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E-healthy diet literacy is associated with psychological well-being and diet-related risk behaviors among university students in Türkiye: a cross-sectional study

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E-healthy diet literacy is the ability to find, understand, appraise, and apply online healthy-eating information. We examined its associations with psychological well-being and diet-related risk behaviors in a cross-sectional convenience sample of 331 undergraduates aged 18–26 years in Ankara, Türkiye; 84.9% were female. Participants completed the e-Healthy Diet Literacy Questionnaire (e-HDLQ), World Health Organization-Five Well-Being Index (WHO-5), and Eating Habits Index (EHI). Associations were modeled using multivariable linear regression and an exploratory covariate-adjusted path analysis with 5,000 bootstrap resamples. After multivariable adjustment, higher e-HDLQ scores were associated with higher WHO-5 scores (unstandardized B = 0.443; standardized β = 0.179; 95% confidence interval [CI] for B, 0.174 to 0.713; $p = 0.001$) and, in a model additionally including WHO-5, with lower EHI scores (B = − 0.123; β = −0.281; 95% CI for B, − 0.171 to − 0.075; $p < 0.001$). A one-standard-deviation higher e-HDLQ score was associated with a WHO-5 score 3.38 percentage points higher and an EHI score 0.94 points lower. The bias-corrected 95% CI for the indirect component through WHO-5 included zero. Associations were modest; the EHI estimate warrants cautious interpretation because internal consistency was low (Cronbach's α = 0.56). Concurrent measurement does not establish temporal ordering or causality.

Keywords e-healthy diet literacy, Psychological well-being, Diet-related risk behaviors, University students, Path analysis

Healthy dietary patterns are important for individual and public health and are associated with overall well-being[1]. Healthy eating behaviors have been linked to individual preferences, family factors, media exposure, and broader social and cultural contexts[2,3]. Nutrition literacy (the ability to obtain, understand, evaluate, and use nutrition information to make informed diet-related decisions) is one potentially modifiable factor associated with healthier food choices and lifestyle behaviors[4,5]. In university and adult populations, higher health and nutrition literacy has been associated with healthier dietary behaviors, more favorable food choices, and better quality-of-life indicators[6–8].

Digital platforms have become a major source of nutrition information because they provide convenient, low-cost access and can reach wide audiences[9]. However, the variable quality of online nutrition information can make it difficult for users to distinguish credible, evidence-based guidance from inaccurate or misleading claims[10,11]. Among Finnish higher education students, self-perceived ability to assess the relevance and usability of online health information was cross-sectionally associated with mental well-being[12]. As health services become increasingly digitalized, users need the skills to engage with online health information[9,13]. In the present study, eHealth literacy refers to the broad construct of engaging with online health information across health domains. E-healthy diet literacy refers to the narrower ability to find, understand, appraise, and apply online information about healthy eating[9]. This diet-specific construct was assessed using the e-Healthy Diet Literacy

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Questionnaire (e-HDLQ). The 15-item Turkish e-HDLQ used in this study includes a subscale termed Digital Healthy Diet Literacy (DDL). Throughout this manuscript, DDL refers to that subscale rather than to the total e-healthy diet literacy construct.

Psychological well-being reflects positive psychological functioning, including positive mood, vitality, and engagement with daily life, and is an integral component of mental health[14]. Dietary patterns have also been linked to mental well-being[15]. Previous cross-sectional studies have reported associations between higher nutrition literacy and better quality-of-life indicators in adults, including physical and mental quality of life among young adults[16,17]. Similarly, higher levels of the broader eHealth literacy construct have been associated with better mental well-being among young adult digital media users[18].

Psychological well-being was examined as a possible intermediate variable because previous cross-sectional evidence has linked the appraisal of online health information with mental well-being[12], and mental well-being may, in turn, be related to dietary behavior[15]. This represents one possible conceptual pathway rather than an established temporal sequence. Psychological well-being could instead be a parallel outcome or could modify the association between e-healthy diet literacy and diet-related risk behaviors. Because the variables were measured concurrently, the present study cannot distinguish among these alternatives, and the path analysis was therefore exploratory.

Recent studies from Türkiye have examined e-healthy diet literacy in adults and university students in relation to nutrition knowledge, sustainable and healthy eating behaviors, and body appreciation and attitudes toward artificial intelligence[19–22]. However, evidence obtained using the 15-item Turkish e-HDLQ in university students remains limited. In particular, the associations of e-healthy diet literacy with psychological well-being and the specific diet-related risk behaviors assessed in the present study have not been characterized within a single covariate-adjusted framework in this population. Accordingly, this study examined the cross-sectional associations of e-healthy diet literacy with psychological well-being, assessed using the World Health Organization-Five Well-Being Index (WHO-5), and diet-related risk behaviors, assessed using the Eating Habits Index (EHI), among undergraduate students in Türkiye. We hypothesized that higher e-HDLQ scores would be associated with higher psychological well-being and less frequent diet-related risk behaviors. An exploratory path analysis was also conducted to estimate the direct association between e-HDLQ and EHI and the model-based indirect association through WHO-5.

Methods

Study design and participants

This cross-sectional study was conducted among undergraduate students at Ankara University in Ankara, Türkiye, and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies[23]. Undergraduate students aged 18 to 26 years were recruited by convenience sampling between May and June 2024.

