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Mindful eating is associated with a better diet quality in the NutriNet-Santé study

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Abbreviations: BMI, Body Mass Index; BMR, Basal Metabolic Rate; CI, Confidence Interval; CU, Consumption Unit; IPAQ, International Physical Activity Questionnaire ME, Mindful Eating; PAL, Physical Activity Level; MET, Metabolic Equivalent Task; PUFAs, Poly Unsaturated Fatty Acids; SFA, Saturated Fatty Acids; UPF, Ultra-Processed Foods

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DECLARATIONS

Ethics approval and consent to participate

Clinical Trial Registry: The NutriNet-Santé study was conducted in accordance with the Declaration of Helsinki, and all procedures were approved by the Institutional Review Board of the French Institute for Health and Medical Research (IRB Inserm n° 0000388FWA00005831) and the Commission Nationale de l'Informatique et des Libertés (CNIL n° 908450 and n° 909216). Electronic informed consent was obtained from all participants. The study was registered at clinicaltrials.gov as #NCT03335644

(<https://clinicaltrials.gov/study/NCT03335644?locStr=Bobigny,%20France&country=France&state=%C3%8ELe-de-France&city=Bobigny&term=Cohort%20Study&rank=6>).

Consent for publication

Not applicable

Availability of data and material

Data sharing statement: Researchers from public institutions can submit a collaboration request including the institution and a brief description of the project to collaboration@etude-nutrinet-sante.fr. All requests will be reviewed by the steering committee of the NutriNet-Santé study. A financial contribution may be requested. If the collaboration is accepted, a data access agreement will be necessary and appropriate authorizations from the competent administrative authorities may be needed. In accordance with existing regulations, no personal data will be accessible.

Competing interest

Not applicable

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ABSTRACT

Background: Mindful eating (ME) is a promising approach for promoting healthy eating. Although an association between ME and healthier eating habits has been indicated in the literature, data remain limited. The aim of this cross-sectional study was to investigate the association between ME and several nutritional indicators, including overall diet quality, consumption of ultra-processed foods (UPF), organic foods, food groups, and intake of energy and nutrients in a large population sample.

Methods: In 2023, 13,759 participants of the NutriNet-Santé cohort study completed the Mind-Eat Scale, assessing total ME (range: 1-5), and its six sub-dimensions, and at least three 24-h dietary records. Multivariable linear regressions were performed to analyze the association between ME (independent variable) and various indices reflecting the nutritional quality of the diet: two scores reflecting the adherence to the French dietary guidelines (sPNNS-GS2) and the Mediterranean diet (MEDI-LITE score), the consumption of UPF (using the NOVA classification), organic foods and food groups, and energy and nutrient intake (dependent variables), adjusted for socio-demographic and lifestyle characteristics.

Results: ME was positively associated with French dietary guideline ($\beta = 0.33$; 95%CI: 0.30, 0.45) and Mediterranean diet ($\beta = 0.37$; 95%CI: 0.30, 0.45) scores and with organic food consumption ($\beta = 9.72$; 95%CI: 8.84, 10.60). Furthermore, ME was negatively associated with energy intake ($\beta = -36.79$; 95%CI: 50.92, -22.67) and UPF consumption ($\beta = -1.55$; 95%CI: 1.81, -1.29). ME was also associated with the intake of several food groups and nutrients.

Conclusion: Overall, ME was associated with a healthier diet. These results suggest that ME could be an interesting lever for promoting healthy eating habits. Further studies are required to better understand the relationships between ME, dietary intake, and health, particularly through the use of longitudinal studies.

Keywords: Cross-sectional study; Epidemiology; Food intake; Mindful eating; Mindfulness; Nutrition; Psychology.

1. INTRODUCTION

Nutrition is an important determinant of chronic diseases (WHO 2002), with one in five deaths that could be preventable through better diet quality (Afshin et al. 2019). Given the importance of nutrition in preventing non-communicable diseases, there is a need to identify potential strategies to promote healthy eating and weight. Common general dietary recommendations and weight management strategies typically focus on food groups such as recommendations to increase the consumption of fruit and vegetables, while decreasing the consumption of sweet, fatty, and salty foods. While effective, these approaches often suffer from low adherence, limiting their effectiveness (Mann et al. 2007). Potential reasons for this low adherence include the frequent failure of these methods to adequately address psychological and cognitive aspects such as the power of food as a tool for emotional regulation (Markus et al. 1998; Spencer et al. 2017) or the impact of attention to food on appetite (Robinson et al. 2013). Increasing awareness of food and the eating process, such as through mindful eating, may therefore be an effective alternative to these strategies.

Mindful eating (ME) can be globally defined as paying attention to the eating experience with all the senses (seeing, tasting, hearing, smelling, and feeling), and witnessing the emotional and physical reactions that occur before, during, and after the eating experience without judgment or reaction (Albers 2008; Warren, Smith, et Ashwell 2017). ME may have a positive effect on food intake by increasing internal physical cues to eat (improving the perception of hunger and satiety) and decreasing emotional and external cues to eat (Warren, Smith, et Ashwell 2017). However, although the ME concept has already been incorporated into dietary guidelines in some countries, such as Canada (Canada Food Guide 2020) or Germany (DGE 2024), studies investigating a possible association between ME and dietary intake remain relatively limited. Observational and interventional studies have suggested an association between overall ME and healthier eating habits such as lower fat and sugar consumption (Mantzios et al. 2018), total daily energy, carbohydrate, and fat intake (Dogan et Tengilimoglu-Metin 2023), self-reported serving size of energy-dense foods (Beshara, Hutchinson, et Wilson 2013), and motivation to eat palatable foods (Keyte, Egan, et Mantzios 2020). ME has also been associated with less impulsive food choices (Hendrickson et Rasmussen 2017) and with a lower risk of food addiction

