



# Food insecurity is associated with an unhealthy lifestyle score in middle- and older-aged adults: findings from the EPIPorto cohort

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## Abstract

The association of food insecurity with the combined effect of lifestyles is still limited. This study evaluated the association between food insecurity and a lifestyle score in middle- and older-aged adults. A cross-sectional study (2013–2016) was performed among 595 individuals ( $\geq 50$  years) from the EPIPorto cohort (Porto, Portugal). Food security status was assessed using the *US Household Food Security Survey Module: Six-Item Short Form*. Information on fruit and vegetable consumption (F&V), physical activity (PA) practice, tobacco smoking, and alcohol consumption were included in a lifestyle score. Those with F&V < five portions/day, < 150 min/week of moderate-intensity PA or < 75 min/week of vigorous-intensity PA, current smokers, consumers of > one drink of alcoholic beverages in women, and > two in men were assigned with one point; all the others had nil points. The score could range from 0 to 4, and was further categorised into three categories. Food insecurity was positively associated with an unhealthy lifestyle profile (OR = 2.272; 95%CI: 1.079–4.782), independently of the adjustment variables. Analysing each lifestyle component, food insecurity was associated with low PA practice (OR = 2.365; 95%CI: 1.020–5.485). Individuals from food insecure households were more likely to have an unhealthy lifestyle profile. Public health strategies should be developed among food insecure individuals to promote healthy lifestyles.

**Keywords** Food insecurity · Lifestyles · Adults · EPIPorto

## 1 Introduction

Food insecurity – “*limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways*” (Anderson, 1990) - is on the public health agenda worldwide. In Portugal, between 2015 and 2016, 10.1% of individuals belong to a food insecure household (Lopes et al., 2018). More recently, data from a survey conducted

during the first COVID-19 lockdown period showed a food insecurity prevalence of 33.2% (Gregório et al., 2021).

This issue is particularly relevant considering its association with negative health outcomes and adverse nutritional effects. Among the adult population, food insecurity has been associated with physical and mental health problems (Leung et al., 2015; Stuff et al., 2004), depressive symptoms (Shafiee et al., 2020), cardiovascular disease (Vercammen et al., 2019), non-communicable diseases (such as diabetes and hypertension) (Stuff et al., 2004; Pan et al., 2012; Seligman et al., 2007; Pérez-Escamilla et al., 2014; Venci & Lee, 2018), and even with increased mortality rates (Walker et al., 2019; Sun et al., 2020). Based on evidence from the Portuguese adult population, food insecurity showed to be associated with chronic diseases, such as diabetes, and also with rheumatic disease, depressive symptoms (Gregório et al., 2018) and obesity (Fernandes et al., 2018).

Individuals who belong to food insecure households are more likely to change their food habits and adopt inadequate and nutritionally poorer dietary patterns (Robaina & Martin, 2013; Franklin et al., 2012; Vuong et al., 2015), particularly

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low fruit and vegetable consumption (Gregório et al., 2018; Drisdelle et al., 2020). These unhealthy dietary choices may increase the risk of being overweight and obese (Franklin et al., 2012; Pan et al., 2012), known as the food insecurity-obesity paradox (Dinour et al., 2007). Additionally, adults in food insecure households were less likely to accomplish physical activity recommendations (To et al., 2014) and had poorer sleep quality (Jordan et al., 2016; Ding et al., 2015b).

Food insecurity was also associated with other unhealthy behaviours, particularly tobacco use and alcohol consumption (Kim-Mozeleski & Pandey, 2020; Reitzel et al., 2020). On the one hand, food insecurity was associated with increased odds of smoking (Kim et al., 2017; Mayer et al., 2019) and alcohol consumption (Bergmans et al., 2019), as the stress caused by food insecurity may increase the likelihood of tobacco use and alcohol consumption. In addition to these points, alcohol and tobacco are seen as being used to reduce appetite due to the effect of nicotine (Chun et al., 2015; Kim-Mozeleski & Pandey, 2020). On the other hand, smoking and alcohol behaviours may further increase the risk of food insecurity (Kim-Mozeleski et al., 2018; Hernandez et al., 2017; Chun et al., 2015), as the money required to buy food is instead used to acquire alcohol and tobacco (Chun et al., 2015; Kim-Mozeleski & Pandey, 2020; Bergmans et al., 2019).

