FLUID AND TOTAL WATER INTAKE IN A SENIOR MEDITERRANEAN POPULATION AT HIGH CARDIOVASCULAR RISK: DEMOGRAPHIC AND LIFESTYLE DETERMINANTS IN THE PREDIMED-PLUS STUDY

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ABSTRACT

Purpose

We aimed to evaluate associations between compliance with recommendations for total water intake (TWI) and total water intake from fluids (TWIF), and some sociodemographic and lifestyle factors of a senior Mediterranean population at high cardiovascular risk.

Methods

Cross-sectional analysis with data of 1,902 participants from the PREDIMED-PLUS study. A validated 32-item Spanish fluid-intake questionnaire was used to assess beverage consumption and water intake. Multivariable logistic regression models were used to assess the odds ratio (OR) and the 95% confidence interval (CI) for complying with European Food Safety Agency (EFSA) recommendations for TWI and TWIF according to various sociodemographic and lifestyle factors, and for the joint associations of Mediterranean diet (MedDiet) adherence and moderate-vigorous physical activity (MVPA).

Results

The mean total volume of fluid intake in the population studied was 1,934 ± 617 mL/day. Water was the most frequently consumed beverage. Significant differences between sex were only observed in alcoholic and hot beverage consumption. Compliance with TWIF was associated with being women (OR: 3.02;2.40,3.80), high adherence to MedDiet (OR: 1.07;1.02,1.12), and participants who were more engaged in physical activity (PA) (OR: 1.07;1.02,1.13). Age was inversely associated (OR: 0.96;0.94,0.98). Similar results for TWI recommendations compliance were observed in relation to being women (OR: 5.34;3.85,7.42), adherence to MedDiet (OR: 1.16; 1.02,1.31) and PA (OR: 1.07;1.00,1.15). The joint association of PA and MedDiet, showed that participants with higher adherence to MedDiet and meeting WHO recommendations for MVPA complied better the TWI recommendations (OR: 1.66;1.19, 2.32).

Conclusions

High compliance with recommendations for TWI was associated with being a woman, and a healthy lifestyle characterized by high adherence to the MedDiet and PA.

Keywords

Total water intake (TWI), Fluid Intake, Beverages, Mediterranean Diet.

INTRODUCTION

Water is essential for the optimal physiological function of the human body, because it is a source of minerals and electrolytes and is involved in metabolic processes [1]. Low fluid consumption and inadequate water intake could induce dehydration and its consequences, increase the risk of urolithiasis and non-communicable chronic diseases [2] and have some undesirable effects on cognitive function and physical performance [3]. Consequently, adequate water intake is necessary in order to maintain a good health status. The elderly are at special risk of low water intakes because they lose their sensation of thirst and appetite, and their renal ability to concentrate urine is impaired [4,5]. In fact, a previous study in US citizens reported that elderly population had inadequate water intake [4], and higher risk of dehydration.

In order to prevent dehydration and its undesirable effects on health, reference values for water intake have been established. The European Food Safety Agency's (EFSA) recommendation for total water intake (TWI) for the elderly is 2.5 L/day and 2.0 L/day for men and women respectively in conditions of moderate environmental temperature and moderate physical activity [5]. Water intake consists largely of the consumption of drinking water and other beverages (80%), although it is generally held that approximately 20% is consumed through food [5]. Beverages provide not only water, but also some minerals, vitamins and other nutrients such as carbohydrates, proteins and fats. Therefore, total fluid intake and the beverage pattern, as well as food consumption, is fundamental to determine the health and disease, not just hydration.