28 (Kaya Cebioğlu et al. 2022). However, a recent study reported no significant association between ME
29 and overall scores for healthy eating and the Mediterranean diet (Dogan et Tengilimoglu-Metin 2023).
30 Given the significant impact of overall diet scores on health, further research examining the relationship
31 between ME and these scores is warranted. In particular, adherence to the Mediterranean dietary pattern,
32 which has a strong plant-diet component, or the French dietary guidelines, which encompass a broader
33 range of dietary recommendations, are interesting as they have been demonstrated to have a significant
34 impact on health (Chaltiel et al. 2022; Ventriglio et al. 2020). In addition, to our knowledge, no study in
35 the literature has addressed a possible association between ME and the consumption of ultra-processed
36 and organic foods. Investigating this association is of great interest due to the significant rise in the
37 consumption of these foods in recent decades (Kesse-Guyot et al. 2020; Srour et al. 2022) coupled with
38 evidence suggesting their adverse (Lane et al. 2024) and beneficial (Jiang et al. 2023; Ventriglio et al.
39 2020) health effects, respectively. It should also be noted most of the studies on ME and dietary intake
40 have focused on specific populations such as students (Kaya Cebioğlu et al. 2022; Keyte, Egan, et
41 Mantzios 2020; Mantzios et al. 2018) or had relatively limited sample sizes ($N < 250$) (Beshara,
42 Hutchinson, et Wilson 2013; Dogan et Tengilimoglu-Metin 2023; Hendrickson et Rasmussen 2017;
43 Keyte, Egan, et Mantzios 2020). In addition, they have used non-validated tools to evaluate the
44 association between global ME and food intake, highlighting the need for well-conducted studies using
45 validated assessments of exposure and outcomes.

46 The aim of this large population-based cross-sectional study was therefore to examine the associations
47 between ME (total score and sub-dimensions) and a wide variety of indicators reflecting different
48 aspects of the nutritional quality of the diet and exerting different influences on health. These included
49 adherence to the French dietary guidelines and the Mediterranean diet scores, the contribution of both
50 UPF and organic food to the diet, the consumption of food groups, and the intake of energy and nutrients.

51

52

53

54 2. METHODS

55 2.1 *Study population and design*

56 Participants were volunteers aged 15 years or older from the NutriNet-Santé study, a large ongoing
57 French web-based prospective cohort launched in May 2009 (Hercberg et al. 2010). The overall aim of
58 this study is to investigate the relationship between nutrition and health, as well as the determinants of
59 health and eating behaviors. At inclusion and every year thereafter, participants are required to complete
60 a series of online questionnaires designed to assess a range of factors, including their dietary habits,
61 anthropometric measurements, levels of physical activity, socioeconomic and demographic data,
62 lifestyle characteristics, and health status. In addition, they complete monthly questionnaires related to
63 determinants of eating behaviors, nutritional status, and specific health-related aspects.

64 This study was conducted according to guidelines laid down in the Declaration of Helsinki. All
65 procedures were approved by the Institutional Review Board of the Institut National de la Santé et de la
66 Recherche Médicale (IRB Inserm no. 0000388FWA00005831), and the Commission Nationale de
67 l'Informatique et des Libertés (CNIL no. 908 450 and no. 909 216). It is registered at ClinicalTrials.gov
68 with the number NCT03335644. Electronic informed consent was signed by all participants at inclusion.

69

70 2.2 *Data collection*

71 2.2.1 *Assessment of mindful eating (ME)*

72 Participants completed the Mind-Eat Scale, a validated 24-item self-report questionnaire (Van Beekum
73 et al. 2024), once between March and September 2023. This scale features one overall dimension of ME
74 and six sub-dimensions: awareness (e.g. “When I eat, I take the time to savor my foods”), non-reactivity
75 (e.g. “When I see foods that I love, I find it hard not to eat them”), openness (e.g. “I like to choose
76 unfamiliar foods (meals at home or when out”), gratitude (e.g. “I am grateful to the people who prepared
77 the food I eat”), non-judgment (e.g. “I blame myself if I’ve eaten more than my body needs”), and
78 hunger/satiety (e.g. “I trust my body to know when to stop eating”), each of which includes four items.
79 Each item is rated on a Likert scale from 1 (never or almost never) to 5 (always or almost always). The
80 score for the global ME scale and each subdimension is obtained by adding individual scores of the

81 respective items (after reverse-coding of the appropriate items) and dividing by the number of items.
82 The final scores range from 1 (low ME) to 5 (high ME). The Mind-Eat Scale showed good internal
83 consistency for the global dimension and all sub-dimensions (Cronbach's α ranging from 0.78 to 0.91).

84 2.2.2 Assessment of food intake

85 At inclusion and every six months afterward, participants were asked to complete a set of three 24-hour
86 dietary records (randomly distributed between two weekdays and one weekend day, not necessarily
87 consecutive). To obtain an adequate representation of food consumption, participants were selected if
88 they had completed at least one set of three 24-hour dietary records during a period of two years before
89 completing the Mind-Eat Scale and eight months after (end of available data). Participants were
90 instructed to self-report on the NutriNet website, each food and drink consumed for each meal and
91 occasion during the selected day and to estimate the portion sizes consumed using validated photographs
92 (Moullec et al. 1996). Participants were asked to choose among seven portion sizes: three main portion
93 sizes, two intermediate, and two extreme sizes. The average daily food intake was weighted for the type
94 of day of the week (weekday or weekend). Nutrient and energy intakes were estimated using the
95 published NutriNet-Santé food composition database, which contains more than 3,500 items (NutriNet-
96 Santé 2013). The method proposed by Black was employed to identify and exclude under-reporters.
97 This entailed first calculating the basal metabolic rate (BMR) using Schofield equations and then
98 identifying under-reporters based on the average daily energy intake and Goldberg cut-off points (Black
99 2000).

