



Adherence to the Mediterranean Diet, emotional well-being and lifestyle patterns in Spain: A cross-sectional study

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ABSTRACT

Objectives: This study examined whether adherence to the Mediterranean Diet (MedDiet) is associated with emotional states, lifestyle behaviors, and subjective well-being in Spanish adults.

Methods: We conducted a cross-sectional survey in Spain between July and October 2023 of 2751 adults across 14 major cities. Participants completed digital questionnaires on weekly frequency of six basic emotions, anxiety, life satisfaction, happiness, and health behaviors. MedDiet adherence was assessed via a weighted 15-item score and categorized into tertiles. Associations were examined using multivariate, covariate-adjusted models.

Results: Higher MedDiet adherence was significantly associated with greater joy and surprise, and lower anger, disgust, and sadness (all $p < 0.05$). Participants in the highest tertile reported more frequent sport ($p < 0.01$), cooking, and social activities, along with higher life satisfaction and happiness ($p < 0.01$). Beer and wine showed distinct patterns: beer was linked to greater anger, whereas wine related to more sport and reduced anxiety.

Conclusions: MedDiet adherence reflects a lifestyle characterized by emotional balance and well-being, with distinct psychosocial patterns for wine and beer.

1. Introduction

The Mediterranean Diet (MedDiet) is widely recognized as a plant-forward, minimally processed eating pattern centered on vegetables, fruits, legumes, nuts, and extra virgin olive oil, with moderate fish and white meat intake, limited red and processed meats, and convivial consumption of fermented beverages such as wine and, regionally, beer (Bach-Faig et al., 2011). Over the past two decades, higher MedDiet adherence has been linked to cardiometabolic, neurocognitive, and anti-inflammatory benefits (Barber et al., 2023), yet its associations with day-to-day emotional tone and subjective well-being remain comparatively underexplored.

Emerging cross-sectional research in Southern Europe and the Near East suggests that greater MedDiet adherence are associated with higher happiness, life satisfaction, and positive affect (Ferrer-Cascales et al., 2019; Metin and Bakır, 2021), and to lower anxiety and distress (Allcock et al., 2024). Mechanistic studies propose synergistic roles of polyphenols, ω -3 fatty acids, and B vitamins in modulating neuro-inflammation, monoaminergic signaling, and the gut–brain axis (Grosso et al., 2017; Micek et al., 2023). Lifestyle factors integral to Mediterranean culture—physical activity, home cooking, and social engagement—also covary with diet quality (Navarro-Martínez et al., 2022; Pfeifer et al., 2021), while wine and beer consumption have been described as “social lubricants” with potential affective relevance (López

Abbreviations: BMI, Body Mass Index; GLM, General Linear Model; KDE, Kernel Density Estimate; MedDiet, Mediterranean Diet; SWLS, Satisfaction With Life Scale.

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Moreno and Bühler, 2024; Moreno-Llamas and De la Cruz-Sánchez, 2023). Notably, beer and wine drinkers differ in typical socioeconomic and leisure profiles (Grønbaek et al., 1999), suggesting beverage-specific psychosocial correlates.

Despite these insights, three gaps persist. First, most prior work relies on composite mood or distress indices, obscuring potential emotion-specific associations. Second, little is known about how the MedDiet relates to discrete life satisfaction domains—such as work, health, or time use—that jointly shape global well-being (OECD, 2013). Third, wine and beer are often analyzed together or omitted, limiting the ability to examine their distinct emotional and behavioral signatures. Although recent studies have linked MedDiet adherence to global well-being (Godos et al., 2025; Camprodón-Boadas et al., 2025), few have jointly examined emotion-specific patterns, domain-level life satisfaction, fermented beverage distinctions, and contextual lifestyle factors. By integrating these dimensions, this study provides a more detailed account of how Mediterranean dietary patterns relate to everyday affective and lifestyle profiles.

Building on this framework, the primary objective was to test whether higher MedDiet adherence is associated with a more favorable emotional profile and greater subjective well-being in a large, nationally representative Spanish cohort. We hypothesized that: (a) individuals in the highest adherence tertile would report more frequent positive emotions and fewer negative emotions and anxiety; (b) higher adherence would coincide with healthier lifestyle behaviors and greater global and domain-specific life satisfaction; and (c) beer and wine would display distinct associations with emotional and satisfaction outcomes.

2. Methods and materials

2.1. Study design and population

We conducted a national cross-sectional study in Spain. A small pilot was carried out to estimate response times and potential inconveniences for participants, but those data were not included in the final analyses. The sample size was calculated with a 95 % confidence interval and a 2 % margin of error, giving a target of about 2400 individuals. In total, 2957 adults were recruited, and 206 incomplete questionnaires were excluded, resulting in a final valid sample of 2751 participants.

The study covered all Spanish cities with more than 150,000 residents, except those in the Canary and Balearic Islands. This included Madrid, Barcelona, Logroño, Badajoz, Santander, Albacete, Pamplona, Gijón, Vigo, Valladolid, Bilbao, Murcia, Zaragoza, Sevilla, and Valencia, representing all Autonomous Communities of mainland Spain. Within each city, quotas were proportional to population size to ensure balanced representation. Eligible participants were aged 18 years or older, with no upper age limit.

Data were collected through digital tablets provided to each participant. Questionnaires were administered between 5 and 11 PM on Tuesdays, Wednesdays, and Thursdays, in order to minimize the influence of weekend-related habits.