An a priori sample-size calculation was performed using G*Power version 3.1.9.7 for the larger of the two regression models, in which EHI was the dependent variable and eight predictors were entered[24]. The calculation tested whether the overall coefficient of determination (R^2) differed from zero. Assuming an effect size of $f^2 = 0.05$, an α of 0.05, and 80% power, the minimum required sample size was 310 participants. The final analytical sample comprised 331 participants and exceeded the minimum requirement.

Eligibility criteria

Inclusion criteria were enrollment as an undergraduate student at Ankara University, age between 18 and 26 years, and ability to provide written informed consent. Exclusion criteria were pregnancy or breastfeeding, self-reported regular use of psychiatric medication, and enrollment in a nutrition and dietetics program. All eligibility criteria were assessed by participant self-report at recruitment. Nutrition and dietetics students were excluded because exposure to formal nutrition training could be related to both e-healthy diet literacy and diet-related risk behaviors. Regular use of psychiatric medication was an exclusion criterion because psychiatric conditions and their pharmacological treatment may be associated with appetite, eating behavior, and psychological well-being independently of e-healthy diet literacy. Regular medication use was assessed using a self-reported yes/no item followed by an open-text field in which participants specified the medication. Information on psychiatric diagnosis, medication dose, duration of use, treatment indication, and symptom severity was not collected. Therefore, no specific clinical or pharmacological mechanism was assumed. Criterion-specific exclusion counts were not recorded and therefore could not be reconstructed.

Ethics approval

All procedures were conducted in accordance with the Declaration of Helsinki and were approved by the Ankara University Ethics Committee (Date: 25/04/2024; No: 07/62). Written informed consent was obtained from all participants before data collection.

Data collection process

Participants were recruited in campus common areas and immediately after lectures. Eligible students received written and verbal information about the study and completed the questionnaire in a face-to-face setting. Participation was voluntary, and participants could withdraw at any time. No directly identifying information was collected, and each questionnaire was assigned a numerical code before analysis.

Questionnaires and measures

Sociodemographic information form

Information on age, sex, chronic disease status, exercise frequency, current smoking, alcohol use, the numbers of main meals and snacks consumed per day, and daily water consumption was collected using a structured questionnaire. Water consumption was recorded as the self-reported number of 200-mL glasses consumed per day. Chronic disease status, current smoking, and alcohol use were each assessed using self-reported yes/no items. For regression analyses, exercise frequency was dichotomized as never versus at least once per week because several higher-frequency categories contained few participants. Body mass index (BMI) was calculated from self-reported weight and height. BMI categories were defined according to World Health Organization (WHO) criteria as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obesity (≥ 30.0 kg/m^2)[25,26].

Eating Habits Index (EHI)

Diet-related risk behaviors were assessed using the six-item EHI, which was initially developed by Demirezen[27] and subsequently revised by Demirezen and Coşansu[28]. All six items use a five-point response scale ranging from "never" to "always." Items 1–5 assess unhealthy dietary behaviors and are scored from 0 ("never") to 4 ("always"), whereas Item 6 assesses fruit, vegetable, and legume consumption and is reverse-scored from 4 ("never") to 0 ("always"). The total score ranges from 0 to 24, with higher scores indicating more frequent diet-related risk behaviors. Items 1–5 cover the following behaviors: consuming fatty and sugary foods, adding salt to meals, frequently drinking coffee, tea, or cola, consuming red and processed meats, and eating fast-food items such as hamburgers, pizza, and fried potatoes. In the present study, the EHI was used as a summary score for the specific diet-related risk behaviors represented by its items rather than as a comprehensive measure of overall diet quality. The EHI was selected because a Turkish-language version was available and its brevity made it practical for face-to-face data collection on campus. Although the EHI was originally developed for adolescents and evidence of its construct validity in university students remains limited, the published six-item total score was retained to preserve the original scoring approach. The original study reported a Cronbach's α of 0.68[28]; in the present sample, Cronbach's α was 0.56.

World Health Organization-Five Well-Being Index (WHO-5)

The WHO-5 is a self-administered instrument for assessing subjective psychological well-being[14]. It comprises five positively framed items rated on a six-point Likert scale from 0 ("at no time") to 5 ("all of the time"). The total raw score ranges from 0 to 25, with higher scores indicating a higher perceived level of well-being. The scale contains no reverse-coded items. The total raw score was multiplied by four to convert it into a percentage score, ranging from 0% to 100%. Eser et al.[29] adapted and validated the scale for use in Türkiye and reported a Cronbach's α coefficient of 0.81. In the present sample, Cronbach's α was 0.85.

e-Healthy Diet Literacy Questionnaire (e-HDLQ)

The original e-HDLQ, developed by Van Duong et al.[9], comprised 11 items across four domains: Finding (three items), Understanding (four items), Judging (two items), and Applying (two items). The 15-item Turkish version validated by Onbaşı and Türker[30] additionally includes a four-item DDL subscale, resulting in five subscales in the version used in this study.