100

101 2.2.3 Assessment of the adherence to the French dietary guidelines (sPNNS-GS2)

102 Adherence to the French dietary guidelines was assessed using the sPNNS-GS2 score, a validated *a*
103 *priori* nutritional diet quality score (Chaltiel et al. 2019) that reflects the French dietary
104 recommendations at the time of the study. The score is made up of 13 components, six of which relate
105 to food serving recommendations (fruit and vegetables, nuts, legumes, wholegrain foods, milk and dairy
106 products, fish and seafood) and seven to moderation of nutrients or foods (red meat, processed meat,
107 added fat, sugary foods, sweet-tasting beverages, alcoholic beverages, salt). In addition, the sPNNS-

108 GS2 score is penalized on energy intake when it exceeds energy expenditure based on basal metabolic
109 rate (BMR) and physical activity level (PAL) (FAO 1991). The sPNNS-GS2 final score ranges from
110 $-\infty$ (low adherence to dietary guidelines) to 14.25 (high adherence to dietary guidelines).

111 *2.2.4 Assessment of the adherence to the Mediterranean diet (MEDI-LITE)*

112 Adherence to the Mediterranean diet was assessed using the validated “Mediterranean diet based on the
113 literature” score (MEDI-LITE) (Sofi et al. 2017). It includes six beneficial components that are typical
114 of the Mediterranean diet (fruit, vegetables, wholegrain cereals, legumes, fish and seafood, and olive
115 oil), two moderation components for which consumption is to be limited (meat including processed
116 meat, and dairy products), and an alcohol component (Sofi et al. 2017). Each food group is divided into
117 three categories using fixed cut-offs (Sofi et al. 2017). For the beneficial food components, two points
118 are given to the highest category of consumption, one to the middle category, and zero to the lowest
119 category. A reverse scoring is applied for the moderation components, that is two points for the lowest
120 category, one for the middle category, and zero for the highest category. For alcohol specifically, the
121 scoring is two points if the intake is comprised between 12 and 24 g, one point if < 12 g, and zero point
122 if > 24 g (Baudry et al. 2023). The final score is ranked from 0 to 18 points.

123 *2.2.5 Assessment of ultra-processed food (UPF) consumption*

124 The NOVA classification was used to assess the degree of food processing (Monteiro et al. 2018). The
125 food items were classified into one of the four NOVA categories: unprocessed / minimally processed
126 foods, culinary ingredients, processed foods, and UPF (Martinez-Steele et al. 2023). The classification
127 has been described in detail elsewhere (Martinez-Steele et al. 2023). The present study focused on the
128 UPF category. We calculated the proportion of UPF in the diet by dividing the total UPF consumption
129 (in grams) by the total food consumption (in grams) by calculating a weight ratio.

130 *2.2.6 Assessment of organic food consumption*

131 When completing the 24-hour dietary records, participants were asked to indicate whether the food was
132 organic or not. We calculated the proportion of organic foods in the diet by dividing the total organic
133 food consumption (in grams) by the total food consumption excluding water (in grams).

134 2.2.7 *Assessment of food group consumption and nutrient intake*

135 The 24-hour dietary records allowed to define 13 macronutrient categories i.e. proteins, animal proteins,
136 plant proteins, carbohydrates, simple carbohydrates, added simple carbohydrates, lipids, animal lipids,
137 plant lipids, added lipids, saturated fatty acids (SFA), polyunsaturated fatty acids (PUFAs), fibers, and
138 23 food groups i.e. fruits, vegetables, starchy foods, whole-grains, legumes, red meat, white meat and
139 poultry, processed meat, seafood (e.g. fish and shellfish), meat and dairy substitutes (e.g. soy steak,
140 cereal patties), dairy products (e.g. milk, yogurts with less than 12% of added sugar), cheese, dairy
141 desserts, fats (oil, butter, and margarine), fast food (e.g. pizzas, hamburgers, sandwiches, hot dogs),
142 appetizers (e.g. crisps, salted biscuits, salted oilseeds), sugar and confectionery (e.g. honey, jelly, sugar,
143 sweets), sweet products (e.g. biscuits, cakes, pastries), chocolate based products, non-salted oleaginous
144 fruits, alcoholic beverages, sugary non-alcoholic beverages, and 100% pure fruit and vegetable juices.

145 2.2.8 *Covariates*

146 Potential confounding factors were selected based on the literature. We used the most recent data
147 available before the Mind-Eat Scale was completed. A literature-based approach was used to select the
148 following confounders: age (years), sex (male, female), educational level (primary, secondary,
149 undergraduate, postgraduate), occupational status (unemployed, student, self-employed and farmer,
150 employee and manual worker, intermediate profession, managerial staff and intellectual profession,
151 retired), monthly income per household unit, smoking status (current, former, never), physical activity
152 (low, moderate, high), number of filled 24-hour dietary records, and energy intake (except when energy
153 intake was the outcome). Body Mass Index ($BMI < 18.5 \text{ kg/m}^2$, $18.5 \text{ kg/m}^2 \leq BMI < 25 \text{ kg/m}^2$, $25 \leq BMI$
154 $< 30 \text{ kg/m}^2$, $BMI \geq 30 \text{ kg/m}^2$), cognitive restraint and anxiety were also considered in sensitivity analysis
155 as potential confounders. The number of people in the household was converted into a number of
156 consumption units (CU) according to the Organization for Economic Cooperation and Development
157 (OECD) equivalence scale: 1 CU is attributed to the first adult in the household, 0.5 to other persons
158 aged 14 and older and 0.3 for children under 14 (Insee 2022). Monthly income categories were defined
159 as follows: $< 1,200$ / $1,200-1,799$ / $1,800-2,699$ / $> 2,700$ euros per household unit, and “unwilling to
160 answer”.

161 Physical activity was assessed using the short form of the French version of the International Physical
162 Activity Questionnaire (IPAQ) (Craig et al. 2003). Weekly energy expenditure, expressed in Metabolic
163 Equivalent of Task (MET) in minutes per day, was estimated and three levels of physical activity were
164 defined: low, moderate, and high.

