ORIGINAL ARTICLE

Annals of Agricultural and Environmental Medicine
www.aaem.pl

Nutrient density, energy availability and stress levels in relation to well-being among physically active adults

Katarzyna Łożyńska[1,A-F], **Olga Surała**[2,A,C,E-F], **Maria Szmidt**[1,C,E-F], **Joanna Kałuża**[1,A,C-F]

[1] *Human Nutrition, University of Life Sciences, Warsaw, Poland*
[2] *Division of Nutrition Physiology and Dietetics, Institute of Sport – National Research Institute, Warsaw, Poland*

A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Łożyńska K, Surała O, Szmidt M, Kałuża J. Nutrient density, energy availability and stress levels in relation to well-being among physically active adults. Ann Agric Environ Med. doi:10.26444/aaem/225100

Abstract

Introduction and Objective. Well-being in physically active adults is shaped by multiple interacting lifestyle factors. The aim of the study is to examine associations between nutrient density, energy availability (EA), and stress levels with well-being in adults meeting the World Health Organisation (WHO) physical activity guidelines.

Materials and Method. The cross-sectional study included 312 female 115 male amateur athletes (18–40 years old; mean age ± SD: 29.8 ± 5.7 for women and 31.2 ± 5.7 for men) who reported engaging in ≥75 minutes of vigorous-intensity aerobic activity per week. Food intake was assessed using a validated 138-item food frequency questionnaire; stress level was measured using a Visual Analogue Scale (VAS), and well-being measured using the WHO-5 Well-Being Index (WHO-5-Index). EA was calculated as dietary energy intake minus exercise energy expenditure, normalised to body mass. To identify predictors of well-being, multivariate-adjusted logistic regression models were used to estimate odds ratios (ORs) and 95% confidence intervals (95% CIs).

Results. Overall, 36.2% of women and 29.6% of men were classified as having poor well-being (WHO-5-Index <13). In multivariable models, lower perceived stress was independently associated with better well-being (OR=0.62 per 1-point increase on the VAS; 95% CI: 0.54–0.70; P-trend <0.001). Additionally, higher dietary densities of vitamin A, folate, vitamin B12, potassium, iron and copper, were significantly associated with better well-being (all P-trends ≤0.05). No such associations were observed for EA.

Conclusions. These findings indicate that lower perceived stress and higher dietary nutrient density are independently associated with better well-being in physically active adults.

Key words
well-being, physical activity, energy availability, stress levels, nutrient-density

INTRODUCTION

The World Health Organization (WHO) defines mental health as 'a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively, and is able to make a contribution to his or her community' [1]. This definition emphasizes that mental health is not merely the absence of mental disorders, but also encompasses a dynamic process involving subjective well-being, resilience to stress, the ability to build relationships, and make decisions [2]. At the same time, according to the WHO, overall health is understood as a state of complete physical, mental, and social well-being rather than merely the absence of disease or infirmity; within this holistic framework, mental health refers specifically to the psychological and emotional components of this broader construct, and therefore constitutes one of the key dimensions of overall health.

Well-being is influenced by multiple factors, and studies often do not account for them simultaneously. Until now, most studies that have examined various determinants in relation to well-being focused only on individual factors, such as physical activity [3–7], diet quality [3, 8–11], and other diet aspects [4, 12], stress levels [13], and some key studies in this area used cross-sectional designs [3, 8, 9]. Moreover, the majority of these studies focused on specific populations, including young adults aged 17–25 [11], adults under 50 years of age [9] or adults aged 50–75 [8], and adults spanning a wide age range [3, 6, 10].

Until now, only a few studies have investigated multiple determinants of well-being in disease-free adults [7–8, 10]. Only one study has examined the associations of diet and physical activity with well-being in middle-aged disease-free adults, but without considering stress, indicating that lower-risk lifestyle behaviours are associated with a greater likelihood of reporting good well-being. Moreover, previous research has mostly focused on sedentary individuals or on participants who do not identify themselves as physically active [8, 10, 11], and studies examining combinations of these factors in physically active adults remain limited [7].

The findings regarding the individual effects of diet, physical activity or stress on well-being are inconsistent. Diet appears to be an important determinant of overall well-being, with studies reporting that healthier diets are associated with better well-being [10, 11]. However, some researchers found no significant associations between

Address for correspondence: Katarzyna Łożyńska, Human Nutrition, University of Life Sciences, Nowoursynowska 166, 02-787 Warsaw, Poland
E-mail: d003200@sggw.edu.pl

Received: 26.01.2026; accepted: 25.06.2026; first published: 20.07.2026

diet quality, inflammatory markers, and well-being [11], suggesting that the relationship may vary across populations. Regular moderate physical activity is generally beneficial for mental health [14], improving mood and emotional well-being through neurochemical, psychological, and social mechanisms [7], yet excessive or overly intense exercise, especially when combined with inadequate recovery or high stress, can lead to psychological strain and reduce these benefits [15, 16]. Stress is a well-established negative predictor of subjective well-being, with higher perceived stress consistently linked to poorer mental health outcomes [13, 14]. However, interventions that reduce stress have been shown to significantly improve well-being, highlighting its modifiable nature [3].

Considering the interplay of diet, exercise, and stress on well-being, and the possibility that the positive effects of physical activity on well-being may be diminished without adequate dietary support or a reduction in external stress, comprehensive, integrated studies are needed in this area. Therefore, this study aimed to examine diet nutrient density, energy availability, and stress levels in relation to well-being among young and middle-aged disease-free women and men who met the WHO physical activity guidelines [1]. It was hypothesised that higher dietary nutrient density, higher energy availability, and lower stress levels would be associated with better well-being among adult amateur athletes.

MATERIALS AND METHOD

Study population. The study was conducted between April 2023 – February 2024 using the Computer-Assisted Web Interview (CAWI) method. Participants were recruited via social media platforms (Facebook and Instagram). Study invitations were posted in Facebook groups related to physical activity and healthy lifestyle, and shared on Instagram by several well-known Polish dietitians. Although no financial compensation was provided, participants could receive a short educational e-book on nutrition for physically active individuals prepared by the principal investigator. The following inclusion criteria were used for participants: 1) male or female, 2) age 18–40 years, and 3) ≥75 minutes of vigorous-intensity amateur physical activity per week, ≥150 minutes of moderate-intensity physical activity per week, or an equivalent combination of both [17]. Exclusion criteria: 1) declaration of using of substances prohibited by the World Anti-Doping Agency, 2) presence of diseases, such as epilepsy, asthma, cardiovascular diseases, cancer, type 1 diabetes, primary amenorrhea or erectile disorders, 3) breastfeeding, 4) pregnancy, 5) energy intake <500 or >8,000 kcal/day, 6) corrected MET-h/d >40 for females and >50 for males, 7) professional athlete.