All participants were informed about the objectives of the study and relevant procedural details, including compliance with the General Data Protection Regulation (GDPR, EU 2016/679) and the Spanish Organic Law 3/2018 on the Protection of Personal Data and Guarantee of Digital Rights. The questionnaire was fully anonymous, and all data were used exclusively for research purposes. In accordance with Spanish legislation (Law 14/2007 on Biomedical Research and Organic Law 3/2018), this anonymous, observational study involving adult participants in public spaces did not require approval from a Research Ethics Committee, as it involved no collection of personal or sensitive data, and no biomedical or psychological intervention.

2.2. Measures

Participants completed the survey on tablet devices (Huawei

Mediapad T3); responses were stored locally and backed up on secure servers. Median completion time was approximately 11 min.

The survey comprised three blocks. (a) Mediterranean Diet and beverages: Dietary habits were assessed with 15 items adapted from the Mediterranean Diet pyramid (e.g., vegetables, fruits, legumes, nuts, cereals, dairy, olive oil, fish/seafood, meats, potatoes, sweets), each rated from 0 to 10 and weighted from 1 (low adherence) to 6 (high adherence). Scores were summed to obtain an overall MedDiet adherence score, which was normally distributed and divided into tertiles (low, medium, high adherence). Weekly beer and wine consumption were recorded using the same response format. (b) Emotions and anxiety: Participants rated the weekly frequency of seven emotional states—joy, sadness, anger, surprise, anxiety, disgust, and fear—on a 0–10 scale. (c) Lifestyle and well-being: Following OECD guidelines, satisfaction with seven life domains (work, income, social life, health, leisure, time use, and love life) was rated on a 0–10 scale. Global life satisfaction was assessed with the 5-item Satisfaction With Life Scale (SWLS, Likert 1–5). Additional items captured sport and sleep hours, frequency of social meetings, cooking hours, and happiness. Self-reported height and weight were used to calculate BMI. Age and sex were collected at the end.

Data were collected between July and October 2023.

2.3. Statistical analysis

Data were collected from participants nested within 14 cities across Spain. Although participants were recruited from multiple urban centers, preliminary intraclass correlation coefficients (ICCs) for the primary outcomes (emotional states, lifestyle variables, and satisfaction domains) were negligible (ICCs <0.02), indicating minimal clustering by city. Consequently, city-level random effects were not incorporated into the primary analyses. All models adjusted for age and sex as individual-level covariates.

Continuous variables are presented as means and standard deviations, and categorical variables as frequencies. MedDiet adherence served as the main independent variable and was categorized into tertiles using the weighted MedDiet score ($\leq$ mean – 1 SD; mean $\pm$ 1 SD; $\geq$ mean + 1 SD).

To examine the associations between MedDiet adherence and emotional states, we first conducted a multivariate analysis of covariance (MANCOVA) adjusting for age, sex, and each participant's mean emotional frequency. When the multivariate test reached significance, we performed univariate ANCOVAs with planned contrasts comparing low vs. high and medium vs. high adherence.

Separate ANCOVAs, adjusted for age and sex, were used to evaluate the associations between MedDiet adherence and lifestyle variables, including sport participation, social interactions, cooking time, sleep, BMI, and well-being indicators (SWLS scores, general life satisfaction, and happiness). Tukey's HSD was applied for post-hoc comparisons following significant omnibus tests.

Satisfaction across seven life domains was analyzed using a multivariate general linear model controlling for age, sex, and satisfaction bias, followed by univariate ANCOVAs with planned contrasts.

Finally, partial Pearson correlations—adjusted for age and sex—were computed to explore associations among individual MedDiet components, beverage consumption (beer and wine), emotional frequencies, lifestyle behaviors, and domain-specific satisfaction. Statistical significance was defined as $p < 0.05$ (two-tailed).

All models included age and sex as covariates, as these demographic factors are consistently related to both dietary behavior and emotional well-being. Other potentially relevant confounders—such as socioeconomic status, educational attainment, personality traits, and chronic health conditions—were not available in the dataset and could not be included. Therefore, the reported effect estimates should be interpreted as associations adjusted only for demographic characteristics, with the possibility of residual confounding.

All analyses were conducted using SPSS v29.

3. Results

The analytic sample comprised 2751 adults (53.9 % men; mean age 29 years) with an average BMI of 23.8, within the normal range (Fig. 1A). The weighted MedDiet adherence score followed a normal distribution and was classified into low (16 %), medium (68 %), and high (16 %) adherence tertiles (Fig. 1B).

3.1. Frequency of emotions and Mediterranean Diet adherence

MedDiet adherence was significantly associated with the emotional profile ($p < 0.05$; Fig. 2). Participants with higher adherence reported more joy and surprise, and less anger, disgust, and sadness. Anxiety showed modest differences, while fear did not vary. (See Supplementary Table S1 for detailed statistics).

3.2. Health- and lifestyle-related variables and Mediterranean Diet adherence

Lifestyle patterns differed clearly across tertiles (Fig. 3). Participants with high adherence engaged in about twice as many weekly sport hours as those with low adherence and also reported more cooking and social meetings. Both general life satisfaction and happiness rose with adherence, whereas sleep duration and BMI showed no significant differences.

(See Supplementary Table S2).

3.3. Seven satisfaction domains and Mediterranean Diet adherence

At the domain level (Fig. 4), higher adherence was linked to greater satisfaction with health and time use. Job satisfaction peaked in the medium group, while income, leisure, love life, and social life showed no clear variation. (See Supplementary Table S3).

3.4. Interrelationships of Mediterranean Diet components

Correlation analyses (Fig. 5) revealed two clusters. A strong plant-based module (e.g., fruit and vegetables, $r = 0.43$, $p < 0.05$) contrasted with a looser animal-protein cluster. Beer and wine were modestly correlated ($r = 0.26$), but wine was more often consumed with fish/seafood, whereas beer was associated with red/processed meats and potatoes. (See Supplementary Table S4).