The five subscales use different response and scoring formats. In the Finding subscale, responses range from 1 ("never") to 5 ("every day"). In the Understanding subscale, participants select one of three options: "correct," "incorrect," or "don't know." Correct responses are scored 5 points, whereas both "incorrect" and "don't know" responses are scored 1 point. The Judging subscale is rated from 1 ("strongly disagree") to 5 ("strongly agree"), the Applying subscale is rated from 1 ("never") to 5 ("always"), and the DDL subscale is rated from 1 ("very difficult") to 4 ("very easy"). For consistency with the Turkish validation study, the scores for all 15 items were summed to obtain the e-HDLQ total score used in the analyses. The possible total score ranges from 15 to 71, with higher scores indicating greater e-healthy diet literacy. The Turkish validation study reported a Cronbach's α coefficient of 0.77 for the total score[30]. In the present sample, Cronbach's α was 0.65 for the total e-HDLQ score. Cronbach's α was calculated for each subscale. For the two-item Judging and Applying subscales, inter-item correlations and Spearman–Brown coefficients were also calculated.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). IBM SPSS AMOS version 22.0 (IBM Corp., Armonk, NY, USA) was used to conduct path analysis and to estimate direct, indirect, and total effects using bootstrap resampling. Descriptive statistics for continuous variables were reported as mean ± standard deviation (SD), median (first quartile [Q1] to third quartile [Q3]), or both, as appropriate. Categorical variables were reported as frequencies and percentages. Distributional characteristics were evaluated using histograms, quantile–quantile (Q–Q) plots, and summary measures of skewness and kurtosis. For the regression analyses, distributional assumptions were evaluated using model residuals rather than the marginal distributions of the individual variables. Corrected item–total correlations were calculated for the six EHI items, and Cronbach's α was recalculated after omitting the item with the lowest corrected item–

total correlation. An additional sensitivity analysis repeated Model 2 using a five-item EHI score calculated by summing Items 1–5 and omitting the reverse-scored sixth item.

Associations between continuous variables were assessed using Spearman's rank correlation coefficients (ρ). Two-sided p values were reported for the three correlations among the e-HDLQ total score, WHO-5, and EHI. Correlations involving the e-HDLQ subscales were treated as exploratory. Multiple linear regression models were fitted to estimate the adjusted associations of e-HDLQ scores with WHO-5 and EHI scores. Model 1 used WHO-5 as the dependent variable and included the e-HDLQ total score and six covariates selected a priori. Model 2 used EHI as the dependent variable and additionally included WHO-5 as a predictor. The e-HDLQ coefficient in Model 2 therefore represents the conditional association with EHI at a given WHO-5 score, whereas the corresponding model-based total effect from the path model is reported in Table 4. Regression coefficients were reported with 95% confidence intervals (CIs). Age, sex, BMI, smoking, alcohol use, and exercise at least once per week were selected a priori as covariates based on prior empirical studies examining these or closely related factors in relation to e-healthy diet literacy, psychological well-being, or diet-related behaviors[9,12,18,31–33]. Regression assumptions were evaluated using residual and normal probability plots, variance inflation factors (VIFs), tolerance values, and Cook's distance.

An exploratory observed-variable path model was fitted in IBM SPSS AMOS to estimate the direct effect of e-HDLQ on EHI, the indirect effect through WHO-5, and the total effect. The observed-variable path model was saturated (df = 0); therefore, global fit indices could not be used to evaluate model adequacy and were not reported. Indirect effects were assessed via bootstrap resampling (5,000 samples) with bias-corrected 95% confidence intervals (BC CIs). Direct, indirect, and total effects were reported as model-based statistical estimates. The same covariates were modeled as exogenous predictors of both WHO-5 and EHI. Chronic disease status was not included in the main covariate set because the questionnaire did not collect information on diagnosis, duration, severity, or treatment. Its potential role as a confounder was examined in sensitivity analyses by adding chronic disease status to Models 1 and 2 and modeling it as an exogenous predictor of both WHO-5 and EHI in the exploratory path model. Sex was coded as male = 1 and female = 0, and exercise was coded as at least once per week = 1 and never = 0. Smoking and alcohol use were coded as yes = 1 and no = 0. All 331 participants had complete data for the variables included in Models 1 and 2. Both models therefore used the same analytical sample. No missing-data procedure was required. All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant.

Results

The sociodemographic, health, and lifestyle characteristics of the participants are presented in Table 1. A total of 331 university students participated in the study, with a mean age of 20.32 ± 1.51 years. The sample was predominantly female (84.9%). Current smoking and alcohol use were reported by 30.8% and 21.8% of participants, respectively. Exercise at least once per week was reported by 66.5% of participants, whereas 33.5% reported never exercising. A chronic disease was reported by 31 participants (9.4%). On average, participants consumed 2.41 ± 0.57 main meals, 1.73 ± 0.89 snacks, and 7.51 ± 3.59 glasses (200 mL each) of water per day. The mean BMI was 22.07 ± 3.28 kg/m². Overall, 8.5% of participants were classified as underweight, 75.2% as normal weight, 13.9% as overweight, and 2.4% as having obesity.

Descriptive statistics for the e-HDLQ, WHO-5, and EHI are presented in Table 2. The mean ± SD and median (Q1–Q3) were 37.63 ± 7.63 and 37 (33–42) for e-HDLQ, 47.63 ± 18.91 and 48 (36–60) for WHO-5, and 11.24 ± 3.34 and 11 (9–13) for EHI, respectively. Internal consistency varied across the e-HDLQ subscales. Cronbach's α was 0.75 for Finding, 0.34 for Understanding, 0.71 for Judging, 0.68 for Applying, and 0.78 for DDL. Cronbach's α for the EHI was 0.56. Corrected item–total correlations were 0.244 for Item 1, 0.279 for Item 2, 0.372 for Item 3, 0.428 for Item 4, 0.491 for Item 5, and 0.028 for the reverse-scored Item 6. Cronbach's α increased to 0.62 when Item 6 was omitted. The e-HDLQ total score was positively correlated with WHO-5 ($\rho = 0.147$, $p = 0.007$) and inversely correlated with EHI ($\rho = -0.299$, $p < 0.001$) (Fig. 1). WHO-5 was also inversely correlated with EHI ($\rho = -0.162$, $p = 0.003$).