The study was conducted among Polish amateur adult athletes who met the inclusion and exclusion criteria. Details regarding participant exclusions are shown in Figure 1. A total of 654 respondents were recruited for the study. Of these, 227 participants were excluded for the following reasons: age below 18 or above 40 (n=2), gender other than male or female (n=1), and incorrectly completed questionnaires (n=7). Additional exclusions were made due to implausible energy intake (<500 or >8,000 kcal/day; n=62), insufficient physical activity (<75 or vigorous <150 min moderate/week, n=72), or implausible high physical activity levels (>40 MET-hours/day for women and >50 MET-hours/day for men, n=6). Participants were also excluded if they were pregnant or breastfeeding (n=10), had chronic diseases (n=32), or reported the use of doping or substances prohibited by the WADA list (n=35). After all exclusions, the final analysis included 427 individuals, consisting of 312 women and 115 men.

All study procedures were conducted in accordance with the Declaration of Helsinki. The Warsaw University of Life Sciences Ethics Committee approved the study at the beginning of 2023 (Resolution No. 14/RKE/2023). By completing the questionnaire, participants provided their informed consent.

Basic data collection. Data on sex, age, place of residence, education level, and marital status were collected using a general questionnaire. The questionnaire also included questions on cigarette smoking, alcohol consumption, usage of substances prohibited by the WADA (World Anti-Doping Agency) [18], and history of consultations with a psychologist. Additionally, participants were asked to self-report their overall health status using four pre-defined categories (very good, good, average or poor) and to provide their height and body mass. Body mass index (BMI) was calculated using the formula: body mass [kg]/height [m]^2. Total daily activity was assessed using a structured questionnaire consisting of two sections. The first section covered the average daily time spent on the six activities: sleep, sedentary behaviors (e.g., reading, writing, screen time), household chores, personal hygiene, occupational activities (categorized as sedentary, standing, moving, or mixed), and walking. The second section focused on structured physical activity. Participants reported engagement in 23 predefined specific disciplines, including strength training, calisthenics, fitness classes, gymnastics, pilates, high-intensity circuit training (e.g., CrossFit, kettlebell workouts), running, cycling, swimming, martial arts, and team sports. For each activity reported in both sections, participants indicated the duration of a single session (in minutes) and the weekly frequency, which enabled the calculation of the exercise duration – the time spent on physical activity – by summing-up the time of all reported activities and expressing it in minutes per week (min/week).

Well-being status. The validated WHO-5 Index was used to assess subjective psychological well-being [19]. The validated Polish version of this tool was used in the study [20]. The WHO-5 Index consists of five positively-worded statements that assess an individual's emotional well-being over the past two weeks. The five items of the WHO-5 Index include: 1) 'I have felt cheerful and in good spirits', 2) 'I have felt calm and relaxed', 3) "I have felt active and vigorous', 4) "I woke up feeling fresh and rested', 5) "My daily life has been filled with things that interest me'. Each item was scored on a 6-point Likert scale, ranging from 0 (at no time) to 5 (all the time), yielding a total score of 0–25, with higher scores indicating better well-being. Participants with a WHO-5 Index score <13 were classified as having poor well-being, while those with a score ≥13 were categorised as having good well-being [19].

Food consumption and diet nutrient density. A semi-quantitative 138-item FFQ, developed and validated for the Polish population, was used to assess food intake [21]. The questionnaire included questions on consumption of the following food groups: cereal products (n=12); milk products (n=12); meat and poultry (n=10); eggs, fish and seafood (n=9); vegetables (n=21); fruits (n=14); legumes (n=5); sugar and confectionery (n=13); non-alcoholic beverages (n=9); alcoholic beverages (n=5); nuts and seeds (n=11); fats and spreads (n=11); other products (n=6). Additionally, the questionnaire included seven additional blank fields that allowed specifying the consumption frequency of products not listed in the selected groups. Respondents were asked to indicate the average frequency of consumption of each food item in the last year by selecting one of eight pre-defined categories (<1 time per month, 1–3 times per month, 1–2 times per week, 3–4 times per week, 5–6 times per week, 1 per day, 2 per day, or 3 or more times per day). Moreover, they were asked to report the average portion size of each consumed food item (in grams per serving). For each food item, the frequency of consumption was converted to a daily frequency and multiplied by the indicated portion size to express consumption in grams per day. Energy and nutrient value were calculated for each food item based on food composition tables [The book *Tables of Composition and Nutritional Value of Food,* accessed October 22, 2025], and the next nutrient density was calculated as the ratio of nutrient content to energy content and expressed per 1,000 kcal of diet to represent the overall nutrient density of the diet [The book *Dietary Reference Intakes for the Polish Population and Their Application* by Jarosz et al., 2020] provides the current national dietary standards for Poland. The FFQ was validated in a sample of 121 women aged 18 – 30 years by comparing it against a three-day dietary record as the reference method [21]. The average Pearson correlation coefficients between the FFQ and the reference method was 0.51 for macronutrient intake and 0.63 for micronutrient intake, indicating moderate validity of the FFQ.

Energy expenditure (EE) and energy availability. EE was estimated separately for each reported activity based on its assigned metabolic equivalent of task (MET) value, following the *Compendium of Physical Activities 2024* [17]. Each activity was assigned a specific MET value, standardized as 1 MET = 3.5 mL O_2/kg/min (Suppl. Tab. 1). The MET-hours per day (MET-h/d) for each activity were calculated by multiplying the MET value by the activity's daily duration (in hours). To account for individual physiological differences, corrected MET values were obtained by adjusting the standard METs using participant-specific correction factors (age, gender, and resting metabolic rate). For analytical purposes, only the corrected MET values were used.

From these data, two indicators were derived: 1) Exercise MET: MET-hours per day attributable to exercise, calculated as the sum of corrected MET values multiplied by daily duration (hours) for all reported physical activities. 2) Exercise Energy Expenditure (EEE): the daily energy expenditure related specifically to exercise, expressed in kilocalories per day (kcal/day), and calculated by multiplying the corrected MET value by body mass (kg), duration (hours), and the energy equivalent of oxygen consumption.

In addition, Total Energy Expenditure (TEE) was calculated by summing-up the energy costs of all reported activities across the full spectrum of daily behaviours (including sedentary time, household chores, occupational activity, and physical activity), yielding an estimate of total daily energy expenditure (kcal/day).

Energy availability (EA) is the dietary energy remaining for optimal physiological function after accounting for energy expended during exercise [15]. In the current study, due to the absence of body fat measurements, the calculation of EA was based on total body mass, following the approach proposed in the early work of Loucks and Callister from 1993 [16] as follows:

$$\text{EA} = (\text{Energy Intake} - \text{Exercise Energy Expenditure (kcal)}) / \text{Total Body Mass (kg)}.$$

Statistical Analysis. Categorical variables were presented as percentage distributions, while continuous variables were reported as means with standard deviations. Comparisons between participants with good and poor well-being were performed using the Chi-square test for categorical variables. The means between groups were compared using the Mann-Whitney U test due to non-normal distributions, as assessed by the Shapiro–Wilk test. The internal consistency of the scales was assessed using Cronbach's alpha. Spearman's rank correlation coefficients were calculated to assess the correlation between lifestyle factors, including physical activity, and diet-related parameters.