There are several determinants of total fluid intake and beverage consumption. For example, healthy dietary patterns and regular physical activity (PA) have proved to be associated with a healthier beverage pattern and general lifestyle [6, 7]. The Mediterranean diet (MedDiet), a healthy dietary pattern associated with a reduced risk of several chronic health conditions, is characterized by the consumption of water as the main drinking fluid, a daily but moderate consumption of red wine especially with meals, a moderate consumption of milk or yogurt, and a low consumption of sugar-sweetened beverages (such as soda and sugar-sweetened fruit juice or tonic) [7, 8]. PA has also been associated with healthier dietary patterns. People who are more physically active are more likely to adhere to the MedDiet [9] and, therefore, consume healthier beverages. In fact, a previous study by our research group reported that healthy young and adult individuals who adhere more closely to the MedDiet and who engage in more physical exercise had a healthier fluid intake pattern, and a greater probability of complying with EFSA's recommended total daily fluid intake and the World Health Organization's recommendations on the intake of free sugars to reduce the risk of non-communicable diseases [10]. These associations have been especially explored in adolescents or healthy adults, but not in individuals at high cardiovascular risk.

Because fluid consumption has been the object of few studies and these relationships have been poorly studied in old populations, the aim of the present study was to describe the fluid intake pattern of a senior Mediterranean population with overweight/obesity and Metabolic Syndrome (MetS), and to evaluate possible associations between compliance with TWI and TWIF recommendations and some sociodemographic and lifestyle factors.

MATERIALS AND METHODS

Study design and participants

The present study is a cross-sectional baseline analysis within the frame of the PREDIMED-PLUS study, a large, multicentre, parallel-group, randomized and controlled clinical trial conducted in Spain to assess the effect of an intensive weight loss intervention program based on an energy-restricted traditional MedDiet, PA promotion and behavioural support, in comparison with an intervention based on energy-unrestricted traditional MedDiet (control group) on cardiovascular disease (CVD) morbi-mortality. A more detailed description of the PREDIMED-PLUS study is available at https://www.predimedplus.com. This study was registered at the International Standard Randomized Controlled Trials (ISRCT; http://www.isrctn.com/ISRCTN89898870) on 24 July 2014.

From October 2013 to October 2016, 6,874 participants were recruited and randomized in 23 centres from various universities, hospitals and research institutes in Spain. The eligible participants were adults (aged 55–75 for men; 60–75 for women) with overweight/obesity [body mass index (BMI) ≥27 and <40 kg/m^2], who had at least three components of the Metabolic Syndrome according to the updated harmonized criteria between the International Diabetes Federation, the American Heart Association and National Heart, Lung and Blood Institute [11]. The age cutoff has been defined in order to have enough power to find differences between groups in relation to the primary end-point of the trial (a composite of CVD incidence and mortality). Detailed inclusion and exclusion criteria has been extensively described elsewhere [12].

This is a sub study conducted in 10 out of the 23 PREDIMED-Plus recruiting centres. Out of 6,874 total participants enrolled in the PREDIMED-Plus trial, 2,068 individuals full-filled the validated 32-item Spanish fluid-intake questionnaire. From those 2,068 participants with Spanish fluid-intake questionnaire, we excluded participants without the baseline food frequency questionnaire (FFQ), or who reported implausible total energy intakes (≤500 and ≥3,500 kcal/d in women and ≤800 and ≥4,000 kcal/d in men; n = 55), and, those participants who reported a total fluid intake above or below two standard deviations from the median value (<303 and >3,684 mL/d in men and <474 and >3,295 mL/d women; n = 111). Hence, the final sample analysed in present study was 1,902 individuals (945 men and 957 women).

As the present cross-sectional analysis has been conducted with baseline data of the study participants (before the intervention was started), results of the present study were not reported separately by intervention or control group.

All participants provided written informed consent, and the study protocol and procedures were approved according to the ethical standards of the Declaration of Helsinki.

Assessment of fluid and water intake.