3.5. Interrelationships of beer and wine intake with emotional frequency, health behaviors, and life-domain satisfaction

Both beverages were significantly linked to socializing, happiness, and life satisfaction ($p < 0.05$; Fig. 6). Yet distinct patterns emerged: beer was associated with more anger and lower income satisfaction, while wine related to more sport, better time use, and reduced anxiety. (See Supplementary Table S5).

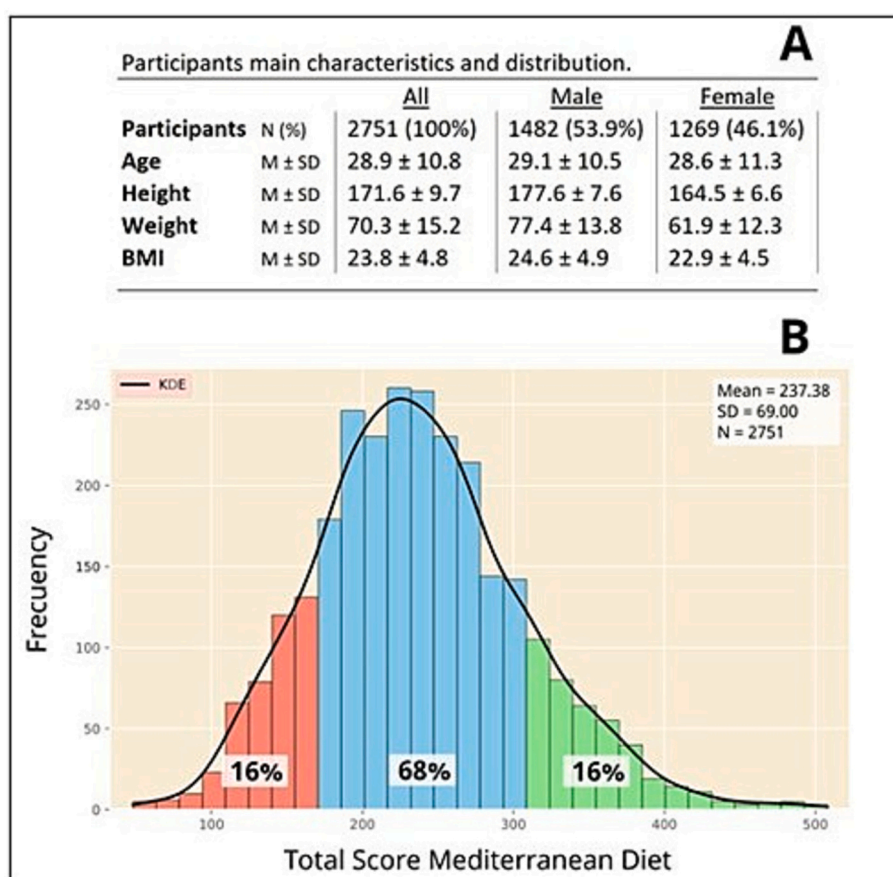


Fig. 1. Descriptive statistics and Mediterranean Diet adherence distribution among Spanish adults ($N = 2751$), Spain, July–October 2023. Panel A shows participant characteristics overall and by sex: number and percentage of participants, age (years), height (cm), weight (kg), and body mass index. Panel B shows a histogram (30 bins) with superimposed kernel density estimate showing the distribution of the total weighted Mediterranean Diet adherence score (mean = 237.38, standard deviation = 69.00). Bars are color-coded to indicate tertiles based on ± 1 standard deviation around the mean: low adherence (≤ 168.4 ; 16 %, red), medium adherence (168.4–306.4; 68 %, blue), and high adherence (≥ 306.4 ; 16 %, green). Abbreviations: BMI, body mass index; KDE, kernel density estimate; SD, standard deviation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