165 Cognitive restraint was assessed using the TFEQ-R21 (Cronbach's $\alpha = 0.76$) (Tholin et al. 2005), with
166 a score ranging from 6 (low cognitive restraint) to 24 (high cognitive restraint).

167 Anxiety was assessed using the STAI-T (Cronbach's $\alpha = 0.94$), which measures trait anxiety (Thomas
168 et Cassady 2021), with a score ranging from 20 (low anxiety) to 80 (high anxiety).

169

170 *2.3 Statistical analysis*

171 To compare the characteristics of included and excluded participants, we performed Student t-tests for
172 continuous variables and Pearson's chi-square tests for categorical variables. We assessed the reliability
173 of the Mind-Eat Scale by calculating Cronbach's alpha (α). To investigate the relationship between ME
174 total score and participants' characteristics, we used Pearson correlation coefficients (with 95% CI) for
175 continuous variables and Student t-test or ANOVA for categorical variables, as appropriate.

176 Multivariable linear regressions were used to analyze the associations between ME (independent
177 variable) and all outcomes. Analyses were not stratified by sex as interactions between sex and ME were
178 not significant for the large majority of variables. Among potential confounders, those associated with
179 ME and outcomes at the $p < 0.20$ level in bivariate models were retained in multivariable regression
180 models. A minimally-adjusted model adjusted for age and sex was tested, and the main model was
181 adjusted for sex, age, education level, monthly income per household unit, occupational status, physical
182 activity level, smoking status, energy intake (except when energy intake was the outcome), and number
183 of filled 24-hour dietary records. Further, sensitivity analyses were performed with an additional
184 adjustment for Body Mass Index (BMI), cognitive restraint, or anxiety. BMI was categorized because
185 the association with ME was not expected to be linear. Multicollinearity was assessed and ruled out for
186 most confounding variables.

187 Accordingly, the principal analysis involved the execution of five distinct models, each corresponding
188 to a specific principal outcome. These five models were then repeated for each of the six ME sub-
189 dimensions. All tests of statistical significance were 2-sided, and significance was set at 5%. The Holm-
190 Bonferroni method was applied to control the family-wise error rate for multiple tests. Missing data on
191 confounders were handled with multiple imputations by a fully conditional specification (20 imputed
192 datasets). Statistical analyses were performed using SAS software (SAS Institute Inc., version 9.4).

193

194 3. RESULTS

195 3.1 *Sample characteristics*

196 From the NutriNet-Santé sample, 28,857 participants completed the Mind-Eat Scale, of which 14
197 participants were excluded due to an acquiescence bias (i.e. agreeing or disagreeing with all statements
198 without consideration of the reverse-worded items). Among those, we selected 13,759 participants who
199 also completed at least one set of three 24-hour dietary records to obtain a better representation of food
200 consumption (Brussaard et al. 2002).

201 Compared with excluded participants (those who presented acquiescence bias and/or did not have at
202 least three valid 24-hour dietary records), the 13,759 included participants were older (62.46 ± 13.42
203 years for included participants vs. 57.93 ± 14.18 years for excluded participants, $p < 0.0001$) and showed
204 a higher proportion of males (28.5% vs. 22.90%, $p < 0.0001$). Education level, occupational status,
205 smoking status, and physical activity level also differed between included and excluded participants.

206 **Table 1** shows the individual characteristics of the sample and a comparison of ME scores across
207 categories of individual characteristics. On average, total ME was positively associated with age, and
208 was higher in females, in retired participants, in participants with a higher income, and in participants
209 with a higher physical activity, and negatively associated with anxiety and cognitive restraint. No
210 difference according to education level and smoking status was found.

211 **Table 2** shows the descriptive characteristics of the main outcomes. Mean ME scores across sub-
212 dimensions ranged from 3.13 to 3.79. Energy intake averaged around 1700 kcal, with 15% of the diet
213 consisting of ultra-processed foods (UPF) and one-fourth of the diet comprising organic food.

214 **Table 3** shows the associations between the total score of ME and adherence to the French dietary
215 guidelines, the Mediterranean diet, energy intake, UPF, and organic food consumption. Individuals with
216 a higher level of total ME had greater adherence to the French dietary guidelines and the Mediterranean
217 diet. In addition, they had a lower energy intake, a lower UPF consumption, and a higher organic food
218 consumption. Overall, the explained variance (R-squared) ranged from 5% (MEDI-LITE score and
219 UPF) to 20% (energy intake).

220 Associations between ME and food groups were also assessed (**Supplemental table 1**). Individuals with
221 a higher level of total ME consumed more vegetables, starchy foods, whole grains, legumes, meat and
222 dairy substitutes, fats, sugar and confectionery, non-salted oleaginous fruits, and alcoholic beverages.
223 In addition, higher ME was associated with lower consumption of red meat, white meat and poultry,
224 processed meat, dairy products, dairy desserts, fast food, sweet products, and chocolate-based products.
225 No significant association was found for fruit, seafood, cheese, appetizers, sweet beverages without
226 alcohol, and 100% pure fruit and vegetable juices.

227 In terms of nutrients, higher levels of ME were associated with a greater intake of plant proteins, plant
228 lipids, added lipids, polyunsaturated acids (PUFAs), and fibers, and with a lower intake of proteins
229 overall, animal proteins, and animal lipids. (**Supplemental table 2**). No association was found for total
230 carbohydrates, simple carbohydrates, added simple carbohydrates, total lipids, and saturated acids
231 (SFA).

232 **Table 4** shows the association between sub-dimensions of ME and food consumption. Sub-dimensions
233 of ME were positively associated with the sPNNS-GS2 score (except for the Awareness dimension) and
234 the MEDI-LITE score (except for the Non-Reactivity dimension), and negatively associated with energy
235 intake (except for Non-judgment and Openness dimensions) and UPF consumption. For all sub-
236 dimensions, individuals with higher scores of ME consumed more organic foods. Overall, the explained
237 variance (R-squared) was similar for all sub-dimensions and ranged from 4% (MEDI-LITE score and
238 UPF) to 20% (energy intake).