At baseline a trained dietitian held a face-to-face interview with participants and completed a validated 32-item Spanish fluid-intake questionnaire [13], which recorded the frequency of consumption of various beverage types over the previous month. The average daily fluid intake from beverages was estimated from the servings of each type of beverage. The questionnaire items on beverages included: tap water, bottled water, natural fruit juices, bottled fruit juices, natural vegetable juices, bottled vegetable juices, whole milk, semi-skimmed milk, skimmed milk, drinking yogurt (100 and 200 cc), milkshakes, vegetable drinks, soups, jellies and sorbets, soda (200 and 330 cc), light/zero soda (200 and 330 cc), espresso (sweetened and

unsweetened), white coffee (sweetened and unsweetened), tea (sweetened and unsweetened), other infusions (sweetened and unsweetened), beer (200 and 330 cc), non-alcoholic beer (200 and 330 cc), wine, spirits, mixed alcoholic drinks, energy drinks, sports drinks (200 and 330 cc), meal replacement shakes and other beverages. The water and nutrient content of the beverages was estimated mainly with the CESNID Food Composition Tables [14], with complementary data from the BEDCA Spanish Database of Food Composition [15] and nutritional information from the food industry website [16].

Beverages were classified into eight groups for further analysis: water (tap and bottled water), milk and dairy beverages (milk, milkshakes, drinking yogurt, other milk beverages), hot beverages (coffee, tea and other infusions), sugar sweetened beverages (SSBs, including carbonated soft-drinks, natural and bottled fruit juice, energy drinks and sports drinks), artificial sweetened beverages (ASBs, including light/zero carbonated soft drinks), alcoholic beverages (spirits, mixed alcoholic drinks, wine, beer, cider), broths (vegetable soups and natural and bottled vegetable juice), and other beverages (soy drinks, non-alcoholic beer, sorbets and jellies, and meal replacement shakes).

In order to compute the TWI, the water contained in food was also calculated. Additionally, foods from the FFQ were classified into 10 food groups: vegetables, fruits, legumes, cereals, dairy beverages, meat and poultry, fats, nuts, fish/seafood, and other foods in order to assess their contribution to total water intake.

Total daily consumption of fluids (mL) was computed as the sum of all the beverages consumed. Total water intake from fluids (TWIF) (mL) was computed as the water intake through fluids and beverages. TWI (mL) was computed as the sum of the water content of the beverages and foods consumed.

Covariate assessment

At baseline, trained dietitians in a face-to-face interview with the participants completed questionnaires with their socio-demographic information (sex, age, education, and marital status), lifestyle factors (smoking habits, physical activity, and sedentary behaviours), personal medical history, medication use and a 143-item FFQ.

Trained staff in the PREDIMED-PLUS operations protocol determined anthropometric variables. Weight and height were measured with calibrated scales and a wall-mounted stadiometer, respectively. BMI was calculated as the weight in kilograms divided by the height in meters squared. Waist circumference was measured midway between the lowest rib and the iliac crest, after normal exhalation, using an anthropometric tape.

In accordance with the PREDIMED-PLUS protocol, participants in the control group completed a validated 14-item MedDiet adherence questionnaire [17], while participants in the intervention group completed a 17-item questionnaire to assess adherence to an energy-restricted MedDiet. Eleven items were the same in both of them, and they differed in the amount or number of portions of olive oil, red meat and sugar sweetened beverages consumption. In order to measure adherence to the MedDiet in both groups, these three items were calculated using baseline data from the FFQ. The correlation coefficient between the 14-item MedDiet adherence score and the estimation using the FFQ data was 0.8590 ($n = 960$, $P \leq 0.001$) in the control group.

Sedentary behaviours were evaluated using the validated Nurses' Health Study questionnaire for sedentary behaviours [18]. It consists of a set of open-ended questions assessing the average daily time spent over the last year watching TV, sitting while using a computer, sitting on journeys and total sitting. Answers were divided into 12 categories ranging from 0 to 9 h/day of sitting time for the corresponding activity.