To the best of our knowledge, despite a wide range of individual lifestyle behaviours (diet, physical activity, smoking and alcohol consumption) having been associated with food insecurity (Drisdelle et al., 2020; To et al., 2014; Bocquier et al., 2015; Bergmans et al., 2019), the association of food insecurity and the combined effect of these lifestyle behaviours, using indices or scores, is still limited. From a public health perspective, combining different behaviours into a single measure better represents the synergistic interaction between them, and may be more predictive and informative than using each one separately (Sotos-Prieto et al., 2015; Foster et al., 2018). Nonetheless, they are complementary approaches that may deserve attention.

Thus, this study aimed to evaluate the association between food insecurity and a combined lifestyle score, along with its components in a sample of middle- and older-aged adults from a Portuguese population-based cohort.

## 2 Methods

### 2.1 Study design and participants

A cross-sectional study was performed based on data from the EPIPorto cohort (2013–2016). In brief, EPIPorto includes non-institutionalized Portuguese Caucasian inhabitants of Porto, Portugal, aged 18 years old or older at the time of

recruitment, assembled between 1999 and 2003 (Ramos et al., 2004). Households were selected by random digit dialling of landline telephones. For each household, a permanent resident was identified using simple random sampling. The proportion of participation was 70% ( $n=2485$  participants) (Ramos et al., 2004). A second evaluation of the cohort was conducted between 2005 and 2008 ( $n=1682$  participants), and a third evaluation took place between 2013 and 2015 where 995 individuals were assessed. As part of the third cohort evaluation, data on socio-demographic, behavioural and anthropometric characteristics were collected through face-to-face interviews by trained researchers. Computer-assisted telephone interviewing also assessed food security status (Maia et al., 2019). This assessment had as inclusion criteria being 50 or more years of age, and being responsible or co-responsible for cooking and/or buying food for the household (Hamilton et al., 1997). Of the 995 individuals assessed during the third cohort evaluation, 604 individuals were assessed regarding food security status (Maia et al., 2019). Of those, 9 had missing data regarding lifestyle information (fruit and vegetable consumption, practice of physical exercise, tobacco smoking or alcohol consumption), thus a final sample of 595 individuals was obtained.

The included EPIPorto participants, compared to those not included, were younger (67.1 (standard deviation (SD)=8.4) *versus* 71.1 years (SD=12.5);  $p<0.001$ ; Cohen's  $d=0.35$ ) and more educated at the baseline (9.0 (SD=4.9) *versus* 7.5 years of schooling (SD=5.0);  $p<0.001$ ; Cohen's  $d=0.30$ ). No differences were observed regarding sex ( $p=0.094$ ; Cramer's  $V=0.04$ ).

EPIPorto was approved by the Ethics Committee of the São João University Hospital, Porto and by the Portuguese Data Protection Authority. All participants provided written informed consent before participation.

### 2.2 Data collection

Data were collected using structured questionnaires. Information on socio-demographics (sex, age, education, marital status, occupation, working status, household income perception and household monthly income), anthropometrics (measured weight and height), food security status and lifestyle characteristics (fruit and vegetable consumption, practice of physical exercise, tobacco smoking and alcohol consumption) were obtained.

Education was asked regarding completed years of schooling. Marital status was categorised into married/in a civil partnership and not-married (including single, widowed and divorced).

The occupation was classified according to the major professional groups following the National Classification of Occupations (Instituto Nacional de Estatística, 2011).

The occupations were then categorised into three different classes: low (blue-collar: farmers, skilled and unskilled workers, craftsmen, machine operators and assembly workers), intermediate (lower white-collar: administrative and related workers, service and sales workers), and high (upper white-collar: executive civil servants, industrial directors, scientists, middle management and technicians) (Oakes & Kaufman, 2006). The working status of individuals was classified as employed, unemployed, retired or housewife.