239 Sensitivity analyses showed similar results compared with the main model, except for the association
240 between ME and adherence to the French dietary guidelines, which was not significant after adjustment
241 for BMI (**Supplemental tables 3, 4, and 5**).

242 **4. DISCUSSION**

243 In this large web-based prospective cohort, individuals with higher levels of ME were found to have a
244 better overall nutritional quality of the diet, both in terms of adherence to the French dietary guidelines
245 and to the Mediterranean diet. ME was also associated with lower energy intake, lower consumption of
246 UPF, and higher consumption of organic foods. These associations were observed for all sub-dimensions
247 of ME, except awareness, which was not associated with adherence to the French dietary guidelines,
248 non-reactivity, which was not associated with adherence to the Mediterranean diet, and non-judgment
249 and openness which were not significantly associated with energy intake. Overall, individuals with
250 higher levels of ME also consumed more healthy food groups (e.g. vegetables, whole grain foods) and
251 nutrients (e.g. PUFAs, fibers).

252 The results of our study indicate an association between ME and adherence to both the French dietary
253 guidelines and the Mediterranean diet. This finding contrasts with that of a recent study (Dogan et
254 Tengilimoglu-Metin 2023), which reported no association between ME assessed by the MEQ and both
255 global healthy eating scores and the Mediterranean diet score. This study had a relatively small sample
256 size (N = 207) and was conducted during the COVID-19 pandemic period when people spent most of
257 their time at home, which may have changed their eating habits. In addition, in agreement with this
258 previous study, we found lower energy intake in individuals with higher levels of ME (Dogan et
259 Tengilimoglu-Metin 2023). However, this association may not be entirely favorable and warrants further
260 consideration, as the average energy intake in our study was lower than the French dietary
261 recommendations (Santé Publique France 2018). Our findings in favor of better diet quality were
262 supported by our food group analyses, which showed that individuals with higher levels of ME had
263 higher consumption of healthy food groups, such as vegetables, whole grains, legumes, and non-salted
264 oleaginous fruits, although they also consumed more alcohol. A lower intake of proteins was also
265 observed, while no difference in terms of total carbohydrates and lipids was found in contrast with the

266 literature that showed a lower intake of carbohydrates and fat with increasing ME scores (Dogan et
267 Tengilimoglu-Metin 2023). Although we found no difference in total lipid intake, individuals with
268 higher ME levels consumed more PUFAs, suggesting an impact of ME on quality rather than on quantity
269 of lipids. Finally, our study was the first to investigate and show a negative association between ME and
270 UPF, and a positive association between ME and organic food consumption, which is an important result
271 given their potential impact on health (Kesse-Guyot et al. 2020; Srouf et al. 2022).

272 Overall, our results showed an association between higher ME and a healthier diet, which could be
273 explained by several mechanisms. In a systematic review investigating the role of ME in changing eating
274 behaviors, the main mechanisms observed involved increased awareness and reduced responsiveness to
275 internal emotional and external cues in individuals with higher levels of ME (Warren, Smith, et Ashwell
276 2017). These findings were primarily supported by studies using functional magnetic resonance imaging
277 (fMRI) (Warren, Smith, et Ashwell 2017). Subdimensions of ME are interesting to consider since they
278 allow highlighting the aspects of ME that are most important for dietary intake, and also clarify the
279 underlying mechanisms linking ME to dietary behavior.

280 The Awareness subdimension was associated with all aspects of diet quality, except for adherence to
281 the French dietary guidelines. The association observed with the Mediterranean diet score may be due
282 to its stronger plant diet component compared to the French dietary guidelines score. Our results on food
283 groups and nutrients also suggested that individuals with higher levels of awareness had a diet with a
284 high contribution of plant-based foods. Similarly, in the literature, awareness has been positively
285 associated with healthy plant dietary patterns (Kawasaki et al. 2021). A systematic review showed that
286 distraction was associated with increased immediate and later food intake while memory decreased later
287 food intake (Robinson et al. 2013). Avoiding distraction and increasing awareness of food while eating
288 could therefore positively influence food intake (Robinson et al. 2013). Awareness may also play a role
289 in food intake by allowing for a better perception of hunger and satiety cues (Albers 2008; Warren,
290 Smith, et Ashwell 2017), by slowing down food consumption (Warren, Smith, et Ashwell 2017). Slow
291 eating has been shown to reduce overall energy consumption during and after eating (Robinson et al.
292 2013).

293 In the present study, the Non-reactivity dimension was associated with all aspects of diet quality, except
294 adherence to the Mediterranean diet. A negative association has been observed between non-reactivity
295 and emotional eating (Verrier et Day 2022), while emotional eating has been associated with a higher
296 snack and fast food consumption (Betancourt-Núñez et al. 2022; G. Camilleri et al. 2014) and a lower
297 healthy food group consumption (Betancourt-Núñez et al. 2022). Therefore, non-reactivity may impact
298 diet quality through its effect on emotional eating. In addition, the inverse association between non-
299 reactivity and UPF consumption observed in the present study could be due to a lower sensitivity to
300 external stimuli in individuals with higher levels of non-reactivity. This may lead to a reduction in the
301 responsiveness of individuals to external cues such as food packaging when purchasing food (Warren,
302 Smith, et Ashwell 2017). Finally, individuals with higher levels of non-reactivity might demonstrate
303 less impulsivity, while impulsivity has been associated with poorer diet quality (Gómez-Martínez et al.
304 2022).