Model 1 and Model 2 each included all 331 participants. In Model 1, higher e-HDLQ scores (B = 0.443, standardized β = 0.179, 95% CI 0.174 to 0.713, $p = 0.001$), male sex (B = 8.454, 95% CI 2.483 to 14.426, $p = 0.006$), and exercise at least once per week (B = 7.665, 95% CI 3.383 to 11.948, $p < 0.001$) were associated with higher WHO-5 scores after multivariable adjustment (Table 3). The model accounted for 11.7% of the variance in WHO-5 scores ($R^2 = 0.117$; adjusted $R^2 = 0.098$; $F(7, 323) = 6.103$, $p < 0.001$). In Model 2, higher e-HDLQ scores were associated with lower EHI scores (B = −0.123, β = −0.281, 95% CI −0.171 to −0.075, $p < 0.001$), whereas WHO-5 was not significantly associated with EHI after covariate adjustment (B = −0.017, 95% CI −0.036 to 0.003, $p = 0.088$). The model accounted for 12.3% of the variance in EHI scores ($R^2 = 0.123$; adjusted $R^2 = 0.101$; $F(8, 322) = 5.654$, $p < 0.001$). All VIFs were < 1.25. In the adjusted models, a 1-SD (7.63-point) higher e-HDLQ score was associated with a WHO-5 score 3.38 percentage points higher and an EHI score 0.94 points lower.

After additional adjustment for chronic disease status, the e-HDLQ coefficient was B = 0.470 (95% CI 0.199 to 0.742, $p = 0.001$) in Model 1 and B = −0.122 (95% CI −0.171 to −0.073, $p < 0.001$) in Model 2. Chronic disease status was not significantly associated with WHO-5 scores (B = −4.799, 95% CI −11.599 to 2.001, $p = 0.166$) or EHI scores (B = −0.160, 95% CI −1.364 to 1.044, $p = 0.794$). In the sensitivity analysis using the five-item EHI score, the adjusted coefficient for the e-HDLQ total score was B = −0.102 (standard error [SE] = 0.024, β = −0.245, 95% CI −0.149 to −0.056, $p < 0.001$).

Variable	
Age (years) *Mean ± SD*	20.32 ± 1.51
Sex *n (%)*	
Male	50 (15.1)
Female	281 (84.9)
Current smoking *n (%)*	
Yes	102 (30.8)
No	229 (69.2)
Alcohol use *n (%)*	
Yes	72 (21.8)
No	259 (78.2)
Exercise status *n (%)*	
Never	111 (33.5)
Once a week	77 (23.3)
Twice a week	70 (21.2)
Three times a week	43 (13.0)
Four times a week	11 (3.3)
Five times a week	10 (3.0)
Six or more times a week	9 (2.7)
Chronic disease status *n (%)*	
Yes	31 (9.4)
No	300 (90.6)
Number of main meals *Mean ± SD*	2.41 ± 0.57
Number of snacks *Mean ± SD*	1.73 ± 0.89
Water consumption (glasses/day) *Mean ± SD*	7.51 ± 3.59
BMI (kg/m²) *Mean ± SD*	22.07 ± 3.28
BMI group *n (%)*	
Underweight	28 (8.5)
Normal weight	249 (75.2)
Overweight	46 (13.9)
Obesity	8 (2.4)

Table 1. Sociodemographic, health, and lifestyle characteristics of the participants ($N = 331$). BMI, body mass index; SD, standard deviation. One glass was defined as 200 mL.

Scale / subscale	Mean ± SD	Median (Q1–Q3)	Cronbach's α
e-HDLQ	37.63 ± 7.63	37 (33–42)	0.65
Finding	6.64 ± 2.35	6 (5–8)	0.75
Understanding	10.37 ± 4.22	12 (8–12)	0.34
Judging	8.02 ± 1.82	8 (7–10)	0.71
Applying	3.47 ± 1.65	3 (2–4)	0.68
DDL	9.14 ± 2.66	9 (7–11)	0.78
WHO-5 (%)	47.63 ± 18.91	48 (36–60)	0.85
EHI	11.24 ± 3.34	11 (9–13)	0.56

Table 2. Descriptive statistics for e-HDLQ, WHO-5, and EHI scores among the participants ($N = 331$). DDL, Digital Healthy Diet Literacy; EHI, Eating Habits Index; e-HDLQ, e-Healthy Diet Literacy Questionnaire; Q1, first quartile; Q3, third quartile; SD, standard deviation; WHO-5, World Health Organization-Five Well-Being Index. For the two-item subscales, the inter-item correlation was 0.56 for Judging and 0.52 for Applying. The corresponding Spearman–Brown coefficients were 0.72 and 0.68. Higher EHI scores indicate more frequent diet-related risk behaviors.