The household income perception was collected in four categories: “insufficient”, “need to be careful about expenses”, “enough to meet needs” or “comfortable”. The household monthly income was coded as lower or equal to 1000€, 1001 € to 1500€, and higher than 1500€.

Concerning anthropometrics, the measurements were performed by trained professionals, following standard procedures. Weight was assessed with participants barefoot and in light clothing, using a digital scale to the nearest 0.1 kg. Height was measured with individuals barefoot, with their heels positioned together, and supported on the back wall of the stadiometer, with the head positioned according to the plane of Frankfurt. The reading was done to the nearest 0.1 cm. The body mass index was calculated by dividing weight (kg) by the height (m) squared.

### 2.2.1 Food security status assessment

Food security status was evaluated using the US Household Food Security Survey Module: Six-Item Short Form (United States Department of Agriculture, 2012), as previously described (Maia et al., 2019). Concerning the previous 12 months, individuals were asked about the food eaten in their households and whether they could afford the food they needed. The participants’ households were classified as food secure if the number of affirmative responses was equal to or less than one, low food secure if there were between two and four affirmative responses or very low food secure if the number of affirmative responses was five or six (United States Department of Agriculture, 2012). In the present study, two categories of household food security status were used, food security and food insecurity, the last including both low food security and very low food security.

### 2.2.2 Lifestyle score

Data on lifestyle characteristics from the third EPIPorto cohort evaluation, particularly on fruit and vegetable consumption, the practice of physical exercise, tobacco smoking and alcohol consumption were used to create a lifestyle score, based on and adapted from previous studies (Foster et al., 2018; Ding et al., 2015a).

For this lifestyle score, recommendations from the World Health Organization on fruit and vegetable consumption of at least five portions per day were considered (World Health Organization, 2003). Also, the recent guidelines of the World Health Organization on physical activity were considered. The practice of at least 150 min per week of moderate-intensity physical activity or 75 min per week of vigorous-intensity physical activity is recommended (Bull et al., 2020). The recommendations of the American Heart Association concerning alcohol consumption of less than or equal to two drinks per day in men and less than or equal to one drink per day in women were used (Lichtenstein et al., 2006).

For each unhealthy behaviour, namely fruit and vegetable consumption lower than five portions per day, less than 150 min per week of moderate-intensity physical activity or less than 75 min per week of vigorous-intensity physical activity, current smoking, and drinking more than one drink of an alcoholic beverage in women and more than two in men were assigned one point; all the others conditions had nil points. The final score ranged between zero and four. A lower score represents a healthier lifestyle profile, while a higher score represents a worse and unhealthier one. Considering the frequencies of the total score, it was further categorised into three categories: zero to one, two, and three to four.

## 2.3 Statistical analysis

Continuous variables were described as mean and SD and compared using the Student T-test. Categorical variables were summarised as counts and proportions and were compared using the Chi-square test.

Multinomial logistic regression models and odds ratios (ORs) and respective 95% confidence intervals (CIs) were computed to assess the association between food security status and the lifestyle score (as a categorical variable). Also, binary logistic regression models were performed to evaluate the associations between food security status and each component of the lifestyle score (out *versus* within recommendations (reference class)). ORs and respective 95% CIs were calculated.

Adjustments were performed according to crude significant associations of the covariates with food security status and the lifestyle score and its components, and change of the adjusted association of more than 10% and statistical significance of the variable in the models. Interactions within the models were also tested, and the only significant interaction observed was between sex and food security status in the models regarding tobacco smoking.

Statistical analysis was performed using SPSS Statistics 27.0 (IBM Corp., Armonk, NY, USA), and the significance level was set at 0.05.

