective and reliable measurement tool for the evaluation of food security and related factors in Turkish university students.

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Authorship

Cansu Memiç-İnan and **Büşra Başpınar**: Conceptualization, Methodology, Software, Formal Analysis, Data Curation, Writing – Original Draft, Writing – Review and Editing. **Fatih İmrol**: Methodology, Writing – Original Draft, Writing – Review and Editing.

Data availability statement

Data are available from the corresponding author upon request.

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