Leisure-time PA was assessed using the validated Registre Gironí del Cor (REGICOR) questionnaire [19], which collects information about the type of activity, frequency (days) and duration (min./day) in a month. The intensity was assigned using the compendium of PA [20]. A trained interviewer collected the information for six types of activity during a conventional month: brisk walking (5 MET), walking at a slow/normal pace (4 MET), walking in the countryside (6 MET), climbing stairs (7 MET), working in the garden (5 MET), exercise or playing sports either at home, outdoors or in a gym (11 MET). Depending on the PA intensity, activities were categorized into light PA ≤ 4.0 MET or moderate and vigorous PA > 4.0 MET.

Statistical analysis

For the present report we used the PREDIMED-PLUS data base updated until October 2018. In order to report differences in beverage consumption and water intake between male and female individuals, all analyses were conducted separately by sex. Sociodemographic characteristics, beverage consumption, total fluid intake and TWI are reported as means and standard deviation (SD) for continuous variables or numbers and percentages (%) for dichotomous variables. Pearson's x^2 tests or Student's t-tests were used to compare the quantitative or general categorical characteristics of the studied population.

The odds ratio (OR, 95%CI) for meeting the EFSA recommendations for TWIF (2L/day and 1.6L/day, for men and women respectively) and TWI (2.5L/day and 2L/day, for men and women respectively) (dependent variables) was assessed by logistic regression models adjusted for age (continuous), sex, educational level (primary education, secondary education and academic/graduate), smoking status (never smoker, former smoker and current smoker), sedentary time (hours/day), leisure-time physical activity (30min./day), MedDiet adherence (<9, low or ≥9, high adherence) and recruitment centre (in quartiles by number of recruited participants). The percentage of individuals who met EFSA recommendations for TWIF and TWI was calculated.

We also explored the joint associations of MedDiet adherence and moderate-vigorous physical activity (MVPA) and the compliance with EFSA TWIF and TWI recommendations by logistic regressions adjusted by the variables mentioned above except for sedentary time, leisure-time physical activity and MedDiet adherence. For both analyses, each participant was cross-allocated to one of the four joint categories in which low adherence to MedDiet and not meeting MVPA recommendations was considered as the reference category. MVPA was first dichotomized into meeting (≥150min/week) or not meeting (<150min/week) based on current World Health Organization's recommendations for elderly population [21]. Because the EFSA recommendations are reported by sex, we present the results for the total population and separately by sex. We then conducted stratified analyses to investigate whether the observed associations were modified by sex and age. Interaction was tested with likelihood ratio tests, which involved comparing models with and without cross-product terms.

All analyses were conducted with robust estimates of the variance to correct for intra-cluster correlation in the logistic regression models. Intra-cluster was defined as the participants sharing the same household. Significance level was set at $P < 0.05$. All analyses were cross-sectional, and performed using Stata (14.0, StataCorp LP, Tx. USA).

RESULTS

The present analysis included 1,902 participants (945 men and 957 women) with a mean age of 65 ± 5 years. The general characteristics of the studied population are shown in **Table 1**. There were no statistically significant differences between women and men in terms of diabetes or hypertension prevalence and adherence to MedDiet. However, the men were younger, had low BMI values, spent more time on PA, were more likely to smoke, and had a higher educational level. Participants involved in the present analysis did not differ from the rest of the participants enrolled in the PREDIMED-PLUS trial in terms of age, sex, BMI, and prevalence of obesity and T2D ($P > 0.05$ for all comparisons)

Table 2 shows the fluid consumption pattern by sex. The mean total volume of fluid intake in the studied population was 1,934 ± 617 mL/day. Total fluid intake was higher in men than in women (women 1,876 ± 574 and men 1,991 ± 653). Although water was the most frequently consumed beverage followed by milk and dairy beverages, differences by sex were only significant for alcoholic and total hot beverage consumption. The consumption of alcoholic beverages was higher in men than women. We also observed that alcohol consumption decreased with age ($P < 0.01$, data not shown). In contrast, women consumed more hot beverages than men. No significant differences were observed by sex in terms of drinking water, dairy beverages, soup or vegetable juices, sugar and sweetened beverages and artificially sweetened beverages.