To evaluate associations between well-being status and potential predictors, multivariate-adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were estimated using logistic regression models. Participants with good well-being (WHO-5-Index ≥13 points) served as the reference group. The baseline model (Model 1) adjusted for key demographic and clinical covariates, including age (continuous), gender (male or female), BMI (continuous), EA level (continuous), and stress levels (measured via VAS, continuous). To evaluate dietary nutrient densities (expressed per 1,000 kcal), subsequent logistic regression models (Model 2) were further adjusted for Model 1 covariates to analyse the intake of total protein, total fat, total carbohydrates, dietary fibre, vitamins (A, B_1, B_2, B_6, folate, B_{12}, C, E), and minerals (calcium, magnesium, potassium, iron, zinc, copper). Model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test.

All statistical analyses were conducted using STATISTICA 13.0; statistical significance level was set at P-value ≤ 0.05.

RESULTS

Basic characteristics. The cross-sectional study included 312 women and 115 men (mean age ± SD: 29.8 ± 5.7 and 31.2 ± 5.7 years, respectively) who reported engaging in ≥75 minutes of vigorous-intensity aerobic activity per week. Participants most frequently engaged in endurance sports (45.2%), followed by strength training (32.2%) and mixed activities (22.6%). Endurance disciplines included speed walking, running, cycling, swimming, and dancing. Strength-based activities included weight resistance training, calisthenics, yoga, and Pilates, whereas mixed sports comprised fitness, gymnastics, CrossFit, volleyball, and other activities.

The majority of participants – both genders – were classified into the good well-being group (WHO-5 Index ≥13), with mean scores of 16.7 ± 3.0 (median 16.0) for women and 17.5 ± 3.2 (median 17.0) for men. Conversely, poor well-being (WHO-5 Index <13) was observed in 36.2% of women and 29.6% of men (Fig. 2). Within this low-scoring group, the mean WHO-5 Index score was 8.5 ± 3.0 (median 9.0) for women and 9.6 ± 2.5 (median 10.5) for men. The WHO-5-Index demonstrated a high reliability in this sample, with Cronbach's alpha of 0.88, indicating good internal consistency.

The basic characteristics of participants, categorised by well-being status, are presented in Table 1. Both men and women with good well-being were more likely to have a university education and to rate their overall health status as very good than those with poor well-being. Furthermore, women with good well-being were less likely to use contraceptive pills compared to those in the poor well-being group.

No significant differences were found between well-being groups in both men and women regarding marital status, BMI, cigarette smoking, alcohol drinking, and physical activity levels, as reflected by exercise duration, exercise MET and EEE (Tab. 1).

Energy availability and stress status by well-being status. There were no statistically significant differences between the well-being groups in EA parameters, such as daily energy intake, total energy expenditure, and EA in either gender (Tab. 2).

Men and women with good well-being reported significantly lower stress levels compared to those with poor well-being (Tab. 2). Among the women with good well-being, the average VAS score was 4.8 ± 1.8, whereas among those with poor well-being, the average score was 6.4 ± 2.0 (*P*-value<0.001). Among the men with good well-being, the mean VAS score was 4.3 ± 1.8, whereas among those with poor well-being, the score was 6.0 ± 1.6. Furthermore, both the men and women with good well-being were more likely to be classified in the low-stress category (0–3 points) on the VAS, whereas those with poor well-being were more likely to be classified in the highest-stress category (7–10 points). Moreover, psychological consultations were significantly less frequent among both the men and women with good well-being. This difference was especially pronounced among the men, with only 3.7% in the good well-being reporting consultations, compared to 20.6% in the poor well-being group.

Analysis of the correlation between the WHO-5-Index and BMI, EI, Exercise duration, Exercise MET, EEE, TEE, EA, and VAS is presented in Supplementary Table 2S.

Diet density by well-being status. Women with good well-being consumed more nutrient-dense foods and fewer energy-dense foods compared to those with poor well-being (Tab. 3). Specifically, consumption of fruits, vegetables, and whole grains per 1,000 kcal of diet was higher in women with good well-being, although the difference was statistically significant only for fruit consumption (106 ± 101 g vs. 77 ± 58 g). Moreover, women with good well-being tended to consume less processed meat, other types of fat such as margarine and fat mix for spreading, fast-food products, sweets and sweetened foods, and sweetened beverages than the poor well-being group. However, the only statistically significant difference was observed in fast-food product consumption, which was lower among women with good well-being compared to those with poor well-being (13 ± 22 g vs. 19 ± 29 g). Men with good well-being compared to those with poor well-being, consumed non-significantly more fruits, vegetables, legumes, eggs, fish and seafood, sports products, juices, sweetened beverages, and alcoholic beverages, although only a trend toward lower whole grain consumption in the good well-being compared to the poor well-being group was found.

Although energy intake did not differ significantly between well-being groups in either men or women, differences in diet nutrient density were observed (Table 4). Women with good well-being consumed a more nutrient-dense diet compared to poor well-being women, with significantly higher intakes of dietary fibre (13 ± 5 vs. 12 ± 6 g/1,000 kcal), vitamin A (768 ± 532 vs 652 ± 497 µg RAE/1,000 kcal), vitamin C (68 ± 38 vs. 60 ± 38 mg/1,000 kcal), magnesium (206 ± 65 vs. 189 ± 66 mg/1,000 kcal), potassium (1,892 ± 588 vs 1716 ± 577 mg/1,000 kcal), iron (8 ± 2 vs. 7 ± 3 mg/1,000 kcal), and copper (0.7 ± 0.3 vs 0.6 ± 0.3 mg/1,000 kcal). Additionally, among women with good well-being, a tendency to consume more carbohydrate-dense and less fat-dense diets was observed, compared with women with poor well-being. In men, only a statistically higher intake of vitamin A (1,084 ± 1338 vs. 593 ± 418 µg RAE/1,000 kcal) was observed in the good well-being group (Tab. 4).

The correlation between the WHO-5-Index and food consumption and nutrient intake per 1,000 kcal of diet is presented in Supplementary Tables 3S and 4S, respectively.

Predictors of well-being. Among the basic demographic and clinical predictors (Model 1), only lower perceived stress was significantly associated with better well-being. Higher well-being was associated with lower odds of experiencing stress (OR=0.62 per 1-point VAS increment; 95% CI: 0.54–0.70) (Tab. 5). In the nutrient density models (Model 2), higher nutrient densities of vitamin A (OR=1.04 per 50 µg RAE/1,000 kcal; 95% CI: 1.02–1.07), folate (OR=1.09 per 25 µg/1,000 kcal; 95% CI: 1.01–1.17), vitamin B_{12} (OR=1.09 per 1 µg/1,000 kcal; 95% CI: 1.00–1.18), potassium (OR=1.02 per 50 mg/1,000 kcal; 95% CI: 1.00–1.05), iron (OR=1.08 per 1 mg/1,000 kcal; 95% CI: 1.00–1.16), and copper (OR=2.16 per 1 mg/1,000 kcal; 95% CI: 1.19–3.91) were associated with greater odds of better well-being (Tab. 5).