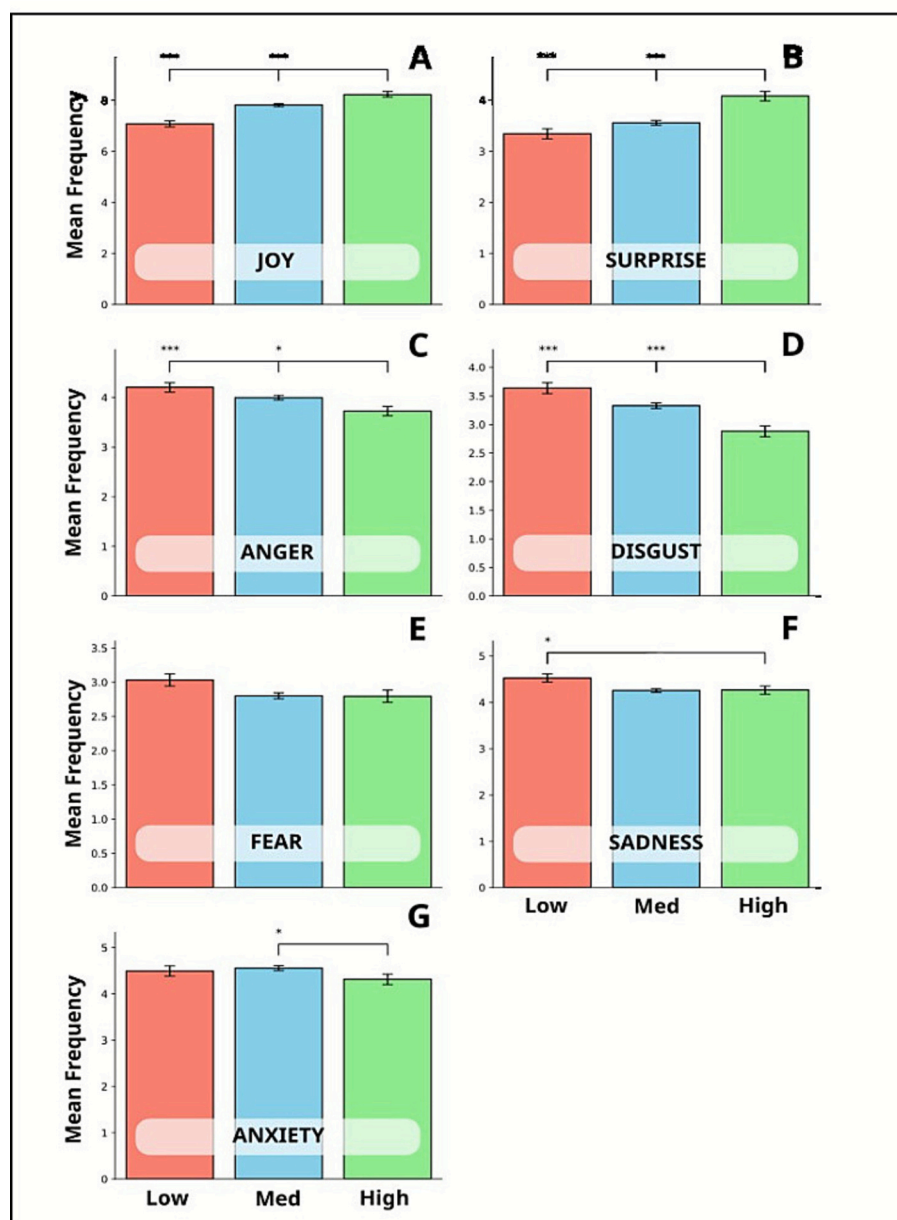


Fig. 2. Mean weekly frequency of basic emotions and anxiety by Mediterranean Diet adherence tertile among Spanish adults ($N = 2751$), Spain, July–October 2023. Panels A–G show estimated marginal means $\pm$ standard error from analyses of covariance controlling for sex, age, and each participant's overall emotional frequency. “Low,” “Med,” and “High” denote the first, second, and third tertiles of the weighted Mediterranean Diet adherence score, respectively. Brackets indicate simple contrasts comparing Low vs. High and Med vs. High adherence groups. Asterisks denote significance levels from planned contrast tests: * $p < 0.05$, *** $p < 0.01$. Abbreviations: Med, medium; SE, standard error.

4. Discussion

Consistent with prior evidence, our data showed a dose-dependent association between MedDiet adherence and everyday emotional experience. After adjusting for age, sex, and overall expressiveness, participants in the highest adherence tertile reported more joy and surprise and less anger, disgust, and sadness than those in the lowest, while anxiety declined modestly and fear remained unchanged (Fig. 2). These results support hypothesis (a) and align with previous work (Ferrer-Cascales et al., 2019), extending it by identifying emotion-specific patterns—particularly in joy, surprise, anger and disgust.

The pattern is biologically plausible. Core MedDiet foods rich in polyphenols, ω -3 fatty acids, and B vitamins modulate

neuroinflammation and monoamine pathways. Conversely, low adherence may increase oxidative stress and disrupt the gut–brain axis, fostering irritability and dysphoria.

These findings require cautious interpretation. Emotional states were assessed with single-item frequency indicators that do not capture intensity, context, or regulation. Residual confounding is possible: although models adjusted for age and sex, key variables such as socioeconomic status, education, personality traits, and chronic health conditions were unavailable.

Our data show a stepwise increase in sport participation as MedDiet adherence rises (Fig. 3A), consistent with previous work (Rosi et al., 2020; Mantzourou et al., 2023), suggesting shared behavioral determinants, including heightened health consciousness and greater time