Total water intake was 2,845mL (men 2,861 ± 656 and women 2,830 ± 628). Fluids contributed to total water intake by 1,819 ± 558 mL/day (women 1,778 ± 536 and men 1,861 ± 577). The contribution of each beverage group to total fluid intake is shown in **Figure 1**. Drinking water constitutes more than 50% of total fluid intake.

The mean total intake of macro and some micronutrients through fluids for the total population and separated by sex is shown in **Supplementary Table 1.** In the total sample, energy, carbohydrate, protein and fat intake from fluids was 420 ± 257 kcal/day, 51 ± 39g/d (more than 70% was from sugars), 23 ± 15g/d, and 7 ± 6g/d, respectively. The mean total alcohol intake was 8 ± 13g/d. Significant differences were observed between sex in terms of energy, sugar, alcohol and potassium intake, which proved to be higher in men than in women.

Mean water intake from food was 1,026 ± 286 mL/day (women 1,553 ± 289 and men 1,000 ± 280). The contribution of water from various food groups is shown in **Supplementary Table 2**. The mean volume of TWI was 2,845 ± 642 mL/day (women 2,830 ± 628 and men 2,861 ± 656). The percentage contributed by fluids and various food groups to total water intake is shown in **Figure 2**. Fluids contributed to 65% of TWI, while food contributed to the rest. Fruits and vegetables were the two food groups that contributed most to TWI (11% each). **Supplementary Figure 1** shows the contribution of various food groups and fluids to total water intake by sex. Statistical significant differences by sex in the percentage of water contributed were observed for several food groups and fluids at exception for legumes, fish/seafood, fats and nuts ($P < 0.01$).

In total, 80% of the studied population (91% of women and 69% of men) met EFSA's recommendations for TWI (2.5L/d for men and 2L/day for women). In contrast, only 51% of the study population (62% of

294 women and 39% of men) met the EFSA's recommendation for TWIF (**Supplementary Figure 2**). **Table**
295 **3** shows the associations (OR and 95% CI) between various socio-demographic and lifestyle factors and
296 compliance with the EFSA recommendations for TWIF and TWI. As far as TWIF is concerned, women
297 are more likely to comply with the EFSA's recommendations than men (OR: 3.02, 95%CI: 2.40, 3.80, $P <$
298 0.001). Besides, women with higher adherence to the MedDiet were 8% more likely to meet EFSA
299 recommendations than women with low adherence (OR: 1.08, 95%CI: 1.01, 1.16, $P < 0.025$). PA in leisure
300 time was also positively associated with complying with TWIF EFSA recommendations (OR: 1.07, 95%CI:
301 1.02, 1.13, $P < 0.05$). In addition, we observed an unexpected positive association between time spent on
302 sedentary behaviours and compliance with the EFSA recommendations for TWIF in the total population
303 (OR: 1.06, 95%CI: 1.01, 1.12, $P < 0.05$). In contrast, for both sexes a significant inverse association
304 between age and compliance with TWIF EFSA recommendations (OR: 0.96, 95%CI: 0.94, 0.98, $P < 0.001$)
305 was found. Similar results were observed for TWI. Being a woman (OR: 5.34, 95%CI: 3.85, 7.42, $P <$
306 0.001) with high adherence to the MedDiet (OR: 1.16, 95%CI: 1.02, 1.31, $P < 0.02$) was associated to
307 better compliance with EFSA recommendations for TWI. We also observed that populations that engaged
308 most in PA in their leisure time (OR: 1.07, 95%CI: 1.00, 1.15, $P < 0.05$) and in sedentary behaviours were
309 more likely to comply with TWI EFSA recommendations (OR: 1.11, 95%CI: 1.04, 1.18, $P < 0.001$).