DISCUSSION

The findings of this cross-sectional study partially support the study hypothesis. Higher well-being was associated with lower stress levels and higher dietary nutrient density of selected vitamins and minerals in amateur adult athletes; however, no such association was observed for energy availability.

Evidence from systematic reviews and meta-analyses consistently shows that healthier dietary patterns are associated with better mental health outcomes and lower psychological distress; however, these results do not account for participants' physical activity levels [5, 12]. Specifically, a meta-analysis of observational studies showed that higher consumption of ultra-processed foods was associated with increased odds of depressive symptoms and poorer mental health outcomes [12]. In a cross-sectional study of 2,047 adults not included in that meta-analysis, participants with the highest dietary quality were nearly twice as likely to report better well-being than those with poorer diets (OR=1.92; 95% CI: 1.14–3.23) [8]. Similarly, a longitudinal study of Dutch adults demonstrated that each additional 100 g/day of fruit and vegetable intake was associated with a

7-point increase in the WHO-5-Index [10]. This aligns with findings in young Polish women, in which each additional point on the Mediterranean Diet Score was associated with a 17% (95% CI: 3–35%; *P*-trend=0.016) higher likelihood of reporting good well-being [9].

Consistent with these results, the findings of the current study indicate that better diet quality, characterised by higher nutrient density, was associated with better well-being. However, the associations observed in the study were more specific, reflecting individual nutrients rather than overall dietary patterns. Specifically, higher nutrient densities of vitamin A, folate, vitamin B_{12}, potassium, iron and copper, were associated with greater odds of better well-being. Notably, this pattern forms a biologically plausible profile linked to oxidative stress regulation, haematopoietic, energy metabolism, antioxidant defence mechanisms [22], neurotransmitter synthesis, and gut-brain axis signalling [23].

Beyond dietary factors, lower perceived stress emerged as another independent predictor associated with better well-being. Both men and women with poorer well-being reported markedly higher stress levels on the VAS scale. These findings are consistent with evidence from a large cohort study of 121,008 adults (age 18–93 years), which demonstrated that higher stress levels are associated with both poorer diet quality and adverse mental health outcomes [3]. Chronic stress can detrimentally affect well-being through neuroendocrine and inflammatory pathways, while simultaneously promoting unhealthy eating behaviours, particularly the consumption of highly processed, energy-dense foods [23]. This pattern is consistent with observations in the current study, as women with poorer well-being reported higher consumption of fast food and sweetened products (mean intake in g/1,000 kcal of diet). Furthermore, the current results suggest that psychological well-being may be linked not only to lower intake of unhealthy foods, but also to a higher consumption of nutrient-dense options. Collectively, these findings suggest that stress is intertwined with both psychological well-being and dietary behaviours, although the nature of these relationships remains to be further clarified.

Contrary to hypothesis of this study, no significant associations were observed between well-being and EA. This finding contrasts with previous evidence suggesting that inadequate EA may negatively affect physiological and psychological functioning, particularly in physically active populations [15, 24, 25]. Low EA has been identified as a key factor underlying relative energy deficiency in sport (RED-S), a condition associated with impaired health outcomes, including disturbances in mood and psychological well-being [15]. Therefore, the absence of a significant association between EA and well-being in the current study suggests that this relationship is complex and may depend on additional factors.

Several methodological and physiological factors may explain this lack of association within our specific study group. First, all participants met the WHO physical activity guidelines, resulting in a relatively homogeneous sample regarding exercise habits, which may have limited the statistical variability necessary to detect differences in well-being. Second, although low EA has been linked to psychological disturbances and the development of RED-S among elite athletes [16, 24], the EA range within the study sample may not have been sufficiently extreme to alter subjective well-being. Therefore, moderate fluctuations in EA among recreationally active adults may have limited relevance for well-being, provided that basic energy needs are largely met.

Although gender differences in well-being have been reported in previous studies [3], gender was not a significant predictor in the presented multivariable models. This finding should be interpreted with caution, as the relatively small number of men included in the study may have limited the statistical power required to detect potential gender-related differences. Therefore, the lack of significant associations does not rule out the existence of true differences between men and women. Future studies, including a larger and more balanced study group, are warranted to further investigate the role of gender in well-being outcomes.

A major strength of this study is its comprehensive assessment of multiple factors potentially associated with well-being, including dietary nutrient density, BMI, stress levels, and EA. Another important strength is the use of the validated WHO-5 Index to assess overall well-being [19]. Similarly, the use of the validated FFQ enhances the reliability and credibility of dietary data collected [21]. Furthermore, the study went beyond assessing food consumption alone by evaluating diet nutrient density, providing a more detailed understanding of how dietary quality may relate to well-being. Including stress assessments provides additional insight into participants' psychological context, complementing the evaluation of dietary factors and well-being. Finally, the use of multivariate regression models enabled the simultaneous assessment of demographic, clinical, and nutrient-density variables, allowing for the identification of factors independently associated with well-being.

Limitations of the study. However, certain limitations should be acknowledged. The cross-sectional nature of the study limits the ability to draw firm conclusions about the directionality of the relationships between stress, dietary intake, and well-being. Longitudinal studies or randomised controlled trials would be needed to confirm whether dietary modifications directly influence the well-being of physically active men and women. Moreover, recruiting participants aged 18–40 years through social media may have limited the sample's representativeness; therefore, the findings are primarily generalisable to young and middle-aged physically-active adults. Despite the validated FFQ used for collecting intake data [21], self-reported dietary intake may be subject to recall bias, and participants may have underestimated or overestimated their consumption of specific food items.

Another limitation of the study is that, due to the lack of body composition measurements, EA was calculated relative to total body mass rather than fat-free mass. In subsequent studies, Loucks and Thuma refined this formula by expressing EA relative to fat-free mass, a formulation that has since become the standard in EA research due to the greater metabolic relevance of lean tissue [25]. Nevertheless, when body composition data are unavailable, the body mass-based method remains a valid alternative.

Finally, although the study included both men and women, the relatively small number of male participants limited the statistical power and precluded reliable gender-specific regression analyses.