### 3 Results

The characteristics of the studied sample are presented in Table 1. The middle- and older-aged adults included in this study had a mean (SD) age of 67.1 years (8.4) and were mainly women (68.1%). Most of the individuals had high occupations (44.2%), were retired (63.6%) and reported the need to be careful about expenses (41.6%). A food insecurity prevalence of 16.6% was observed among participants' households.

Inadequacy of fruit and vegetable consumption (67.4%), the practice of physical activity below recommendations (84.7%), current smoking habits (12.6%), and alcohol consumption above the recommended levels (27.7%) were reported in the middle- and older-aged adults. Most individuals (49.9%) had a lifestyle score of two.

Individuals belonging to food insecure households more often presented an unhealthier lifestyle score when compared to food secure ones ( $p=0.014$ ). Also seen were a higher proportion of fruit and vegetable inadequacy amongst food insecure individuals ( $p=0.029$ ), along with below recommendation practice of physical activity ( $p=0.013$ ), current smoking use ( $p=0.863$ ) and alcohol consumption above the recommended rates ( $p=0.704$ ) (Table 2).

Positive associations between food insecurity and the lifestyle score categories were observed. Those in a food insecure household had a higher odds of having a lifestyle score of two (OR=2.256; 95%CI:1.250–4.073) or between three and four (OR=2.375; 95%CI:1.214–4.645), comparing to the healthiest category. After adjustment for sex, education and household income perception, only the association with the intermediate category lost its statistical significance.

Concerning each component of the lifestyle score, food insecurity was associated with fruit and vegetable consumption lower than five portions per day (OR=1.739; 95%CI:1.053–2.872), and the practice of physical activity lower than 150 min per week of moderate-intensity or lower than 75 min per week of vigorous-intensity physical activity (OR=2.680; 95%CI:1.200–5.984) (Table 3). However, after adjustments for potential confounders, only the association between food insecurity and a low practice of physical activity remained (OR=2.365; 95%CI:1.020–5.485), independently of household income perception and alcohol consumption. No other significant associations were observed for the other lifestyle score components (Table 3).

### 4 Discussion

According to this study's findings, middle- and older-aged adults who belong to food insecure households were more likely to have an unhealthier lifestyle profile. Regarding the individual components of the lifestyle score, although food insecurity was associated with inadequate consumption of fruit and vegetables, after adjustments, only a significant association with physical activity below the recommended was observed.

Previous research on metabolic syndrome (Sotos-Prieto et al., 2015) and other health outcomes (Foster et al., 2018) have used lifestyle scores, reporting that combining different behaviours may be more powerful than individual components. In line with previous evidence, the combination of different adverse behaviours in a combined lifestyle score, rather than looking at them separately, could be more informative (Sotos-Prieto et al., 2015; Foster et al., 2018) and capture better the influence of different health behaviours, considering their complexity and multiple dimensions (Jiao et al., 2009).

Indeed, in this study, we observed that food insecurity was associated with a combination of adverse lifestyle behaviours, which may adversely affect individuals' health. Despite data on the association between food insecurity and the combination of lifestyles still scarce, which limiting comparisons, a previous study (Gharachorlo et al., 2018) including 120 women with gestational diabetes explored the relationship between food insecurity and lifestyle. This study used a lifestyle questionnaire composed of 10 dimensions. These dimensions included: physical health, exercise and fitness, weight control and nutrition, illness prevention, psychological health, spiritual health, social health, drug and alcohol avoidance, accident prevention and environmental health. This study reported a significant relationship between food security status and lifestyle in households without children, which could somehow support our results, despite the different characteristics of the sample. Nonetheless, further studies are needed, especially with a longitudinal design, to clarify the associations between food insecurity and lifestyle behaviours.