310 **Figure 3** shows the association between MedDiet adherence and moderate-vigorous physical activity
311 (MVPA) and compliance with EFSA TWIF (a) and TWI (b) recommendations. Compared to the reference
312 category (low adherence to the MedDiet and non-compliance with MVPA recommendations), low
313 adherence to the MedDiet and compliance with MVPA recommendations (OR: 1.30, 95%CI: 1.01, 1.65, P
314 < 0.039), high adherence to the MedDiet and non-compliance with MVPA recommendations (OR: 1.43,
315 95%CI: 1.09, 1.89, $P < 0.011$) and high adherence to the MedDiet and high compliance with MVPA
316 recommendations (OR: 1.63, 95%CI: 1.26, 2.10, $P < 0.001$) showed to be positively associated with higher
317 compliance with EFSA TWIF recommendations. Also compared to the reference category, those
318 participants with higher adherence to the MedDiet and who complied with World Health Organization's
319 recommendations for MVPA were more likely to comply with TWI recommendations (OR: 1.66, 95%CI:
320 1.19, 2.32, $P < 0.003$).

321 **Discussion**

322 Few studies have analysed the demographic and lifestyle determinants of fluid intake, and to the best of our
323 knowledge the present study is the first one, which analyses the TWI (considering water from fluids and
324 water contained in food) determinants. In the present analysis, we have described the fluid intake pattern
325 of a Mediterranean population at high cardiovascular risk and its determinants. We have reported that 80%
326 of the study population met the water recommendations established by the EFSA. High compliance with
327 TWI recommendations was associated with age, being a woman, and having a healthier lifestyle
328 characterized by high adherence to the MedDiet and spending more time on PA. Furthermore, when we
329 analysed the joint association of PA and MedDiet with the EFSA's recommendation for TWI and TWIF
330 we observed that people with higher adherence to the MedDiet and who spent more time on MVPA were
331 more likely to meet the recommendations.

In our study a higher percentage of men (69%) and women (91%) complied with the TWI recommendations than in the recent Anthropometry, Intake and Energy Balance (ANIBES) study conducted in a representative healthy Spanish sample [22], in which only 67% and 79% of men and women, respectively, complied with these recommendations. These differences might be explained in part by the fact that we used a specific validated fluid intake assessment questionnaire to assess the water intake from fluids whereas the ANIBES study method estimated the water intake was through a non-validated 3-day record of all the food and drinks consumed using photographic records for estimating the consumed amounts.

According to EFSA's recommendations, 80% of the TWI comes from drinking water and beverages, whereas food only accounts for the remaining 20%. In our study, however, approximately 65% of water intake was supplied by drinking water and other fluids whereas food contributed to the remaining 35%. The MedDiet pattern followed by our studied population could partly explain this discrepancy, since it is characterized by a high consumption of fruits and vegetables, which are known to provide significant amounts of water [14]. In fact, in our study these two food groups by themselves made up 22% of the TWI (62.8% of water intake through food). In addition, in a previous study it has been shown that those individuals with high adherence to MedDiet reported to drink more water and wine that those with low adherence to the Mediterranean diet [10]. This also occurred in the present study in relation to wine consumption (data not shown).

In a seminal study conducted by our group in the context of a healthy Mediterranean population we have also reported that sex and age were important determinants of fluid intake [23]. In the present study, we extended the results to TWI in a population at high risk of CVD with overweight/obesity and MetS. The positive association between being women and the compliance with EFSA's recommendations for TWI and TWIF, might be explained by the fact that women are more likely to adhere to a healthier lifestyle [24], and, in general, adults with healthier dietary pattern usually have a healthier fluid intake pattern [6]. The inverse association observed in both studies between age and TWI, TWIF or TFI might be related to the elderly's inability to perceive thirst [25] regardless health status, although other cultural or sociodemographic determinants cannot be excluded as explanations for this association.

Along the same lines, a previous study of healthy Spanish adults had shown that adherence to the MedDiet and PA were positively associated with Total Fluid Intake (TFI) [10]. However, the previous study reported these associations for TFI instead of TWI, which may not assure that TWI EFSA's recommendations, were complied. Furthermore, we observed that participants who showed a higher adherence to MedDiet and who engaged in MVPA were more likely to comply with EFSA's recommendations for TWI.