305 We observed that the Openness dimension was associated with all variables except energy intake. This
306 dimension assesses open-mindedness about food and an attitude of curiosity. Our results confirm
307 previous research on openness and a healthier Mediterranean diet (Lunn et al. 2014). Openness is
308 strongly linked to intellectual curiosity (Beaulieu et al. 2022), which may facilitate a varied diet,
309 including the consumption of less familiar or less palatable foods, but also facilitate new cooking
310 experiences or attraction to alternative cultures, such as organic farming. Higher levels of openness may
311 also result in greater sociability prompting individuals to engage in social meals more frequently. Such
312 shared meals have been correlated with increased consumption of alcohol (Dunbar 2017). This
313 association could explain the positive link between ME and alcohol consumption observed in our study.
314 However, it can also be postulated that individuals with higher ME levels, may be more likely to be
315 aware of and accountable for their alcohol consumption, and therefore less likely to underreport their
316 intake.

317 The Gratitude dimension was associated with a better diet quality overall. A study derived from the
318 same cohort found that gratitude was associated with a higher adherence to dietary guidelines, a higher
319 consumption of organic foods, and a lower consumption of UPF (Robert et al. 2022), as well as healthier

320 dietary behaviors overall (Fritz et al. 2019). Better diet quality in people with greater gratitude may be
321 due to their higher body satisfaction (Wolfe et Patterson 2017) and lower stress and depression (Wood
322 et al. 2008), which have been shown to lead to healthier diets (Chatelan et Carrard 2021). Gratitude can
323 also allow consideration of the far-reaching effects of food choices, including the origin of foods and
324 the elements that contributed to their growth.

325 The Non-judgment dimension was associated with higher nutritional quality of the diet (except for
326 energy intake). In the literature, non-judgment has been inversely associated with anxiety (Beaulieu et
327 al. 2022), which, in turn, has been associated with unhealthy eating patterns (Aucoin et al. 2021).
328 However, our findings contrast with previous research showing an association between higher levels of
329 non-judgment and less healthy eating habits (Kawasaki et al. 2021). Non-judgment scales may be
330 associated with either self-compassion or self-indulgence, which could explain these contrasting results.
331 Self-compassion corresponds to being kind and understanding to oneself in cases of pain or failure rather
332 than being harshly self-critical and might lead to healthier behaviors (Sirois, Kitner, et Hirsch 2015). On
333 the other hand, higher negative affect may feed the vicious dietary cycle, which includes overeating after
334 restrained eating (Marks 2015), and which can partially be avoided by non-judgment. Self-indulgence
335 differs from self-compassion, as it is the act of allowing oneself to have or do anything that one enjoys
336 (Cambridge Dictionary 2024). Self-indulgence may lead to an unconditional right to eat whatever one
337 wants potentially leading to more unhealthy choices. Finally, to our knowledge, no previous study had
338 tested the association between non-judgment and organic food consumption. Nevertheless, research
339 indicates that individuals with higher levels of non-judgment are more likely to engage in responsible
340 and respectful behaviors (Beaulieu et al. 2022). This could potentially lead to a more responsible
341 approach to food consumption, including a greater inclination towards organic food choices.

342 The Hunger/Satiety dimension was associated with all the variables of diet quality. In the literature,
343 individuals with higher scores on the hunger/satiety dimension of the intuitive eating scale, a construct
344 close to the present dimension, had a lower energy intake (G. M. Camilleri et al. 2017), supporting our
345 results. Satiety should be linked to hunger and satiation in a manner that naturally results in a balance
346 between energy intake and expenditure (Tremblay et Bellisle 2015). Listening to hunger and satiety

347 sensations, and physiological needs, could therefore be an appropriate strategy to promote better diet
348 quality.

349 Our data showing a potential beneficial effect of ME on healthy eating is encouraging in the promotion
350 of healthy eating and the prevention of obesity, particularly since ME can be learned. Incorporating ME
351 programs or components into interventions could offer a novel approach to aid in healthier eating or
352 weight management. Various ME programs are already available (Alberts, Thewissen, et Raes 2012;
353 Kristeller et Wolever 2011), which encompass elements related to the awareness of food, the awareness
354 of physical hunger and satiety cues, environmental or emotional triggers to eat, and the acceptance of
355 one's body. Furthermore, it may be worthwhile to consider integrating the ME concept into the French
356 dietary guidelines, as has already been done in Germany (DGE 2024) and Canada (Canada Food Guide
357 2020) with messages such as "Be mindful of your eating habits" or "Eating slowly and consciously also
358 helps you feel full."

359 To our knowledge, the present work is the first observational study to explore and establish an
360 association between ME and healthier dietary choices within a large sample. However, the cross-
361 sectional design of our study limits our ability to infer causality between ME and food intake, and reverse
362 causation cannot be ruled out. A notable strength of the study is its large sample size, which provides
363 high statistical power and allows for control of multiple confounders. Nonetheless, this may result in P-
364 values that show significance for minor effects, making the assessment of the proportion of variance
365 explained by the model valuable.

366 Additionally, our study allowed the inclusion of individuals with diverse sociodemographic and lifestyle
367 characteristics. However, the voluntary recruitment of participants may introduce selection bias, as those
368 interested in health and nutrition were more likely to participate (Andreeva et al. 2015). In addition,
369 although internet penetration in France is high at 94 % (Digital 2024 2024), certain groups such as non-
370 graduate individuals have lower access (Baromètre du numérique - Edition 2021 2021), which may lead
371 to the under-representation of these populations. Therefore, caution is warranted when generalizing our
372 results to the French population. Another strength is the validated Mind-Eat Scale, which has shown
373 good psychometric properties and is the only scale available that allows the calculation of a total ME
374 score validated by confirmatory factor analysis (CFA) (Van Beekum et al. 2024). The use of 24-hour

375 dietary records in the present study allowed detailed and representative assessment of food consumption.
376 Twenty-four-hour dietary records are widely used in epidemiological research (Willett 2012) and
377 provide internationally comparable data (Brussaard et al. 2002). However, this method can lead to
378 estimation errors and under-reporting of quantities consumed. To minimize these issues, photographs
379 validated for portion sizes (Moullec et al. 1996) were used, and under-reporters were identified and
380 excluded using Black's method (Black 2000). Additionally, the validity of dietary records was ensured
381 through comparison with biomarkers (Lassale et al. 2015, 2016) and interviews conducted by a dietitian
382 (Andreeva et al. 2015). Nevertheless, 24h records are susceptible to additional measurement error. For
383 instance, participants aware of the recording date in advance may have adjusted their consumption
384 unintentionally or intentionally (Rutishauser 2005).