Despite the aforementioned scarcity of research on food insecurity and the combination of lifestyles, some research on individual lifestyle score components has been performed, which can be helpful for discussing our findings. In a representative sample of adults from France, and using the United States Department of Agriculture's Food Sufficiency Indicator as a proxy of food insecurity (food insufficiency an inadequate amount of food intake due to a lack of money or resources), food insecurity showed to be associated with lower fruit and vegetable consumption (Bocquier et al., 2015). Moreover, Drisdelle et al. (2020) recently reported

**Table 1** Characteristics of the EPIPorto sample of middle- and older-aged adults (n = 595)

	n (%)*	Missing
<b>Sex</b>		0
Women	405 (68.1)	
Men	190 (31.9)	
<b>Age (years) (mean (SD))</b>	67.1 (8.4)	0
<b>Education (years) (mean (SD))</b>	9.4 (5.4)	1
<b>Marital status</b>		0
Married / in a civil partnership	406 (68.2)	
Not married	189 (31.8)	
<b>Occupation</b>		43
High	244 (44.2)	
Intermediate	173 (31.3)	
Low	135 (24.4)	
<b>Working status</b>		4
Employed	142 (24.0)	
Unemployed	32 (5.4)	
Retired	376 (63.6)	
Housewives	41 (6.9)	
<b>Household income perception</b>		
Insufficient	73 (12.3)	1
Need to be careful about expenses	247 (41.6)	
Enough to meet needs	187 (31.5)	
Comfortable	87 (14.6)	
<b>Household monthly income</b>		32
≤ 1000 €	185 (32.8)	
1001–1500 €	118 (21.0)	
> 1500 €	260 (46.2)	
<b>Body mass index (kg/m<sup>2</sup>) (mean (SD))</b>	27.8 (4.7)	0
<b>Food security status</b>		0
Food security	496 (83.4)	
Food insecurity	99 (16.6)	
<b>Lifestyle score</b>		0
0 to 1	168 (28.2)	
2	297 (49.9)	
3 to 4	130 (21.8)	
<i>Fruit and vegetable consumption</i>		
<5 portions	401 (67.4)	0
<i>Practice of physical activity</i>		
<150 min/w moderate or <75 min/w vigorous physical activity	504 (84.7)	0
<i>Tobacco smoking</i>		
Current smoking	75 (12.6)	0
<i>Alcohol consumption</i>		
>2 drink/d (men) and >1 drink/d (women)	165 (27.7)	0

d, day; SD, standard deviation; w, week

\* Or otherwise specified

that food insecure adults from a low-income neighbourhood had a lower intake of fruit and vegetables. A systematic review also revealed that food insecure adults had poorer diet quality, consuming less fruit and vegetables than food secure ones (Hanson & Connor, 2014).

Food insecure individuals also tend to consume more energy-dense foods and low-quality diets (Morales & Berkowitz, 2016; Hanson & Connor, 2014; Larson et al.,

2020; Leung et al., 2014). This is supported by findings of a systematic review and meta-analysis, showing that healthy dietary patterns are more expensive than less healthy ones (Rao et al., 2013), justifying the lower consumption of, for instance, fruit and vegetables among food insecure individuals. In our results, after adjustments for education and household income perception, a significant association was

**Table 2** Characteristics of the EPIPorto sample of middle- and older-aged adults according to the food security status