It has been suggested that high compliance with TWI recommendations by people who engage in physical activity might be partly explained by the fact that they tend to drink more as they have increased fluid demands [26]. However, future studies need to be carried out to better understand the determinants/mechanisms that explain why more active people are less prone to be below the fluid intake recommendations. In addition, studies should be conducted in order to verify if people practising MVPA are meeting their water individual demands, since it has been reported that daily water requirements could increase in the performance of modest physical activity [27].

Our results on the beverage pattern are in agreement with those reported for Spain in a previous multicentre study conducted in different continents [28], but specially with those reported in a healthy Spanish population [7, 22, 23]. Drinking water was the most consumed beverage, followed by a moderate-low milk consumption, hot beverages (mainly coffee) and moderate-low alcohol beverages (mainly wine and beer). Although men had a higher alcohol consumption than women, mean alcohol intake was in accordance with Spanish recommendations (no more than 40g/d and 20g/d for men and women, respectively) [29]. Interestingly, although the MedDiet is characterized by a moderate-low consumption of red wine (one cup for women, two cups for men), in the studied population mean consumption was less than 1 cup per day for both sexes. We also observed that alcohol consumption tended to decrease with age. A study conducted on a Spanish elderly population observed that the consumption of alcoholic beverages tends to decrease with age, suboptimal health status, a diagnosis of diabetes or drug use, and CVD, which might partly explain our findings [30]. The consumption of sugar-sweetened beverages in our population was lower than the mean consumption reported in healthy and younger populations [23]. Previous studies reported a positive association between age and higher adherence to the MedDiet [31]. Investigators have suggested that elderly populations at high risk of developing chronic diseases are more likely to adopt healthy dietary habits than young adults [32], which might partly explain the differences observed in our study with other healthy and younger populations.

Fluids contribute not only to water but also to energy intake, mostly from sugars [14]. In addition, some beverages (mainly dairy) can contribute to the intake of fat and protein and micronutrients such as calcium, vitamin C, sodium and potassium [14]. The relatively high intake of fats, protein and calcium through beverages could be explained by the moderate consumption of milk and dairy drinks in the studied population. Furthermore, fluids contributed to almost 50% of the recommended daily vitamin C intake in a Spanish healthy population [33], because of the high consumption of fruit and vegetable juices. In our study a low-to-moderate amount of sugar comes from beverages compared to other countries. This deserves a comment because drinking water or low-calorie beverages consumption should be prioritized in order to decrease energy intake through beverages, especially from SSB, that are characterized by a high content of added sugar and has been related to weight gain [34] and an increase in the risk of non-communicable chronic diseases [35].

Our study has some limitations that should be mentioned. First, it is a cross-sectional analysis, therefore, causal relationships cannot be proven. Second, the studied population is a senior Mediterranean population at high cardiovascular risk, so the results cannot be extrapolated to the general population. Third, the period of food or fluid consumption addressed by each questionnaire differ (in case of the FFQ during the last year, and in case of the Spanish fluid-intake during the last month), which could lead to bias total water intake estimation. Fourth, hydration biomarkers, such as urine osmolality, were not used. If hydration biomarkers had been used, we would have been able to better assess if the individual water demands to maintain an optimal hydration status were covered.

One of the strengths, in our study is that we assessed not only water intake from beverages as is standard in studies using a fluid specific assessment questionnaire validated in Spanish population, but we also assessed water consumption from food. In addition, to the best of our knowledge, this is the first study to

assess the association between compliance with TWI and TWIF, and several social-demographic and lifestyle factors, and it has been able to describe the joint association of MedDiet adherence and physical activity with compliance with the EFSA's recommendations in a senior Mediterranean population at high cardiovascular risk.