As shown in Table 4 and Fig. 2, the bias-corrected 95% bootstrap confidence interval for the indirect effect of e-HDLQ on EHI through WHO-5 included zero (B = – 0.007, 95% BC CI – 0.022 to 0.001). The bias-corrected

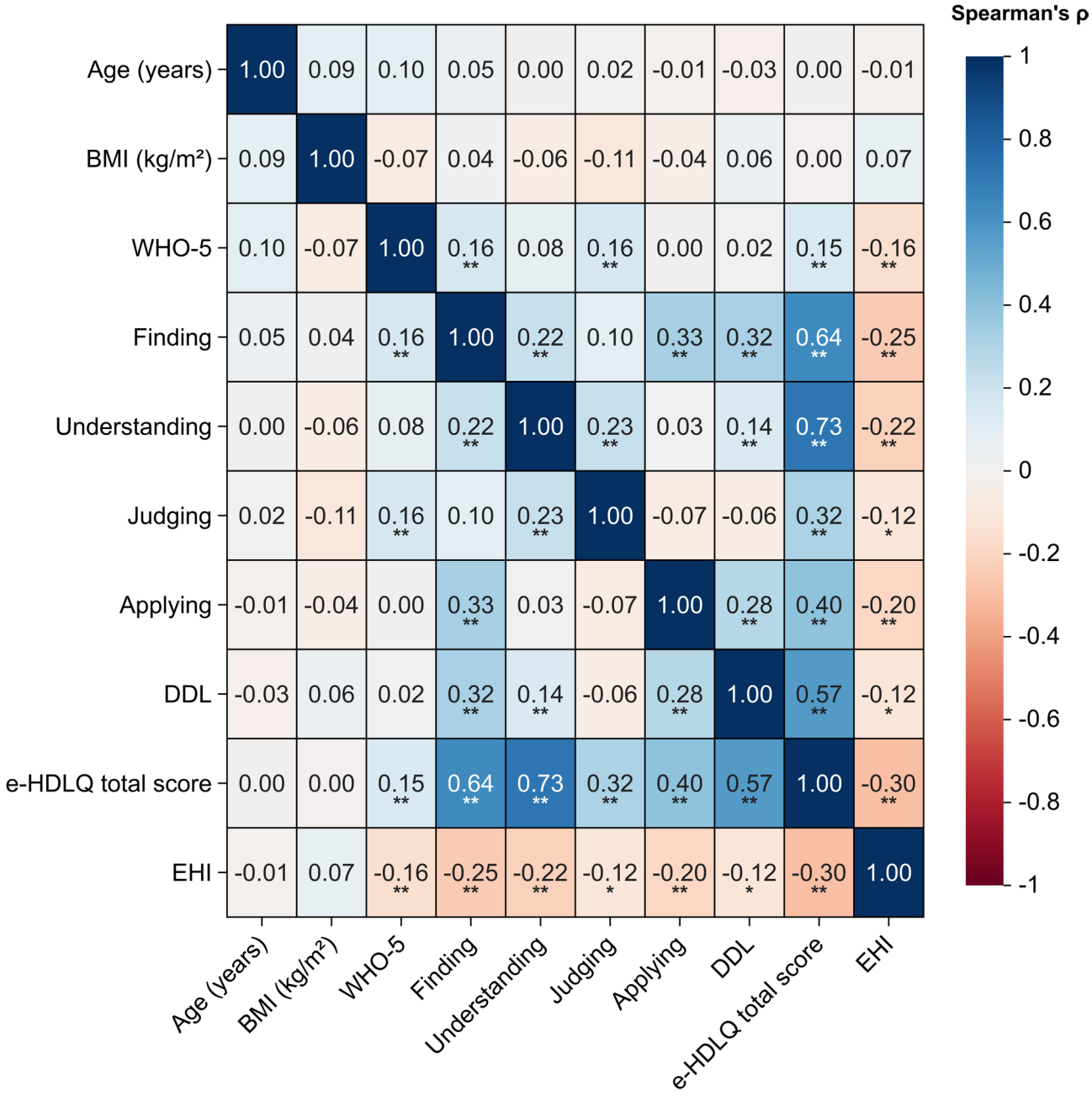


Fig. 1. Spearman's rank correlations among age, BMI, WHO-5, e-HDLQ total and subscale scores, and EHI. Cell values are Spearman's rank correlation coefficients (ρ). Asterisks indicate unadjusted two-sided p values (*$p < 0.05$; **$p < 0.01$). No adjustment for multiple comparisons was applied; correlations involving the e-HDLQ subscales were exploratory. Correlations between the e-HDLQ total score and its constituent subscales represent part–whole associations. WHO-5 was analyzed as a percentage score. BMI, body mass index; DDL, Digital Healthy Diet Literacy; e-HDLQ, e-Healthy Diet Literacy Questionnaire; EHI, Eating Habits Index; WHO-5, World Health Organization-Five Well-Being Index.

95% confidence intervals for the direct effect (B = − 0.123, 95% BC CI − 0.167 to − 0.071) and the total effect (B = − 0.130, 95% BC CI − 0.173 to − 0.080) excluded zero. In the sensitivity path model that additionally included chronic disease status, the model-based direct effect was B = − 0.122 (95% BC CI − 0.169 to − 0.070), the indirect effect was B = − 0.008 (95% BC CI − 0.022 to 0.001), and the total effect was B = − 0.130 (95% BC CI − 0.175 to − 0.081).