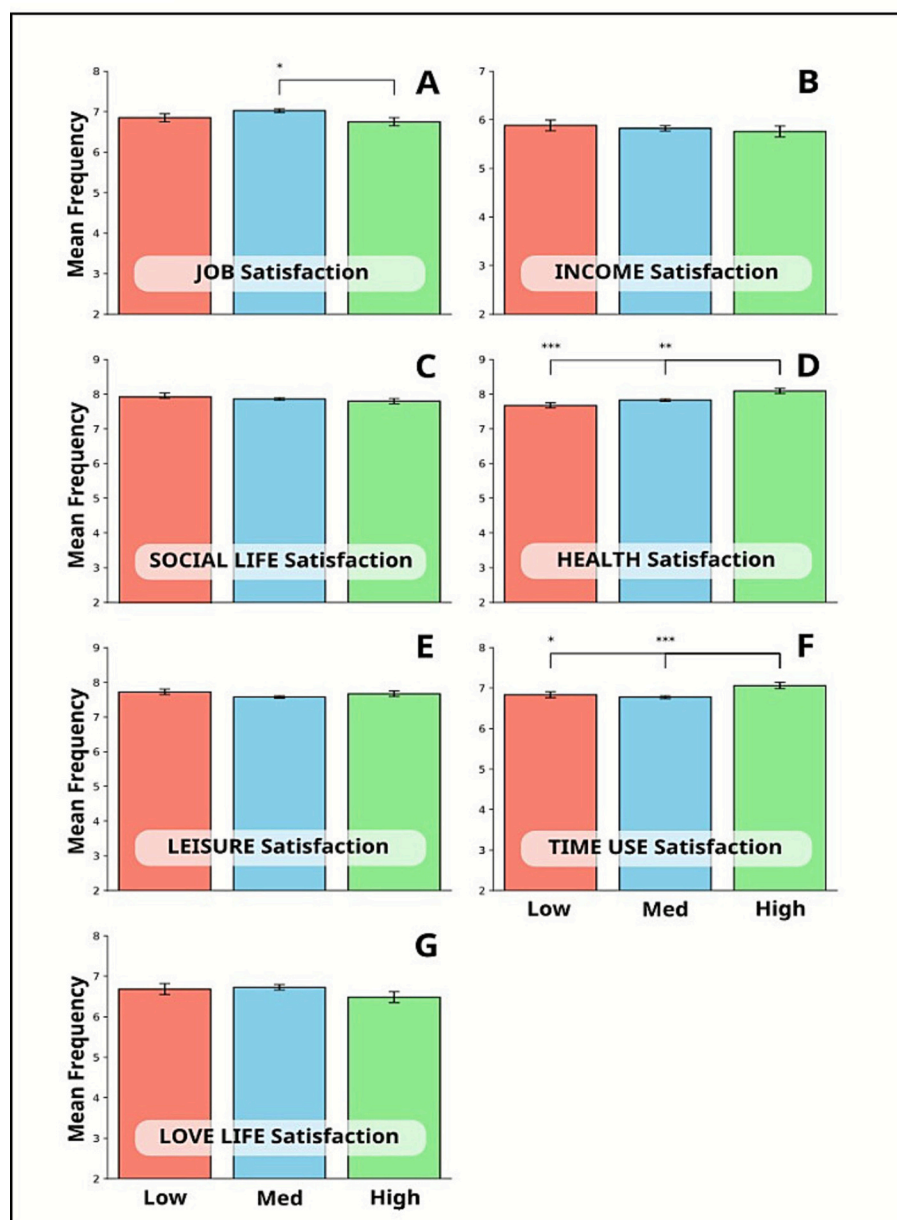


Fig. 3. Lifestyle and well-being variables by Mediterranean Diet adherence tertile among Spanish adults (N = 2751), Spain, July–October 2023. Bars represent estimated marginal means $\pm$ standard error from analyses of covariance controlling for age and sex. “Low,” “Med,” and “High” denote the lower ($\leq$ mean $-$ 1 standard deviation), middle (mean $\pm$ 1 standard deviation), and upper ($\geq$ mean $+$ 1 standard deviation) thirds of the weighted Mediterranean Diet adherence score, respectively. Brackets indicate pairwise Tukey honest significant difference post-hoc comparisons from omnibus tests: * $p < 0.05$; *** $p < 0.01$. No brackets appear for comparisons that did not reach statistical significance. Panels show: (A) sport hours per week, (B) sleep hours per night, (C) social meetings per week, (D) cooking hours per week, (E) Satisfaction With Life Scale total score, (F) body mass index, (G) general life satisfaction rating, and (H) happiness level rating. Abbreviations: BMI, body mass index; Med, medium; SE, standard error; SWLS, Satisfaction With Life Scale.

investment in meal preparation, which likewise increased across adherence tertiles (Fig. 3D).

No associations were found for BMI or sleep, aligning with evidence that diet quality explains little variance in adiposity once activity and energy intake are considered and with heterogeneous findings on MedDiet and sleep (Sánchez et al., 2019; Damigou et al., 2024; Rosi et al., 2017).

The MedDiet is part of a broader lifestyle characterized by cooking and social connectedness. Participants in the highest adherence tertile reported more weekly hours of home cooking and social gatherings (Fig. 3C–D). This aligns with the Croatian COVIDiet study (Pfeifer et al.,

2021) and Turkish data linking cooking skills to higher MedDiet scores (Ünal, 2024). Similarly, greater family cohesion and richer social networks have been associated with stronger MedDiet adherence in Spanish, Italian, and Greek adults (Navarro-Martínez et al., 2022; Marventano et al., 2018; Mamalaki et al., 2020).

We observed a graded increase in overall life satisfaction across adherence levels (Fig. 3E), consistent with findings in Spanish populations (Ferrer-Cascales et al., 2019) and studies showing fruit- and vegetable-rich MedDiet patterns predict higher well-being regardless of adiposity (Godoy-Izquierdo et al., 2021).