	Food security (n = 496 (83.4%))	Food insecurity (n = 99 (16.6%))	<i>p</i> -value
	n (%)*		
<b>Sex</b>			0.003
Women	325 (65.5)	80 (80.8)	
Men	171 (34.5)	19 (19.2)	
<b>Age (years) (mean (SD))</b>	66.9 (8.4)	68.0 (8.4)	0.231
<b>Education (years) (mean (SD))</b>	10.2 (5.4)	5.6 (3.4)	<0.001
<b>Marital status</b>			0.013
Married / in a civil partnership	349 (70.4)	57 (57.6)	
Not married	147 (29.6)	42 (42.4)	
<b>Occupation</b>			<0.001
High	230 (49.7)	14 (15.7)	
Intermediate	134 (28.9)	39 (43.8)	
Low	99 (21.4)	36 (40.4)	
<b>Working status</b>			0.007
Employed	130 (26.4)	12 (12.1)	
Unemployed	23 (4.7)	9 (9.1)	
Retired	308 (62.6)	68 (68.7)	
Housewives	31 (6.3)	10 (10.1)	
<b>Household income perception</b>			<0.001
Insufficient	40 (8.1)	33 (33.3)	
Need to be careful about expenses	196 (39.6)	51 (51.5)	
Enough to meet needs	175 (35.4)	12 (12.1)	
Comfortable	84 (17.0)	3 (3.0)	
<b>Household monthly income</b>			<0.001
≤ 1000 €	127 (27.0)	58 (63.0)	
1001–1500 €	94 (20.0)	24 (26.1)	
> 1500 €	250 (53.1)	10 (10.9)	
<b>Body mass index (kg/m<sup>2</sup>) (mean (SD))</b>	27.4 (4.4)	29.4 (5.5)	0.001
<b>Lifestyle score</b>			0.014
0 to 1	152 (30.6)	16 (16.2)	
2	240 (48.4)	57 (57.6)	
3 to 4	104 (21.0)	26 (26.3)	
<b>Fruit and vegetable consumption</b>			0.029
<5 portions/d	325 (65.5)	76 (76.8)	
<b>Practice of physical activity</b>			0.013
<150 min/w moderate or	412 (83.1)	92 (92.9)	
<75 min/w vigorous physical activity			
<b>Tobacco smoking</b>			0.863
Current smoking	62 (12.5)	13 (13.1)	
<b>Alcohol consumption</b>			0.704
>2 drinks/d (men) and > 1 drink/d (women)	136 (27.4)	29 (29.3)	

d, day; SD, standard deviation; w, week

\* Or otherwise specified

lost, and this could reflect the role of education on food literacy, even in situations of food insecurity.

Regarding physical activity, a previous study indicated that food insecure adults were less prone to accomplish the physical activity guidelines (To et al., 2014). Our study also found that food insecure middle- and older-aged adults had increased odds of not achieving the physical activity recommendations, regardless of household income perception

and alcohol consumption. To et al. (2014) pointed out possible reasons that could justify the association between food insecurity and less physical activity. On the one hand, food insecurity can contribute to insufficiency of nutrients and poor health, which could contribute to reducing the capacity and amount of physical activity performed by individuals. On the other hand, a lower amount and intensity of physical activity might lead to poorer health outcomes and lower



**Table 3** Associations between food security status and the lifestyle score and its individual components in middle- and older-aged adults

Outcomes \ Exposure	Food security status		
	Food security	Food insecurity	
		Crude OR (95%CI)	Adjusted OR (95%CI)
<b>Lifestyle score</b>	Ref.		
0 to 1		Ref.	Ref.
2		<b>2.256 (1.250–4.073)</b>	1.677 (0.881–3.191)*
3 to 4		<b>2.375 (1.214–4.645)</b>	<b>2.272 (1.079–4.782)*</b>
<b>Components of the lifestyle score</b>			
<b>Fruit &amp; vegetable consumption</b>	Ref.		
<5 portions/d		<b>1.739 (1.053–2.872)</b>	1.204 (0.691–2.097)†
<b>Practice of physical activity</b>	Ref.		
<150 min/w moderate or <75 min/w vigorous physical activity		<b>2.680 (1.200–5.984)</b>	<b>2.365 (1.020–5.485)‡</b>
<b>Tobacco smoking</b>	Ref.		
Current smoking		1.058 (0.557–2.009)	0.703 (0.281–1.759)§
<b>Alcohol consumption</b>	Ref.		
>2 drinks/d (men) and >1 drink/d (women)		1.097 (0.682–1.765)	1.521 (0.915–2.526)¶

CI, confidence interval; d, day; OR, odds ratio; w, week

\* adjusted for sex, education and household income perception

† adjusted for education and household income perception

‡ adjusted for household income perception and alcohol consumption

§ adjusted for sex, age and food security status\*sex

¶ adjusted for sex and practice of physical activity

work capacity, contributing to less capacity to afford the needed food.