Model	Variable	B	SE	β	t	*p*	95% CI for B [LL, UL]	VIF
Model 1 (*N* = 331)	*(Constant)*	15.769	15.095	—	1.045	0.297	[−13.928, 45.466]	—
	Age (years)	0.952	0.664	0.076	1.434	0.152	[−0.354, 2.258]	1.031
	BMI (kg/m²)	−0.482	0.312	−0.084	−1.548	0.123	[−1.096, 0.131]	1.071
	Sex (male)	8.454	3.035	0.160	2.785	0.006	[2.483, 14.426]	1.212
	Smoking (yes)	−2.344	2.363	−0.057	−0.992	0.322	[−6.993, 2.304]	1.221
	Alcohol use (yes)	3.764	2.585	0.082	1.456	0.146	[−1.322, 8.850]	1.167
	Exercise ≥ 1 time/week (yes)	7.665	2.177	0.192	3.521	< 0.001	[3.383, 11.948]	1.084
	e-HDLQ total score	0.443	0.137	0.179	3.239	0.001	[0.174, 0.713]	1.116
	Model fit	**R^2**		**Adjusted R^2**		**F(7, 323)**		***p* value**
		0.117		0.098		6.103		**< 0.001**
Model 2 (*N* = 331)	*(Constant)*	15.881	2.662	—	5.966	< 0.001	[10.644, 21.118]	—
	Age (years)	0.011	0.117	0.005	0.094	0.925	[−0.220, 0.242]	1.037
	BMI (kg/m²)	0.038	0.055	0.037	0.682	0.496	[−0.071, 0.146]	1.079
	Sex (male)	−0.340	0.541	−0.037	−0.630	0.529	[−1.404, 0.723]	1.241
	Smoking (yes)	0.402	0.417	0.056	0.964	0.336	[−0.418, 1.222]	1.225
	Alcohol use (yes)	0.150	0.457	0.019	0.328	0.743	[−0.749, 1.048]	1.175
	Exercise ≥ 1 time/week (yes)	−0.579	0.391	−0.082	−1.482	0.139	[−1.347, 0.190]	1.125
	e-HDLQ total score	−0.123	0.024	−0.281	−5.011	< 0.001	[−0.171, −0.075]	1.153
	WHO-5 (%)	−0.017	0.010	−0.095	−1.711	0.088	[−0.036, 0.003]	1.132
	Model fit	**R^2**		**Adjusted R^2**		**F(8, 322)**		***p* value**
		0.123		0.101		5.654		**< 0.001**

Table 3. Multiple linear regression analyses of factors associated with WHO-5 and EHI scores among the participants. Model 1 used WHO-5 as the dependent variable and included the e-HDLQ total score and six covariates selected a priori. Model 2 used EHI as the dependent variable and additionally included WHO-5 as a predictor. B, unstandardized regression coefficient; BMI, body mass index; CI, confidence interval; EHI, Eating Habits Index; e-HDLQ, e-Healthy Diet Literacy Questionnaire; LL, lower limit; SE, standard error; UL, upper limit; VIF, variance inflation factor; WHO-5, World Health Organization-Five Well-Being Index; β, standardized regression coefficient; F, F statistic; R^2, coefficient of determination; t, t statistic. Sex was coded as male = 1 and female = 0; exercise was coded as ≥ 1 time/week = 1 and never = 0. WHO-5 was analyzed as a percentage score. Higher EHI scores indicate more frequent diet-related risk behaviors.

Path	B	SE	Bias-corrected 95% bootstrap CI	*p* value
Path coefficients				
e-HDLQ → WHO-5	0.443	0.135	0.138 to 0.709	**0.004**
WHO-5 → EHI	−0.017	0.010	−0.038 to 0.004	0.116
Direct effect				
e-HDLQ → EHI	−0.123	0.024	−0.167 to −0.071	**0.001**
Indirect effect				
e-HDLQ → WHO-5 → EHI	−0.007	0.005	−0.022 to 0.001	0.075
Total effect				
e-HDLQ → EHI (direct + indirect)	−0.130	0.023	−0.173 to −0.080	**0.001**

Table 4. Covariate-adjusted path analysis of model-based direct, indirect, and total effects between e-HDLQ and EHI through WHO-5. BMI, body mass index; EHI, Eating Habits Index; e-HDLQ, e-Healthy Diet Literacy Questionnaire; WHO-5, World Health Organization-Five Well-Being Index; B, unstandardized path coefficient; CI, confidence interval; SE, standard error. p values were obtained from the bias-corrected bootstrap procedure in AMOS. The model was adjusted for age, BMI, sex (male = 1, female = 0), smoking (yes = 1, no = 0), alcohol use (yes = 1, no = 0), and exercise at least once per week (yes = 1, no = 0). WHO-5 was analyzed as a percentage score. The labels "direct effect," "indirect effect," and "total effect" are conventional path-analysis terms. These model-based estimates do not establish causal or temporal relationships.