At the domain level (Fig. 4), the strongest gains were in health

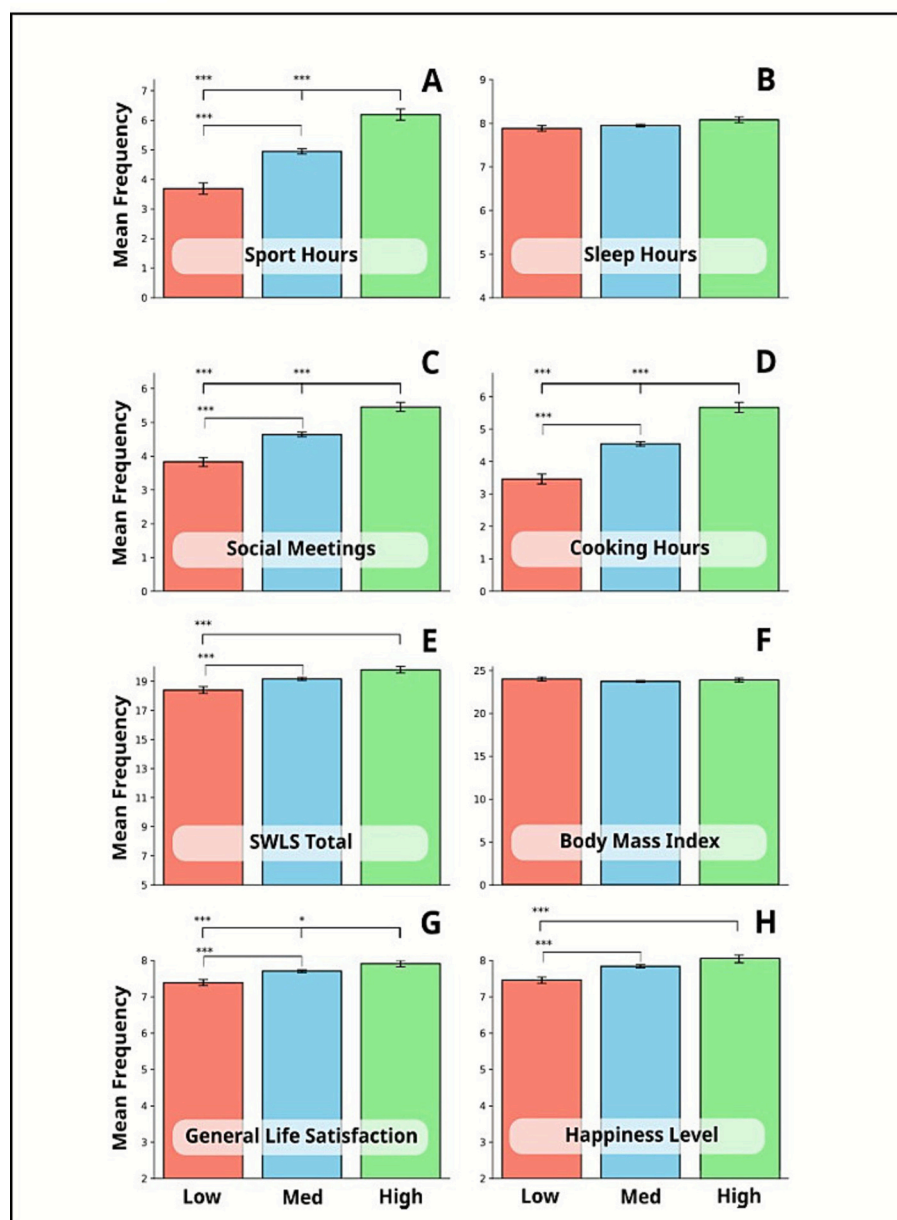


Fig. 4. Seven life-domain satisfaction ratings by Mediterranean Diet adherence tertile among Spanish adults ($N = 2751$), Spain, July–October 2023. Bars represent estimated marginal means $\pm$ standard error from analyses of covariance controlling for age, sex, and overall satisfaction bias. “Low,” “Med,” and “High” denote the lower ($\leq$ mean $- 1$ standard deviation), middle (mean ± 1 standard deviation), and upper ($\geq$ mean $+ 1$ standard deviation) thirds of the weighted Mediterranean Diet adherence score, respectively. Brackets indicate simple-contrast comparisons between Low vs. High and Med vs. High from planned comparison tests: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Panels show satisfaction with: (A) job, (B) income, (C) social life, (D) health, (E) leisure, (F) time use, and (G) love life. Abbreviations: Med, medium; SE, standard error.

satisfaction, consistent with MedDiet's cardiometabolic and anti-inflammatory benefits. Higher adherence was also linked to greater satisfaction with time use, suggesting that structured meal planning may be associated with better daily management. Domains less tied to diet—income, leisure, and love life—showed no change, while job satisfaction peaked in the mid-adherence group.

The stepwise rise in happiness across tertiles (Fig. 3F) echoes experimental findings that MedDiet interventions boost positive affect, plausibly via gut–brain and inflammatory pathways (Ferrer-Cascales et al., 2019).

The correlation matrix (Fig. 5) revealed two clusters reflecting the MedDiet's core structure. A tightly linked plant-based module showed

the strongest associations, consistent with meals emphasizing diversity, unsaturated fats, and antioxidants. This synergy is biologically relevant, as fiber, polyphenols, and ω -3/ ω -9 fatty acids exert additive effects on endothelial function, glycemic control, and gut microbiota (Barber et al., 2023; Zambrano et al., 2024). Animal proteins formed a looser cluster, aligning with evidence that MedDiet components differ in cardiometabolic impact (Grosso et al., 2017). Wine and beer were modestly correlated but linked to distinct foods: wine with fish/seafood, and beer with red/processed meats and potatoes (Román et al., 2019).

Consistent with research portraying fermented beverages as “social lubricants,” both beer and wine were strongly linked to social gatherings and higher happiness and social satisfaction (Fig. 6) (López Moreno and