Future research should include prospective cohort studies or interventional trials to examine causal links between diet,

Table 1S. Assessment of daily activity level and physical activity level

Activity	MET factor based on 2024 Adult Compendium of Physical Activities	Activity code based on 2024 Adult Compendium of Physical Activities
Daily activities		
Sleeping	1.0	Sleeping (07030)
Sedentary activities (reading, writing, working at a computer, watching TV, …)	1.5	Sitting – studying, general, including reading and/or writing, light effort (09060)
Household chores (washing up, cleaning, cooking, …)	3.3	Multiple household tasks all at once, moderate effort (05026)
Hygiene (bathing, care, …)	2.0	Grooming, washing hands, shaving, brushing teeth, putting on make-up, sitting or standing (3040)
sitting	1.5	Sitting tasks, light effort (e.g., office work, chemistry lab work, light assembly repair, watch repair, reading, desk work) (11580)
standing	1.8	Standing tasks, light effort (e.g., bartending, store clerk, assembling, filing, duplicating, librarian, putting up a Christmas tree, standing and talking at work, changing clothes when teaching physical education) (11600)
in move	6.3	Using heavy power tools, such as pneumatic tools (e.g., jackhammers, drills, etc.)
mixed	4.0	Chambermaid, hotel housekeeper, making bed, cleaning bathroom, pushing cart (11070)
Walking (moving around, walking)	4.0	Walking, to work or class (Taylor Code 015) (17270)
Physical activities		
Strength training	6.5	Body weight resistance exercises (e.g., squat, lunge, push-up, crunch), high intensity (02057)
Calisthenics	3.5	Calisthenics, light or moderate effort, general (e.g., back exercises), going up & down from floor (Taylor Code 150) (02030)
Fitness classes	7.3	Aerobic, general (02000)
Gymnastics	3.8	Gymnastics, general (15300)
Pilates	2.8	Pilates, general (02105)
Circuit training (e.g. CrossFit, kettlebell training, high intensity aerobics)	6.0	Circuit training, body weight exercises (02032)
Running	7.5	Jogging, general, self-selected pace (12020)
Cycling	7.0	Cycling, general (01014)
Speed walking	5.3	Walking, for exercise, 3.6 to 4.4 mph (5.8 - 7.1 km/h), with ski poles, Nordic walking, level, moderate pace (17304)
Martial arts (judo, jujitsu, karate, kickboxing, taekwondo, tai-bo, Muay Thai)	5.3	Martial Arts, different types, slower pace, novice performers, practice (15425)
Speed walking	5.3	Walking, for exercise, 3.6 to 4.4 mph (5.8 to 7.1 km/h), with ski poles, Nordic walking, level, moderate pace (17304)
Martial arts (judo, jujitsu, karate, kickboxing, taekwondo, Tae Bo, Muay Thai)	5.3	Martial Arts, different types, slower pace, novice performers, practice (15425)
Boxing	12.3	Boxing, in ring, general (15100)
Dancing	3.8	Contemporary dancing, general (03070)
Pole dance	4.5	Pole dancing, exercise class (02108)
Yoga	2.3	Yoga, General (02175)
Basketball	7.5	Basketball, general (15055)
Volleyball	4.0	Volleyball (Taylor Code 400) (15710)
Soccer	7.0	Soccer, casual, general (Taylor Code 540) (15610)
Handball	12.0	Handball, general (Taylor Code 520) (15320)
Squash	7.5	Squash, general (15652)
Tennis	6.8	Tennis, general, moderate effort (15675)
Golf	4.5	Golf, general (15255)

stress, EA and well-being in physically active individuals. Examining potential gender differences in dietary habits and mental health outcomes could provide further insights into personalized dietary recommendations for psychological well-being. Subsequent studies should also include larger, more diverse samples to enhance generalizability and enable the use of the findings. Samples should be sufficiently large to allow the use of advanced multivariate statistical models that account for complex interactions between dietary factors, psychological variables, and potential confounders.

Table 2S. Analysis of the correlation between well-being status (the WHO-5-Index) and the results of selected parameters in physically active adults (n=427)

Parameters	Women		Men	
	P-value	R*	*P*-value	R*
BMI (kg/m^2)	0.8420	0.0113	0.9463	0.0064
EI (kcal/d)	0.3451	-0.0536	0.3127	0.0945
Exercise duration (min/tyg)	0.1058	0.0917	0.6048	0.0488
Exercise MET	0.2189	0.0698	0.1719	0.1283
EEE (kcal/d)	0.6826	0.0232	0.4138	0.0769
TEE (kcal/d)	0.2228	0.0692	0.1722	0.1282
EA (kcal/kg BM/d)	0.6056	0.0293	0.9008	0.0118
VAS score (points)	<0.001	-0.5087	<0.001	-0.4852

Good well-being – 13–25 points; Poor well-being – <13 points in the WHO-5 Well-Being Index; EA – Energy Availability; EI – Energy Intake; BM – Body Mass; VAS – visual analogue scale of stress level (0 – no stress at all; 10 – very high stress); TEE – total energy expenditure.
*non-parametric Spearman's rank correlation.

Table 3S. Analysis of the correlation between well-being status (WHO-5-Index) and food consumption per 1,000 kcal of diet in physically active adults (n=427)

Food consumption (grams/ml per 1000 kcal of diet)	Women		Men	
	P-value	R*	*P*-value	R*
Fruits, g	0.3152	0.0570	0.5257	0.0598
Vegetables, g	0.7139	0.0208	0.6222	0.0464
Potatoes, g	0.9836	0.0012	0.7040	-0.0358
Whole grains, g	0.4446	0.0434	0.8243	-0.0209
Refined grains, g	0.2545	-0.0646	0.7676	-0.0279
Legumes, g	0.5321	-0.0355	0.2867	0.1002
Dairy products, g	0.7834	-0.0156	0.3977	0.0796
Eggs, g	0.1308	0.0857	0.2148	0.1166
Fish and seafood, g	0.1519	0.0813	0.0651	0.1726
Poultry, g	0.9457	-0.0039	0.3255	-0.0925
Unprocessed red meat, g	0.8873	-0.0082	0.0849	0.1614
Processed meat, g	0.3719	-0.0507	0.4618	-0.0693
Nuts, g	0.3111	0.0575	0.8267	0.0206
Seeds, g	0.7837	0.0156	0.5128	0.0616
Olive oil and other oils, g	0.3683	-0.0511	0.2615	-0.1056
Animal fat, g	0.4665	-0.0414	0.5933	-0.0503
Other types of fat**	0.3844	-0.0494	0.4499	-0.0711
Fast-food products, g	0.0646	-0.1048	0.4378	-0.0731
Sweets and sweetened foods***, g	0.1359	-0.0848	0.6864	-0.0381
Sport products****, g	0.6742	0.0239	0.9374	0.0074
Juices, ml	0.9393	0.0043	0.5191	0.0607
Sweetened beverages, ml	0.0536	-0.1094	0.9718	-0.0033
Ethanol, g	0.6841	-0.0231	0.7111	0.0349
Tea, ml	0.5929	0.0304	0.5489	-0.0565
Coffee, ml	0.3918	0.0486	0.5004	0.0635

Good well-being – 13–25 points; Poor well-being – <13 points in the WHO-5 Well-Being Index. *Mann-Whitney U test; ** margarine and fat mix for spreading; *** table sugar and honey included; **** protein and/or carbohydrate powders, energy gels. isotonic drinks. protein and energy bars
* non-parametric Spearman's rank correlation

Table 4S. Analysis of the correlation between well-being status (the WHO-5-Index) and the nutrient intake per 1000 kcal of diet in physically active adults (n=427)