385

386 **5. CONCLUSION**

387 Our results highlighted that participants with higher ME levels had a better overall diet quality as
388 reflected by higher adherence to the French dietary guidelines and to the Mediterranean diet, a lower
389 energy intake and UPF consumption, and a higher consumption of organic foods. The associations
390 observed for the ME sub-dimensions generally align with the results for the total ME score, suggesting
391 that all facets of ME may be of interest in improving the nutritional quality of the diet. Overall, our
392 results suggest that ME may be a useful resource for promoting healthy eating behavior. Further
393 population-based studies, especially longitudinal and intervention studies, are needed to confirm these
394 findings and provide evidence of causality.

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402 **Authors' contributions**

403 P.P.G. conducted the literature review and drafted the manuscript. P.P.G. performed analyses. P.P.G.,
404 M.V.B., E.K.G., J.B., B.S., A.B., R.S., A.R., C.L., S.H., M.T., B.A., and S.P. were involved in
405 interpreting results and critically reviewed the manuscript. P.P.G., E.K.G., S.H., M.T., and S.P. were
406 responsible for developing the design and protocol of the study. P.P.G., M.V.B., E.K.G., J.B., B.S.,
407 A.B., R.S., A.R., C.L., S.H., M.T., B.A., and S.P. report no conflict of interest.

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Table 1. Individual characteristics of the 13,759 participants (NutriNet-Santé study, 2023)

	% or Mean (SD)	Mindful eating score ¹	r	p-value ²
Age, y	62.46 (13.42)		0.14	<0.0001
Sex (%)				<0.0001
Female	71.65	3.34 ± 0.53		
Male	28.35	3.41 ± 0.46		
Education level (%)				0.54
Primary	1.78	3.39 ± 0.48		
Secondary	26.75	3.35 ± 0.50		
Undergraduate	31.23	3.36 ± 0.52		
Postgraduate	39.65	3.36 ± 0.52		
Missing data	0.60	3.49 ± 0.49		
Occupational status (%)				<0.0001
Unemployed	5.18	3.36 ± 0.57 de		
Student	0.39	3.24 ± 0.47 abcde		
Self-employed, farmer	1.18	3.38 ± 0.60 abcde		
Employee, manual worker	9.38	3.20 ± 0.53 a		
Intermediate professions	10.10	3.28 ± 0.52 bc		
Managerial staff, intellectual professions	18.10	3.31 ± 0.54 cd		
Retired	55.61	3.41 ± 0.49 e		
Missing data	0.07	3.40 ± 0.38 ace		
Monthly income (%)				0.018
<1,200€	5.28	3.31 ± 0.58 a		
1,200-1,799€	15.41	3.35 ± 0.52 ab		
1,800-2,699€	28.45	3.35 ± 0.52 ab		
≥2,700€	38.99	3.37 ± 0.50 b		
Unwilling to answer	11.77	3.28 ± 0.51 ab		
Missing data	0.09	3.63 ± 0.53 ab		
Smoking status (%)				0.56
Current	4.93	3.37 ± 0.52		
Former	52.07	3.36 ± 0.50		
Never	43.00	3.36 ± 0.53		
Physical activity (%)				<0.0001
Low	15.20	3.26 ± 0.53 a		
Moderate	40.05	3.33 ± 0.51 b		
High	44.75	3.42 ± 0.51 c		
Body mass index (BMI) (%)				<0.0001
Underweight (<18.5 kg/m ²)	5.57	3.58 ± 0.54 d		
Normal (18.5-24.99 kg/m ²)	61.49	3.42 ± 0.50 c		
Overweight (25-29.99 kg/m ²)	24.04	3.24 ± 0.49 b		

Obesity (≥ 30 kg/m ²)	8.89	3.09 \pm 0.53 a		
Anxiety ³	35.88 (10.30)		-0.34	<0.0001
Missing data (%)	4.80			
Cognitive restraint ⁴	2.16 (0.60)		-0.24	<0.0001
Missing data (%)	20.60			

¹ Score ranges from 1 to 5. A higher score corresponds to a higher mindful eating level.

² *p*-values based on Pearson correlation coefficients (*r*) for continuous variables and Student *t*-test or ANOVA for categorical variables, as appropriate (corrected for multiple testing with the Holm-Bonferroni method, with a, b, c, d for Tukey post-hoc tests).

³ Measured with STAI-T questionnaire. Score ranges from 20 to 80. A higher score corresponds to a higher anxiety level.

⁴ Measured with TFEQ-R21 questionnaire. Score ranges from 6 to 24. A higher score corresponds to a higher level of cognitive restraint.

Table 2. Descriptive characteristics of mindful eating and food intake in the 13,759 participants (NutriNet-Santé study, 2023)

	% or Mean (SD)
Mindful eating (total score) ¹	3.36 (0.52)
Awareness	3.79 (0.79)
Non-reactivity	3.16 (0.78)
Openness	3.39 (0.89)
Gratitude	3.16 (0.99)
Non-judgment	3.13 (0.83)
Hunger/Satiety	3.53 (0.90)
Adherence to the French dietary guidelines (sPNNS-GS2) ²	2.60 (3.35)
Adherence to the Mediterranean diet (MEDI-LITE) ³	8.25 (9.29)
Energy intake, kcal/d	1,720.97 (476.82)
Ultra-processed food, %	14.75 (8.00)
Organic food, %	26.03 (27.74)

Abbreviations: sPNNS-GS2, simplified French National Nutrition and Health Program Guideline Score 2, MEDI-LITE, validated Mediterranean diet based on the literature

¹ Score ranges from 1 to 5. A higher score corresponds to a higher mindful eating level.