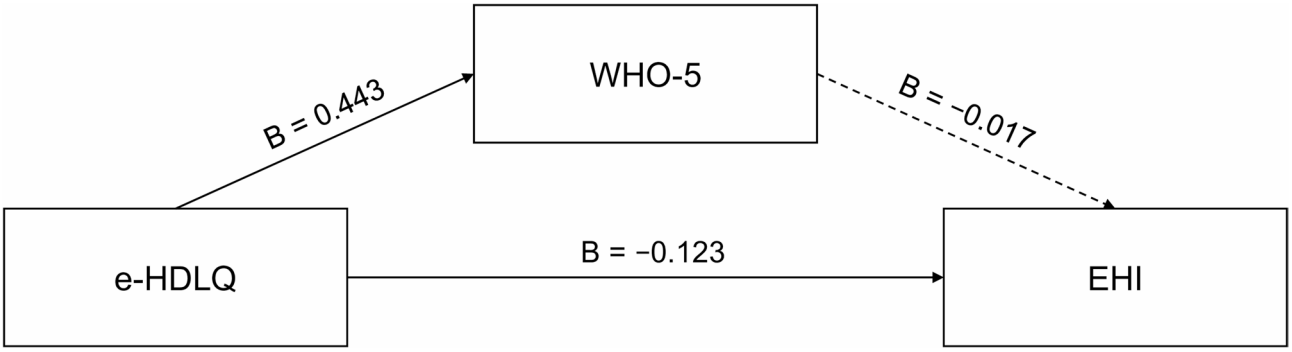


Fig. 2. Covariate-adjusted path model of the associations among e-HDLQ, WHO-5, and EHI. The arrows represent model-specified associations and do not establish causal or temporal direction. Values on the paths are unstandardized path coefficients (B). Solid arrows indicate statistically significant paths ($p < 0.05$), and the dashed arrow indicates a nonsignificant path. Covariates (age, BMI, sex, smoking, alcohol use, and exercise at least once per week) were included in the model but are not displayed for clarity. Bootstrap estimates and bias-corrected 95% confidence intervals for the model-based direct, indirect, and total effects are presented in Table 4. BMI, body mass index; e-HDLQ, e-Healthy Diet Literacy Questionnaire; EHI, Eating Habits Index; WHO-5, World Health Organization-Five Well-Being Index.

Discussion

In this cross-sectional study, the adjusted associations were in the hypothesized directions: higher e-HDLQ scores were modestly associated with higher WHO-5 scores and lower EHI scores among undergraduate students. A 1-SD (7.63-point) higher e-HDLQ score was associated with a WHO-5 score 3.38 percentage points higher and an EHI score 0.94 points lower. Because the EHI showed low internal consistency in this sample and evidence of its construct validity in university students remains limited, this finding should be interpreted as an association with the specific behaviors captured by the index rather than with overall diet quality. In the five-item sensitivity analysis, the standardized coefficient was attenuated in absolute magnitude relative to the primary six-item analysis (β = −0.245 versus − 0.281), and the 95% CI for B excluded zero (− 0.149 to − 0.056; $p < 0.001$). Nevertheless, this analysis does not resolve the EHI's broader measurement limitations in university students. Additional adjustment for chronic disease status did not materially alter the e-HDLQ estimates.

The inverse association with EHI was directionally consistent with previous studies of nutrition literacy and diet-related behaviors[9,31–33]. Because these studies differed from the present study in population, construct, instrument, scoring direction, effect measure, and covariate adjustment, the comparisons concern approximate magnitude rather than statistical equivalence. Kalkan reported a Pearson correlation with an absolute magnitude of |r| = 0.307 between total nutrition literacy and food-habit scores among Turkish health sciences undergraduates[32], whereas Koca and Arkan reported a standardized coefficient of β = 0.357 among Turkish adolescents[33]. These coefficients were similar to or somewhat larger in absolute magnitude than the adjusted standardized coefficient observed in the present study (β = −0.281). Van Duong et al. reported odds ratios for categorical health behaviors and outcomes[9], whereas Mostafazadeh et al. reported model-level variance estimates using different nutrition-literacy and eating-behavior instruments[31]. Direct coefficient-level comparisons with these studies were therefore not appropriate.

After multivariable adjustment, higher e-HDLQ scores, male sex, and exercise at least once per week were associated with higher WHO-5 scores, and the model accounted for 11.7% of the variance ($R^2 = 0.117$; adjusted $R^2 = 0.098$; Table 3). The positive association between e-HDLQ and WHO-5 is consistent with findings from the original e-HDLQ development study in Taiwan[9]. Yang et al. reported inverse bivariate correlations of eHealth literacy with depression ($r = -0.331$), insomnia ($r = -0.366$), and post-traumatic stress symptoms ($r = -0.320$)[34]. These associations were larger in absolute magnitude than the present adjusted association with WHO-5 (β = 0.179), although direct comparison is limited because Yang et al. used a study-specific 15-item eHealth literacy questionnaire and symptom-based outcomes rather than a positive well-being measure. A systematic review of 89 cross-sectional studies among postsecondary students found generally favorable associations between eHealth literacy and several psychosocial outcomes, although evidence specifically concerning overall well-being and depression was inconsistent[35].

In the exploratory path model, the bias-corrected 95% confidence interval for the indirect effect through WHO-5 included zero, whereas the confidence intervals for the direct and total effects excluded zero (Table 4; Fig. 2). These concurrent, model-based estimates do not establish mediation or temporal ordering. Previous research has linked dietary patterns with depressive symptoms[15] and poorer diet quality with worse mental health among students transitioning to university[36]. Aslan Gonul and Caferoglu Akin[37] administered the e-HDLQ and reported an association with Mediterranean diet adherence. They applied the term "digital healthy eating literacy" to the overall construct rather than to the DDL subscale of the Turkish version used in the present study. Associations between nutrition literacy and dietary habits have not been consistent across settings. For example, Taleb and Itani[38] found no association between most nutrition literacy components and food habits among Lebanese adolescents, except for an inverse association involving macronutrient literacy. Environmental and socioeconomic contexts may contribute to this variation[39].

After multivariable adjustment, the estimated WHO-5 score was 8.45 percentage points higher among male participants than among female participants (Table 3). However, this estimate was based on only 50 male participants and should therefore be interpreted cautiously. Sex was not associated with EHI after covariate adjustment, and sex differences in e-HDLQ were not examined.

The standardized associations were modest in magnitude ($\beta = 0.179$ for WHO-5 and $\beta = -0.281$ for EHI). Because no prespecified threshold was applied and no intervention was evaluated, the practical importance of these cross-sectional differences cannot be determined from the present study. These findings alone are insufficient to support specific practice recommendations.