Parameters (per 1000 kcal of diet)	Women		Men	
	P-value	R*	*P*-value	R*
Total protein (g)	0.8267	0.0124	0.1333	0.1408
Total fat (g)	0.3946	-0.0484	0.5482	0.0566
Total carbohydrates (g)	0.3724	0.0507	0.5757	0.0527
Dietary fiber (g)	0.1184	0.0886	0.5601	0.0549
Vitamin A (µg RAE)	0.0491	0.1115	0.0558	0.1789
Vitamin B1 (mg)	0.6915	0.0226	0.0671	0.1714
Vitamin B2 (mg)	0.3616	0.0518	0.0901	0.1588
Vitamin B6 (mg)	0.4149	0.0463	0.3016	0.0972
Folate (µg)	0.4220	0.0456	0.1875	0.1238
Vitamin B12 (µg)	0.7841	0.0156	0.0353	0.1965
Vitamin C (mg)	0.1546	0.0808	0.1208	0.1455
Vitamin E (mg α-TE)	0.5794	0.0315	0.7972	0.0242
Calcium (mg)	0.3590	-0.0521	0.1888	0.1234
Magnesium (mg)	0.0826	0.0984	0.2436	0.1096
Potassium (mg)	0.0052	-0.1579	0.2772	-0.1218
Iron (mg)	0.2723	0.0623	0.1274	0.1430
Zinc (mg)	0.4230	0.0455	0.1906	0.1229
Copper (mg)	0.0063	-0.1545	0.1355	-0.1401

Good well-being – 13–25 points; Poor well-being – <13 points in the WHO-5 Well-Being Index. RAE – retinol activity equivalents; α-TE – alpha-tocopherol equivalents. * non-parametric Spearman's rank correlation

CONCLUSION

The cross-sectional results obtained indicate that lower perceived stress is a key independent predictor of better well-being among physically-active adults. Furthermore, higher nutrient densities of specific nutrients may be positively associated with well-being, whereas well-being appears unrelated to energy availability. While the direction of causality cannot be determined, these results highlight the potential importance of both psychological factors and a nutrient-dense diet in supporting well-being in physically-active amateur adults.

Abbreviations: BM – body mass; BMI – Body Mass Index; CAWI – Computer-Assisted Web Interview; d – day; EA – energy availability; EE – energy expenditure; EEE – exercise energy expenditure (kilocalories per day); FFQ – food frequency questionnaire; g – grams; g/d – grams per day; kcal – kilocalories; kg – kilograms; m – meters; MET – metabolic equivalent of task; MET-h/d – MET-hours per day; min – minutes; PA – physical activity; VAS – Visual Analogue Scale for stress; WADA – World Anti-Doping Agency; WHO-5 Index – World Health Organization Five Well-Being Index.

Table 1. Characteristics of participants stratified by well-being status

Parameters	Women (n=312)			Men (n=115)		
	Good well-being (n=199)	Poor well-being (n=113)	*P*-value*	Good well-being (n=81)	Poor well-being (n=34)	*P*-value*
Basic parameters						
WHO-5 Index (scores)	16.7 ± 3.0[a]	8.5 ± 3.0	<0.001	17.5 ± 3.2	9.6 ± 2.5	<0.001
Age (years)	29.9 ± 6.0	29.6 ± 5.2	0.68	31.6 ± 6.2	30.1 ± 4.5	0.10
Place of residence %						
Rural	18.6	21.2		16.0	11.8	
Urban <100,000	28.1	23.9	0.68	42.0	20.6	0.04
Urban >100,000	53.3	54.9		42.0	67.7	
Educational level, %						
University	70.9	81.4	0.04	53.1	73.5	0.04
High school or lower	29.1	18.6		46.9	26.5	
Marital status, %						
Single	22.6	28.3		38.3	50.0	
Partner	41.7	40.1	0.49	23.4	20.6	0.50
Married	35.7	31.0		38.3	29.4	
Overall health parameters						
Body Mass Index (kg/m^2)	23 ± 3.6	23.1 ± 5.0	0.57	25 ± 3.5	25 ± 6.0	0.28
Body Mass Index (kg/m^2), %						
< 18.5	6.5	7.1		1.2	0.0	
18.5–24.9	74.9	74.3	0.98	55.6	67.6	0.42
≥ 25	18.6	18.6		43.2	32.4	
Overall health status (self-reported), %						
Average or poor	16.1	30.1		11.1	38.2	
Good	59.8	67.3	<0.001	64.2	55.9	<0.001
Very good	24.1	2.7		24.7	5.9	
Cigarette smoking, %	19.1	20.4	0.79	28.4	29.4	0.91
Alcohol drinking, %	58.3	58.4	0.98	55.6	67.6	0.23
Contraceptive pills usage**, %	28.1	41.6	0.02	-	-	-
Physical activity parameters						
Exercise duration (min/week)	281 ± 167	247 ± 145	0.11	399 ± 223	385 ± 253	0.65
Exercise MET (MET-h/d)	9.2 ± 5.6	9.4 ± 6.0	0.22	14 ± 10	12 ± 8	0.40
EEE (kcal/d)	638 ± 411	620 ± 520	0.20	1154 ± 849	967 ± 627	0.38

WHO-5 Index – WHO-5 Well-Being Index (0–25 points); good well-being – 13–25 points; poor well-being – <13 points; EEE – exercise energy expenditure; * p-values calculated using the U Mann-Whitney test for continuous variables and Pearson's Chi-square test for categorised variables; ** last 12 months; [a] – mean ± SD, all such values.

Table 2. Characteristics of energy availability and stress status stratified by well-being status

Parameters	Women			Men		
	Good well-being (n=199)	Poor well-being (n=113)	P-value*	Good well-being (n=81)	Poor well-being (n=34)	P-value*
Energy availability parameters, mean ± SD						
Energy intake (kcal/d)	1977 ± 1138	2232 ± 1256	0.64	2618 ± 1460	2438 ± 1437	0.47
TEE (kcal/d)	1006 ± 533	980 ± 652	0.39	1441 ± 877	1292 ± 664	0.59
EA (kcal/kg BM/day)	25 ± 23	23 ± 20	0.85	19 ± 20	19 ± 22	0.96
Stress status parameters						
Stress level – VAS (points), mean ± SD	4.8 ± 1.8	6.4 ± 2.0	<0.001	4.3 ± 1.8	6.0 ± 1.6	<0.001
Stress level – VAS, %						
Low (0–3 points)	26.6	8.0		38.3	5.9	
Moderate (4–6 points)	52.8	38.9	<0.001	50.6	58.8	<0.001
High (7–10 points)	20.6	53.1		11.1	35.3	
Psychologist, %	17.1	26.5	0.05	3.7	20.6	0.003

Good well-being – 13–25 points; Poor well-being – <13 points in the WHO-5 Well-Being Index.; EA – Energy Availability; BM – Body Mass; VAS – visual analogue scale of stress level (0 – no stress at all; 10 – very high stress); TEE – total energy expenditure; *p-values were calculated using the U Mann-Whitney test for continuous variables and Pearson's Chi-square test for categorical variables.