Concerning tobacco smoking, findings from France reported an association between smoking and food insecurity (Bocquier et al., 2015). However, in this study, no such association was observed. The lower prevalence of smoking could justify this among this Portuguese sample compared to the French one (12.6% versus 31.2%). Another study reported an association between smoking and food insecurity, particularly, the co-occurrence of food insecurity and smoking (Kim-Mozeleski & Pandey, 2020). Indeed, the direction of this association is still not completely clear – if food insecurity increases the risk of becoming a smoker, or the other way around (Kim-Mozeleski & Pandey, 2020).

In this study, no significant associations between food insecurity and alcohol consumption were observed. However, it was described that food insecurity might lead to psychological and behavioural problems (Ciciurkaite & Brown, 2018), including alcohol consumption (Bergmans et al., 2019). A previous study reported that the effect of food insecurity on psychological issues and alcohol consumption is influenced by gender and family context (Ciciurkaite & Brown, 2018). Thus, in our sample, the absence of a significant association with alcohol consumption may somewhat be justified by the fact that no such variability regarding family context was observed in our sample, as the majority of households in this sample were composed of one or two members (data not shown).

This study has limitations that should be acknowledged. Its cross-sectional design limits inference about causality. As only information on the practice of physical exercise was available, it was used as a proxy for physical activity.

Moreover, the absence of data on other lifestyle behaviours than those accounted for in this study, such as screen time and sleep duration, and on different foods or food groups (Foster et al., 2018; Ding et al., 2015a), may pose a limitation of the study. Nevertheless, fruit and vegetables are considered a relevant component of a healthy diet (World Health Organization and Food and Agriculture Organization of the United Nation, 2005), supporting fruit and vegetables as a proxy of diet quality.

Furthermore, the possibility of information bias, particularly social desirability bias cannot be discarded. First, as food insecurity is considered a delicate issue, an underestimation of food insecurity prevalence cannot be precluded. Second, as data on fruit and vegetable consumption, the practice of physical activity, tobacco smoking and alcohol consumption were self-reported, information could be affected by a social desirability bias. Indeed, healthy behaviours (fruit and vegetable consumption and practice of physical activity) could be over-reported, while unhealthy ones (tobacco smoking and alcohol consumption) could be underreported.

Additionally, it is worth of mention that the US Household Food Security Survey Module: Six-Item Short Form has a good internal consistency (Terwee et al., 2007), despite

the fact that, in terms of validity, only Cronbach's alpha was calculated ( $\alpha=0.748$ ).

Despite some differences between the participants included in this study and those not included were observed regarding age and education, the magnitude of the differences was small. Thus, the probability of selection bias was reduced. Moreover, the possibility of residual confounding cannot also be discarded.

Although the included sample may not be representative of all Portuguese middle- and older-aged adults, the findings of this study could be indicative of the situation of food insecure middle- and older adults in Portugal, since this study was strengthened by the use of a sample of middle- and older-aged adults from a population-based cohort, with data on a large number of socio-demographic and behavioural characteristics, creating the possibility to explore the association between food security status and a lifestyle score. Also, food security status was assessed among cohort participants who were responsible or co-responsible for cooking and/or buying food for the household (Hamilton et al., 1997), which may have improved the accuracy of the food security status of individuals' households, representing a strength of this study.

## 5 Conclusion

In conclusion, middle- and older-aged adults belonging to food insecure households were more likely to have an unhealthy lifestyle profile. The findings of this study support the need for the development of public health strategies and interventions to promote healthy lifestyle habits, especially the practice of physical activity, among food insecure individuals and also in guaranteeing and improving food security.

Further studies are still needed, especially since the pandemic, as food insecurity is expected to be exacerbated during that period.

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**Authors' contributions** IM, AO and ACS designed the study. IM performed the statistical analysis. IM drafted the manuscript. All authors read, critically revised and edited the manuscript. All authors approved the final manuscript.

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## Declarations

**Conflict of interest** The authors declare no conflicts of interest.

**Ethical approval** EPIPorto was approved by the Ethics Committee of the São João University Hospital, Porto and by the Portuguese Data Protection Authority. All participants provided written informed consent before participation.

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