Strengths and limitations

Strengths included a sample-size calculation completed before data collection, a final sample exceeding the minimum target, complete data for the regression analyses, covariate adjustment, and bias-corrected bootstrap confidence intervals for the exploratory indirect-effect estimate. Both the e-HDLQ and the WHO-5 have been validated in Turkish[29,30].

The cross-sectional design precludes causal and temporal inference. Reverse directionality remains possible because students with healthier diets or higher well-being may be more motivated to engage with nutrition information[9]. The indirect-effect analysis should therefore be interpreted as exploratory and hypothesis-generating. Participants were recruited by convenience sampling in campus common areas and immediately after lectures. This approach may have underrepresented students who were not present on campus at those times. Willingness to participate in a nutrition-focused survey may also have been related to interest in the topic. The sample was predominantly female (84.9%), with only 50 male participants. This imbalance limits the precision of sex-related estimates and restricts the generalizability of the findings to more sex-balanced university populations. The direction and magnitude of bias resulting from this sex imbalance cannot be determined from the present data. Exclusion was based on self-reported regular use of psychiatric medication rather than on psychiatric diagnosis or mental health status. Because students with mental health conditions who were not taking psychiatric medication, including those receiving nonpharmacological care, remained eligible, this criterion may have affected the distribution of WHO-5 scores in a direction that cannot be established from the present data. The findings may not generalize to students who regularly use psychiatric medication. The number of students approached was not recorded systematically, so neither the participation rate nor the extent of nonresponse bias could be estimated. Criterion-specific exclusion counts were also not recorded and could not be reconstructed. Recruitment from a single university in a single city further limits institutional and geographical generalizability.

Residual confounding remains possible. Socioeconomic position, parental education, living arrangement, social support, health-related motivation, screen time, and patterns of digital media use were not assessed. These factors may be associated with e-healthy diet literacy, psychological well-being, or diet-related risk behaviors. Previous studies have reported associations of socioeconomic, educational, and clinical factors, as well as screen time, with related (but not identical) healthy-diet-literacy measures or dietary outcomes[40,41]. Any bias arising from these unmeasured factors is therefore of uncertain direction and magnitude. Although chronic disease status was examined in sensitivity analyses, it was measured using a single self-reported item without information on diagnosis, duration, severity, or treatment; residual confounding by clinical characteristics therefore remains possible.

Internal consistency was low for the EHI (Cronbach's $\alpha = 0.56$), which combines heterogeneous dietary behaviors that do not necessarily co-occur. The instrument was originally developed for adolescents, and evidence regarding its reliability, dimensionality, and construct validity in university students is limited. Its summed score should therefore be interpreted as the frequency of the specific diet-related risk behaviors captured by the index rather than as a comprehensive measure of diet quality[27,28]. Internal consistency was modest for the e-HDLQ total score (Cronbach's $\alpha = 0.65$) and varied across subscales, with the Understanding subscale showing a low coefficient ($\alpha = 0.34$). Because the Understanding subscale comprises four knowledge items addressing potentially distinct content, the coefficient may partly reflect the limited number and heterogeneity of the items. Nevertheless, subscale-level results should be regarded as exploratory. Because the e-HDLQ total score is calculated by summing items from subscales with different numbers of items and response formats, the relative contribution of each subscale to total-score variability may differ. The e-HDLQ does not directly assess performance during real-world online searching, source appraisal, or decision-making tasks. All measures were self-reported in a single session, so the observed associations may be affected by social-desirability and recall bias and may partly reflect common-method variance. In addition, BMI was calculated from self-reported height and weight and may therefore be affected by reporting error. Data collection between May and June 2024 may have overlapped with end-of-semester examinations for some participants. Individual examination schedules and perceived stress levels were not recorded, and the contribution of this academic context to dietary behavior and psychological well-being could therefore not be assessed.

Future studies should use longitudinal or cross-lagged designs, recruit geographically diverse and more sex-balanced samples, and apply stronger dietary assessment methods, including repeated 24-hour recalls, food records, validated diet-quality indices, or biomarkers where feasible. Further psychometric evaluation of the e-HDLQ and validation of the EHI in university populations are also needed. Future studies may also examine e-healthy diet literacy in relation to students' food purchasing behaviors and out-of-home consumption[42].

Conclusion

In this predominantly female convenience sample of undergraduate students in Türkiye, higher e-HDLQ scores were modestly associated with higher WHO-5 scores and, in a model additionally including WHO-5, with lower EHI scores. The inverse association with EHI should be interpreted cautiously given the scale's low internal consistency in this sample. The confidence interval for the model-based indirect component through WHO-

5 included zero. Concurrent measurement does not establish temporal ordering or causality. Replication in geographically diverse, more sex-balanced samples using stronger dietary assessment methods is needed.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contributions
E.T., E.D., G.Ş.B., and A.K. conceived and designed the study. E.T., E.D., and G.Ş.B. collected and curated the data. E.D. conducted the formal analyses. All authors contributed to the interpretation of the findings, preparation of the original draft, critical revision of the manuscript, and approval of the final version.

Declarations

Competing interests
The authors declare no competing interests.

Ethics approval
All procedures were conducted in accordance with the Declaration of Helsinki and were approved by the Ankara University Ethics Committee (Date: 25/04/2024; No: 07/62). Written informed consent was obtained from all participants before data collection.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process
During manuscript preparation, DeepL and ChatGPT were used for English-language editing and translation from Turkish. All outputs were reviewed and revised by the authors, who take responsibility for the final text.

Additional information
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