Table 3. Food consumption per 1000 kcal of diet stratified by well-being status (mean ± SD)

Food consumption (grams/ml per 1,000 kcal of diet)	Woman			Man		
	Good well-being (n=199)	Poor well-being (n=113)	P-value*	Good well-being (n=81)	Poor well-being (n=34)	P-value*
Fruits, g	106 ± 101	77 ± 58	0.02	116 ± 158	83 ± 81	0.74
Vegetables, g	132 ± 109	121 ± 121	0.14	122 ± 129	91 ± 78	0.40
Potatoes, g	23 ± 24	23 ± 23	0.95	30 ± 39	27 ± 31	0.73
Whole grains, g	37 ± 39	36 ± 37	0.17	43 ± 58	53 ± 48	0.07
Refined grains, g	41 ± 38	48 ± 43	0.16	65 ± 64	65 ± 46	0.59
Legumes, g	11 ± 18	11 ± 18	0.73	21 ± 64	11 ± 23	0.49
Dairy products, g	96 ± 100	101 ± 91	0.32	139 ± 273	131 ± 105	0.45
Eggs, g	26 ± 34	37 ± 176	0.21	37 ± 93	16 ± 20	0.25
Fish and seafood, g	14 ± 30	13 ± 37	0.20	24 ± 85	14 ± 22	0.73
Poultry, g	20 ± 23	22 ± 23	0.33	34 ± 35	36 ± 30	0.47
Unprocessed red meat, g	12 ± 21	12 ± 17	0.49	24 ± 27	20 ± 21	0.45
Processed meat, g	17 ± 27	20 ± 27	0.08	23 ± 26	27 ± 27	0.32
Nuts, g	8 ± 10	6 ± 8	0.23	11 ± 17	10 ± 28	0.16
Seeds, g	2 ± 3	2 ± 3	0.30	3 ± 10	1.2 ± 3	0.68
Olive oil and other oils, g	8 ± 11	11 ± 17	0.16	6 ± 10	7 ± 9	0.52
Animal fat, g	7 ± 11	9 ± 14	0.43	11 ± 20	11 ± 16	0.27
Other types of fat**, g	0.8 ± 3	2 ± 7	0.09	2 ± 7	2 ± 4	0.27
Fast-food products, g	13 ± 22	19 ± 29	0.05	22 ± 36	23 ± 31	0.71
Sweets and sweetened foods***, g	29 ± 60	37 ± 40	0.07	40 ± 43	39 ± 47	0.68
Sport products****, g	14 ± 40	11 ± 30	0.72	31 ± 57	22 ± 42	0.49
Juices, g	31 ± 65	27 ± 61	0.91	50 ± 117	35 ± 68	0.79
Sweetened beverages, ml	29 ± 59	41 ± 78	0.09	100 ± 203	59 ± 77	0.91
Alcoholic beverages, ml	19 ± 36	17 ± 31	0.81	67 ± 131	38 ± 76	0.30
Ethanol, g	2 ± 3	1 ± 2	0.84	3.2 ± 5.6	1.6 ± 3.1	0.25
Tea, ml	202 ± 199	202 ± 246	0.60	154 ± 235	138 ± 192	0.62
Coffee, ml	191 ± 223	182 ± 234	0.29	165 ± 249	101 ± 105	0.54

Good well-being – 13–25 points; Poor well-being – <13 points in the WHO-5 Well-Being Index. * Mann-Whitney U test; ** margarine and fat mix for spreading; *** table sugar and honey included; **** protein and/or carbohydrate powders, energy gels, isotonic drinks, protein and energy bars.

Table 4. Nutrient intake per 1,000 kcal of diet stratified by well-being status (mean ± SD).

Parameters (per 1000 kcal of diet)	Woman			Man		
	Good well-being (n=199)	Poor well-being (n=113)	P-value*	Good well-being (n=81)	Poor well-being (n=34)	P-value*
Total protein (g)	41 ± 11	40 ± 13	0.57	56 ± 36	50 ± 25	0.72
Total fat (g)	41 ± 11	44 ± 12	0.08	53 ± 35	51 ± 37	0.56
Total carbohydrates (g)	120 ± 27	115 ± 27	0.08	165 ± 103	151 ± 85	0.70
Dietary fiber (g)	13 ± 5	12 ± 6	0.02	14 ± 11	13 ± 8	0.88
Vitamin A (µg RAE)	768 ± 532	652 ± 497	0.01	1084 ± 1338	593 ± 418	0.05
Vitamin B1 (mg)	0.6 ± 0.2	0.6 ± 0.2	0.72	0.9 ± 0.6	0.7 ± 0.4	0.27
Vitamin B2 (mg)	0.9 ± 0.3	0.9 ± 0.4	0.16	1.2 ± 0.9	1.0 ± 0.6	0.36
Vitamin B6 (mg)	1 ± 0.5	1.1 ± 0.6	0.22	1.5 ± 1.0	1.5 ± 0.8	0.90
Folate (µg)	205 ± 85	191 ± 91	0.05	223 ± 176	173 ± 91	0.31
Vitamin B12 (µg)	2.8 ± 2.4	2.6 ± 2.8	0.30	5 ± 7	4 ± 3	0.46
Vitamin C (mg)	68 ± 38	60 ± 38	0.02	69 ± 56	50 ± 34	0.13
Vitamin E (mg α-TE)	8 ± 3	8 ± 3	0.94	9 ± 7	9 ± 7	0.61
Calcium (mg)	411 ± 154	418 ± 616	0.62	486 ± 421	433 ± 241	0.62
Magnesium (mg)	206 ± 65	189 ± 66	0.02	240 ± 160	214 ± 113	0.67
Potassium (mg)	1892 ± 588	1716 ± 577	0.01	2198 ± 1426	1827 ± 936	0.28
Iron (mg)	8 ± 2	7 ± 3	0.05	9 ± 6	8 ± 4	0.46
Zinc (mg)	6 ± 1	5 ± 2	0.16	7 ± 4	6 ± 3	0.70
Copper (mg)	0.7 ± 0.3	0.6 ± 0.3	0.01	0.8 ± 0.6	0.6 ± 0.4	0.14

Good well-being – 13–25 points; Poor well-being – <13 points in the WHO-5 Well-Being Index. RAE – retinol activity equivalents; α-TE – alpha-tocopherol equivalents; * Mann-Whitney U test

Table 5. Predictors of well-being (WHO-5-Index) in physically active adults (n=427)