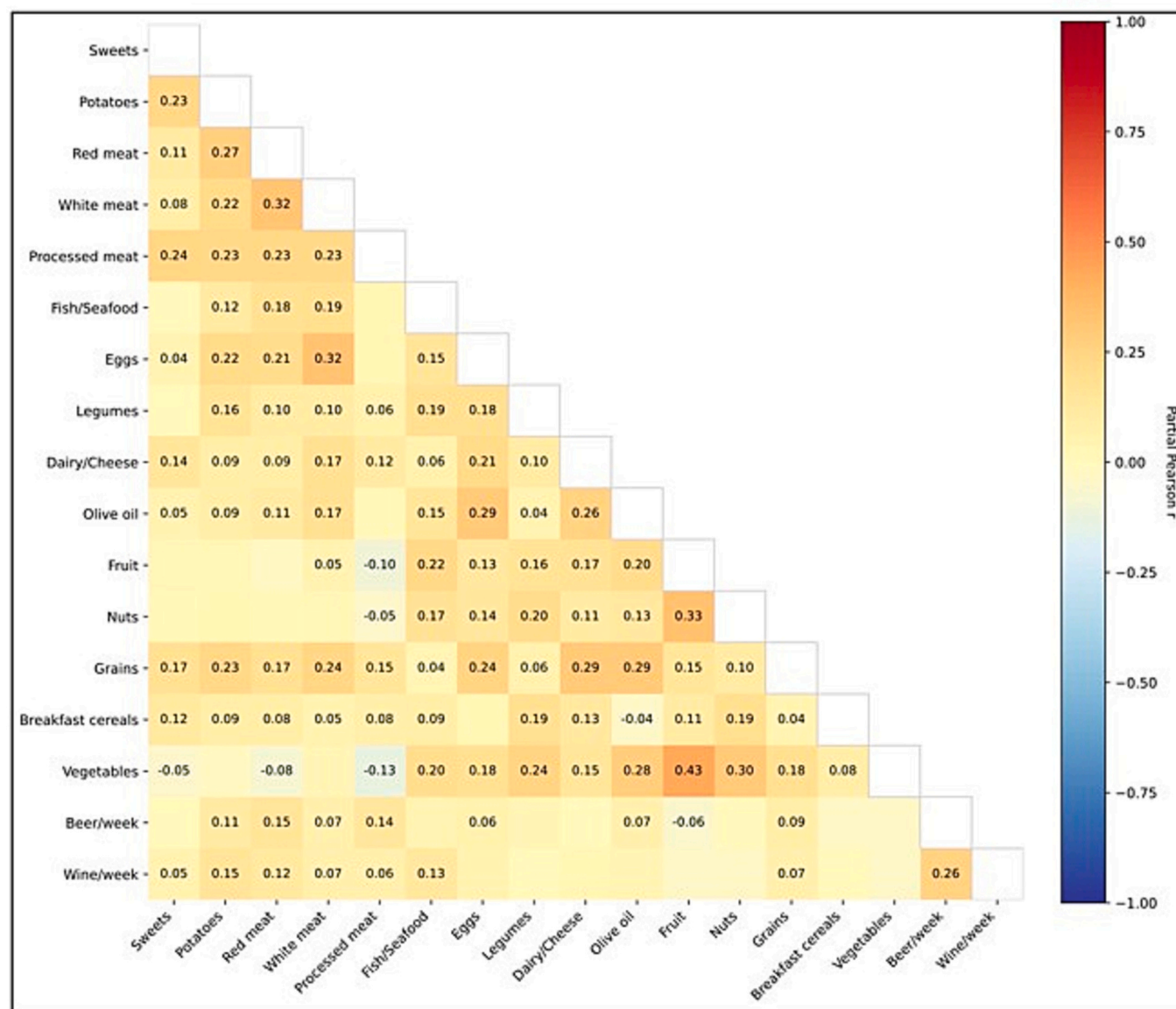


Fig. 5. Partial Pearson correlation coefficients among Mediterranean Diet components, beer, and wine consumption among Spanish adults ($N = 2751$), Spain, July–October 2023. Heat map showing bivariate associations among 15 Mediterranean Diet food components and weekly beer and wine consumption, adjusted for age and sex. Only correlation coefficients significant at $p < 0.05$ from partial Pearson correlation tests are displayed; blank cells indicate non-significant associations. Color intensity corresponds to the magnitude and direction of the correlation coefficient: red indicates positive associations, blue indicates negative associations. Correlation coefficients range from -1.00 (perfect negative correlation) to $+1.00$ (perfect positive correlation). Row and column labels denote individual dietary components. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Bühler, 2024; Moreno-Llamas and De la Cruz-Sánchez, 2023). Yet distinct patterns emerged: beer correlated with anger and lower income satisfaction, resembling profiles of lower-SES, leisure-focused groups (Grønbaek et al., 1999), whereas wine related to more sport and better time use, aligning with healthier lifestyles (González-Rubio et al., 2016). Mechanistically, wine polyphenols such as resveratrol may relate to lower anxiety via gut–brain pathways (Micek et al., 2023), while beer's compounds may be offset by co-consumption with energy-dense foods (Osorio-Paz et al., 2020). All associations were modest. These associations must be interpreted cautiously given possible socioeconomic and cultural confounding. Beer and wine consumers differ systematically in education, income, and lifestyle profiles. Because our dataset lacked socioeconomic indicators, we cannot determine whether observed beverage-related differences reflect beverage-specific patterns or underlying sociodemographic factors. Given the study's partial funding by the Association of Brewers of Spain, findings involving beer

consumption require particular caution: although the funder had no role in data collection, analysis, or interpretation, potential perceived bias cannot be fully excluded.

These findings refine current evidence linking Mediterranean diet adherence to subjective well-being. Beyond confirming associations with global life satisfaction, the study reveals emotion-specific patterns and domain-level differences—particularly in health and time-use satisfaction—that have rarely been examined simultaneously. By incorporating fermented beverage consumption and contextual factors, our analyses show that beer and wine operate within broader lifestyle profiles rather than as isolated correlates of affective states.