² Score ranges from $-\infty$ to 14.5. A higher score reflects a better adherence to the French nutritional guidelines

³ Score ranges from 0 to 18. A higher score reflects a better adherence to the Mediterranean diet

Table 3. Association between mindful eating and food intake in 13,759 participants (NutriNet-Santé study, 2023)

	Mindful eating (total score) ¹		
	Beta-coefficients ² [95% CI]	R-squared ³	p-value ⁴
Adherence to the French dietary guidelines (sPNNS-GS2)	0.33 [0.30,0.45]	0.19	< 0.0001
Adherence to the Mediterranean diet (MEDI-LITE)	0.37 [0.30, 0.45]	0.05	< 0.0001
Energy intake (kcal/d)	-36.79 [-50.92, -22.67]	0.20	< 0.0001
Ultra-processed food, %	-1.55 [-1.81, -1.29]	0.05	< 0.0001
Organic food, %	9.72 [8.84, 10.60]	0.08	< 0.0001

Abbreviations: sPNNS-GS2, simplified French National Nutrition and Health Program Guideline Score 2;

MEDI-LITE, validated Mediterranean diet based on the literature

Main model:

¹Multivariable linear regression with mindful eating as a continuous independent variable and food intake as dependent variables. Main model: Adjusted for sex, age, number of 24-hour dietary questionnaires, educational level, occupational status, monthly household income, smoking status, physical activity, and energy intake (except when energy intake was the outcome).

² Adjusted beta-coefficient: indicates the increase in the outcome variable for a one-point increase in the ME score.

³ Adjusted R-squared: reflects the variance in the outcome variable that is explained by the ME score.

⁴ p-value corrected for multiple testing with the Holm-Bonferroni method.

Table 4a. Association between mindful eating sub-dimensions and food intake in 13,759 participants (NutriNet-Santé study, 2023)

	Mindful eating ¹								
	Awareness			Non-reactivity			Openness		
	Beta-coefficients ² [95% CI]	R-squared ³	p-value ⁴	Beta-coefficients ² [95% CI]	R-squared ³	p-value ⁴	Beta-coefficients ² [95% CI]	R-squared ³	p-value ⁴
Adherence to the French dietary guidelines (sPNNS-GS2)	-0.01 [-0.07, 0.06]	0.18	1.00	0.18 [0.12, 0.25]	0.19	<0.0001	0.15 [0.09, 0.20]	0.19	<0.0001
Adherence to the Mediterranean diet (MEDI-LITE)	0.16 [0.12, 0.21]	0.04	<0.0001	0.06 [0.01, 0.11]	0.04	0.076	0.24 [0.20, 0.28]	0.05	<0.0001
Energy intake (kcal/d)	-18.12 [-27.36, -8.89]	0.19	0.001	-19.22 [-28.49, -9.94]	0.19	<0.0001	3.40 [-4.76, 11.57]	0.19	1.00
Ultra-processed food, %	-0.98 [-1.15, -0.81]	0.05	<0.0001	-0.52 [-0.69, -0.35]	0.04	<0.0001	-0.70 [-0.85, -0.55]	0.05	<0.0001
Organic food, %	4.31 [3.73, 4.89]	0.06	<0.0001	2.10 [1.51, 2.69]	0.05	<0.0001	3.01 [2.50, 3.53]	0.06	<0.0001

Table 4b (continued)

		Mindful eating								
		Gratitude			Non-judgment			Hunger-satiety		
		Beta-coefficients² [95% CI]	R-squared³	p-value⁴	Beta-coefficients² [95% CI]	R-squared³	p-value⁴	Beta-coefficients² [95% CI]	R-squared³	p-value⁴
Adherence to the French dietary guidelines (sPNNS-GS2)		0.15 [0.10, 0.20]	0.19	<0.0001	0.11 [0.05, 0.17]	0.18	0.004	0.08 [0.03, 0.14]	0.18	0.022
Adherence to the Mediterranean diet (MEDI-LITE)		0.15 [0.11, 0.18]	0.04	<0.0001	0.08 [0.03, 0.13]	0.04	0.004	0.08 [0.04, 0.12]	0.04	0.0027
Energy intake (kcal/d)		-12.00 [-19.29, -4.71]	0.19	0.0078	2.50 [-6.20, 11.19]	0.19	1.00	-34.41 [-42.47, -26.35]	0.20	<0.0001
Ultra-processed food, %		-0.37 [-0.50, -0.24]	0.04	<0.0001	-0.44 [-0.60, -0.28]	0.04	<0.0001	-0.37 [-0.52, -0.22]	0.04	<0.0001
Organic food, %		4.81 [4.36, 5.27]	0.08	<0.0001	2.71 [2.16, 3.26]	0.05	<0.0001	2.94 [2.44, 3.45]	0.06	<0.0001

Abbreviations: sPNNS-GS2, simplified French National Nutrition and Health Program Guideline Score 2; MEDI-LITE, validated Mediterranean diet based on the literature

Main model:

¹ Multivariable linear regression with mindful eating subdimensions as continuous independent variables and food intake as dependent variables. Main model: Adjusted for sex, age, number of 24-hour dietary questionnaires, educational level, occupational status, monthly household income, smoking status, physical activity, and energy intake (except when energy intake was the outcome).

² Adjusted beta-coefficient: indicates the increase in the outcome variable for a one-point increase in the ME score.

³ Adjusted R-squared: reflects the variance in the outcome variable that is explained by the ME score.

⁴ p -value corrected for multiple testing with the Holm-Bonferroni method.