Study factors	Unit	Multivariate-Adjusted OR (95% CI)	P-trend per 1 unit
Baseline predictors (Model 1)			
Age	years	1.02 (0.98–1.06)	0.45
Male	-	1.00 (Ref.)	
Female	-	0.93 (0.56–1.58)	0.81
Body Mass Index	kg/m^2	0.98 (0.93–1.03)	0.45
EA	kcal/kg BM/day	1.01 (0.63–1.62)	0.96
VAS stress scale	points	0.62 (0.54–0.70)	<0.001
Nutrient density (Model 2)	**Per 1000 kcal**		
Total protein	25 g	1.01 (0.99–1.03)	0.42
Total fat	25 g	0.63 (0.38–1.05)	0.08
Total carbohydrates	25 g	1.16 (0.94–1.44)	0.16
Dietary fiber	1 g	1.03 (0.99–1.06)	0.17
Vitamin A	50 µg RAE	1.04 (1.02–1.07)	<0.001
Vitamin B_1	1 mg	1.51 (0.65–3.50)	0.34
Vitamin B_2	1 mg	1.49 (0.90–2.48)	0.12
Vitamin B_6	1 mg	1.07 (0.74–1.54)	0.72
Folate	25 µg	1.09 (1.01–1.17)	0.02
Vitamin B_{12}	1 µg	1.09 (1.00–1.18)	0.05
Vitamin C	25 mg	1.01 (1.00–1.01)	0.18
Vitamin E	25 mg α-TE	1.02 (0.94–1.10)	0.66
Calcium	25 mg	1.00 (0.96–1.03)	0.89
Magnesium	25 mg	1.08 (0.99–1.17)	0.11
Potassium	50 mg	1.02 (1.00–1.05)	0.02
Iron	1 mg	1.08 (1.00–1.16)	0.05
Zinc	1 mg	1.07 (0.96–1.19)	0.24
Copper	1 mg	2.16 (1.19–3.91)	0.01

OR – odds ratio; CI – confidence interval; EA – energy availability; BM – body mass; WHO-5-Index – Well-Being Index (0–25 points); VAS – visual analogue scale; RAE – retinol activity equivalents; α-TE – alpha-tocopherol equivalents. **Model 1** – adjusted for age (continuous), gender (male / female), BMI (continuous), EA level (continuous), and stress levels (measured via VAS, continuous); **Model 2** – each nutrient adjusted for the covariates included in Model 1.

REFERENCES

1. WHO. Physical activity and adults. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/physical-activity (access: 2026.06.25).
2. Gautam S, Jain A, Chaudhary J, et al. Concept of mental health and mental well-being, its determinants and coping strategies. Indian J Psychiatry. 2024 Jan;66(Suppl 2):S231–44.
3. Schweren LJS, Larsson H, Vinke PC, et al. Diet quality, stress and common mental health problems: A cohort study of 121,008 adults. Clin Nutr Edinb Scotl. 2021 Mar;40(3):901–6.
4. White RL, Vella S, Biddle S, et al. Physical activity and mental health: a systematic review and best-evidence synthesis of mediation and moderation studies. Int J Behav Nutr Phys Act. 2024 Nov 28;21(1):134.
5. Iasiello M, Ali K, Van Agteren J, et al. What's the difference between measures of wellbeing, quality of life, resilience, and coping? An umbrella review and concept map of 155 measures of positive mental health. Int J Wellbeing. 2024 May 31;14(2):1–25.
6. Singh B, Olds T, Curtis R, et al. Effectiveness of physical activity interventions for improving depression, anxiety and distress: an overview of systematic reviews. Br J Sports Med. 2023 Sep;57(18):1203–9.
7. Schuch FB, Vancampfort D, Firth J, et al. Physical Activity and Incident Depression: A Meta-Analysis of Prospective Cohort Studies. Am J Psychiatry. 2018 Jul 1;175(7):631–48.
8. Meegan AP, Perry IJ, Phillips CM. The Association between Dietary Quality and Dietary Guideline Adherence with Mental Health Outcomes in Adults: A Cross-Sectional Analysis. Nutrients. 2017 Mar 5;9(3):238.
9. Kaluza J, Lozynska K, Rudzinska J, et al. Mediterranean-Style Diet and Other Determinants of Well-Being in Omnivorous, Vegetarian, and Vegan Women. Nutrients. 2023 Feb 1;15(3):725.
10. Van Der Wurff I, Golsteijn R, Stamhuis I, et al. The association between Mediterranean diet, fruit and vegetable consumption, mental well-being, and quality of life in Dutch adults: a longitudinal study. Eur J Nutr. 2025 Aug;64(5):243.
11. Çıtar Dazıroğlu ME, Bilici S, Türker PF. Associations of Dietary Inflammatory and Antioxidant Indices with Mental Health Indicators Among University Students: A Cross-Sectional Study. Nutrients. 2025 Jul 26;17(15):2442.
12. Lane MM, Gamage E, Travica N, et al. Ultra-Processed Food Consumption and Mental Health: A Systematic Review and Meta-Analysis of Observational Studies. Nutrients. 2022 Jun 21;14(13):2568.
13. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983 Dec;24(4):385–96.
14. Schuch FB, Vancampfort D. Physical activity, exercise, and mental disorders: it is time to move on. Trends Psychiatry Psychother. 2021;43(3):177–84.
15. Mountjoy M, Sundgot-Borgen JK, Burke LM, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. Br J Sports Med. 2018 Jun;52(11):687–97.
16. Loucks AB, Callister R. Induction and prevention of low-T3 syndrome in exercising women. Am J Physiol-Regul Integr Comp Physiol. 1993 May 1;264(5):R924–30.
17. Herrmann SD, Willis EA, Ainsworth BE, et al. 2024 Adult Compendium of Physical Activities: A third update of the energy costs of human activities. J Sport Health Sci. 2024 Jan;13(1):6–12.
18. World Anti-Doping Agency (WADA). The World Anti-Doping Agency: Prohibited List. World Anti-Doping Agency. https://www.wada-ama.org/en/prohibited-list (access: 2026.06.25).
19. Topp CW, Østergaard SD, Søndergaard S, et al. The WHO-5 Well-Being Index: A Systematic Review of the Literature. Psychother Psychosom. 2015;84(3):167–76.
20. Cichoń E, Kiejna A, Kokoszka A, et al. Validation of the Polish version of WHO-5 as a screening instrument for depression in adults with diabetes. Diabetes Res Clin Pract. 2020 Jan;159:107970.
21. Szmidt MK, Sicinska E, Januszko O, et al. FFQ-NutriForHer: Reproducibility and Validity of a Semi-Quantitative Food Frequency Questionnaire for Young and Older Women. Nutrients. 2025 Dec 5;17(24):3811.
22. Dias IH, Griffiths HR, Milward MR, et al. Antioxidant micronutrients and oxidative stress biomarkers. In: Seymour GJ, Cullinan MP, Heng NCK, Cooper PR, editors. Oral Biology. New York (NY): Springer US; 2023. p. 41–58. doi:10.1007/978–1–0716–2780–8_4.
23. Huang Q, Liu H, Suzuki K, et al. Linking What We Eat to Our Mood: A Review of Diet, Dietary Antioxidants, and Depression. Antioxidants. 2019 Sep 5;8(9):376.
24. Mountjoy M, Sloan S, Ali-Zada M, et al. International Olympic Committee consensus-driven guidelines for athlete mental health support at sporting events. Br J Sports Med. 2025 Nov 26;59(21).
25. Loucks AB, Thuma JR. Luteinizing Hormone Pulsatility Is Disrupted at a Threshold of Energy Availability in Regularly Menstruating Women. J Clin Endocrinol Metab. 2003 Jan;88(1):297–311.