This study has several limitations. Its cross-sectional design precludes causal inference. All variables were self-reported, introducing potential recall and social desirability bias, with no objective measures to validate reports. Residual confounding is possible. Analyses adjusted only for age and sex because no socioeconomic or personality-related

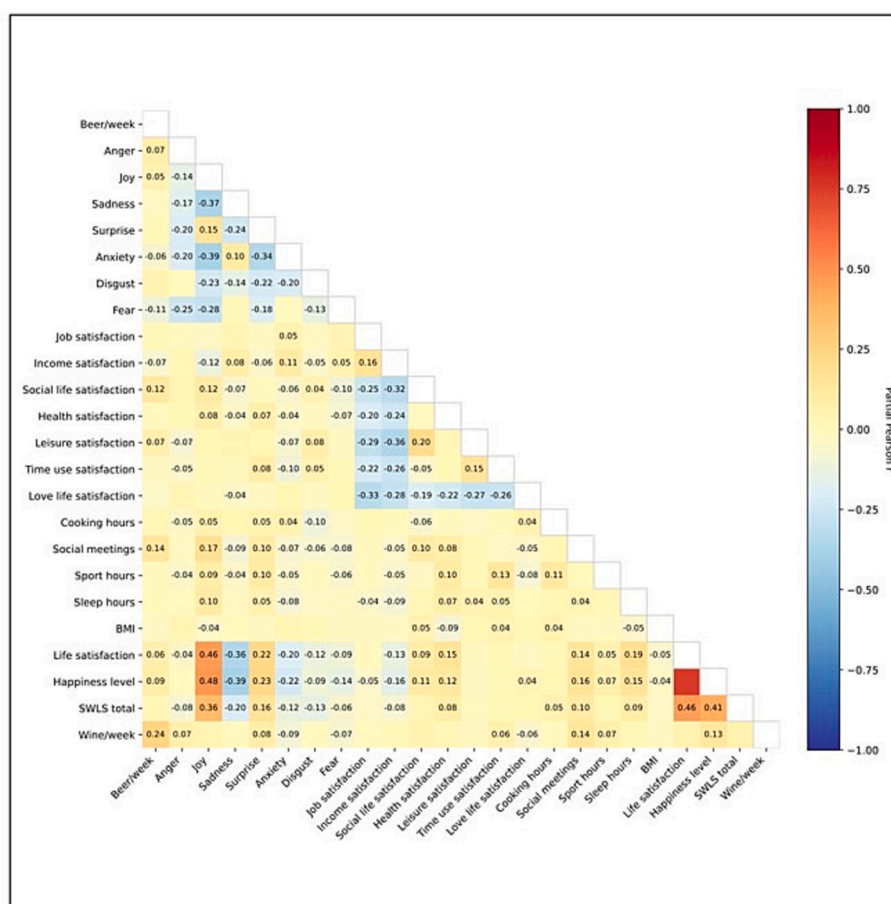


Fig. 6. Partial Pearson correlation coefficients between beer and wine consumption and emotions, health behaviors, and life satisfaction among Spanish adults ($N = 2751$), Spain, July–October 2023. Heat map showing bivariate associations between weekly beer consumption and weekly wine consumption with three sets of variables: (a) frequency of seven discrete emotions and anxiety, (b) eight health and well-being behaviors, and (c) seven life-domain satisfaction ratings. All correlations were adjusted for age and sex; emotional correlations were additionally controlled for mean emotional frequency, and satisfaction correlations were additionally controlled for mean satisfaction level. Only correlation coefficients significant at $p < 0.05$ from partial Pearson correlation tests are displayed; blank cells indicate non-significant associations. Cell color intensity reflects the magnitude and direction of each coefficient: red indicates positive associations, blue indicates negative associations. Abbreviations: BMI, body mass index; SWLS, Satisfaction With Life Scale. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

variables were collected; these unmeasured factors may partly account for observed associations. Findings involving fermented beverages require particular caution: the dataset lacked socioeconomic indicators that typically differentiate beer and wine consumers, and although the study received partial funding from the Association of Brewers of Spain with no role in study procedures, perceived bias cannot be entirely excluded. Emotional states were assessed using single-frequency items that do not capture intensity, variability, or regulation; therefore, findings represent broad patterns rather than detailed constructs. Finally, the study could not assess psychological or neurobiological mechanisms linking diet and affect; such pathways remain speculative and require longitudinal or mechanistic research. Future studies should incorporate multidimensional affective instruments, objective behavioral markers, and repeated-measures or intervention designs.

5. Conclusions

This nationally representative study documents consistent associations between higher adherence to the MedDiet and a more favorable emotional profile and greater subjective well-being. Fermented beverages traditionally associated with the MedDiet—beer and wine—shared social correlates but were associated with distinct emotional and behavioral signatures, underscoring the value of examining them separately.

Overall, MedDiet appears embedded within a broader lifestyle that aligns with selected indicators of emotional well-being and life satisfaction. From a public health perspective, these associations highlight meaningful patterns but should be interpreted cautiously. Given the cross-sectional design, the findings do not establish whether dietary changes lead to improvements in emotional health. Longitudinal cohorts and intervention studies are needed to determine whether increasing adherence to Mediterranean dietary patterns can meaningfully influence emotional well-being or specific life domains. Public health recommendations should therefore emphasize the broader lifestyle context in which dietary behaviors occur, while acknowledging that stronger causal evidence is required before translating these associations into practice.

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Association of Brewers of Spain - [Cerveceros.org](https://www.cerveceros.org)

Authors declaration

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CRedit authorship contribution statement

Kora-Mareen Bühler: Writing – original draft, Investigation. **Javier Calleja-Conde:** Writing – review & editing, Investigation. **Carlo Bressa:** Formal analysis, Data curation. **Félix Gómez Gallego:** Investigation. **Jacobo Albert:** Investigation. **Mateo Pérez Wiesner:** Writing – review & editing, Visualization. **Jose Antonio López Moreno:** Writing – original draft, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT in order to improve the readability and language of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Jose Antonio Lopez-Moreno reports financial support was provided by Association of Brewers of Spain - [Cerveceros.org](https://www.cerveceros.org). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2026.103374>.

Data availability

All data used in this study are confidential. Only the lead author has full access to the data reported in the manuscript.

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