Conclusion

Our study showed that a high percentage of elderly Mediterranean individuals (aged 55-75) at high cardiovascular risk meet the EFSA's recommendation for TWI. We demonstrated that high compliance with TWI recommendations is inversely associated with age, and positively associated with being a woman, and having a healthier lifestyle characterized by high adherence to the MedDiet and PA. These results suggest that a healthy lifestyle is associated with compliance with water recommendations and a lower risk of dehydration and the potential unhealthy effects of excess salt and sugar from beverages.

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Compliance with ethical standards

All participants provided written informed consent, and the study protocol and procedures were approved according to the ethical standards of the Declaration of Helsinki.

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Conflicts of interest

J.S.-S. reports serving on the board of the International Nut and Dried Fruit Council from which he has also received grant support through his institution, receiving consulting fees from Danone, Font Vella Lanjaron, Nuts for Life, and Eroski, and being given grant support through his institution from Eroski. J.S.-S is member of the executive committee of the Instituto Danone Spain and member of the scientific committee of the Institute Danone International. L.D. reports to receive a grant from the Fundación Cerveza y Salud. N-B. declares that she received payments from Danone S.A. for the purposes of scientific and technical consulting but not for preparing this study and grant support through his institution from Font Vella Lanjaron. No other potential conflicts of interest relevant to this article were reported.

Contribution statement:

IP-G, NB-T, NB and JS-S conducted the statistical analyses and drafted the article. IP-G, JS-S, NB and NB-T made substantial contributions to the conception and design of the work. All authors contributed substantially in the acquisition of data or analysis and interpretation of data. All authors revised the article critically for important intellectual content. All authors approved the final version to be published.

Figure legends

Fig 1. Contribution of various beverages (%) to Total Fluid Intake in all participants stratified by sex.

Fig 2. Various food groups and fluid contributions (%) to Total Water Intake in the studied population.

Fig 3. Percentage of individuals from the studied population complying or not with the EFSA recommendation for Total Water Intake from Fluids (TWIF) and Total Water Intake (TWI).

Fig 4 (a). OR (95%CI) for compliance with EFSA recommendations for Total Water Intake from Fluids for the joint association of Mediterranean Diet Adherence and MVPA recommendations (n = 1902).

Fig 4 (b). OR (95%CI) for compliance with EFSA recommendations for Total Water Intake for joint associations of Mediterranean Diet Adherence and MVPA recommendations (n = 1902).

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Table 1. General characteristics of the PREDIMED-PLUS population.

Variables	*All population* (*n* = 1902)	*Women* (*n* = 957)	*Men* (*n* = 945)	*P value*[a]
Age, years	65 ± 5	66 ± 4	64 ± 5	<0.01
Weight, kg	86.6 ± 13.0	80.5 ± 10.8	92.7 ± 12.1	<0.01
BMI, kg/m^2	32.6 ± 3.5	33.0 ± 3.6	32.3 ± 3.4	<0.01
BMI classification, % (n)[b]				
Overweight	26.0 (493)	23.8 (228)	28.0 (265)	0.04
Obesity	74.0 (1409)	76.2 (729)	72.0 (680)	
Central obesity, % (n)	93.8 (1784)	98.4 (942)	89.1 (842)	<0.01
Prevalence of type 2 diabetes, % (n)	28.3 (539)	26.5 (254)	30.2 (285)	0.08
Prevalence of hypertension, % (n)	83.9 (1596)	84.4 (808)	83.4 (788)	0.54
Prevalence of hypercholesterolemia, % (n)	74.1 (1409)	78.2 (748)	70.0 (661)	<0.01
Marital status, % (n)				
Single or divorced	12.5 (237)	13.8 (132)	11.1 (105)	<0.01
Married	77.1 (1467)	69.1 (661)	85.3 (806)	
Widower	10.4 (198)	17.1 (164)	3.6 (34)	
Education, % (n)				
Primary education	52.5 (998)	63.6 (609)	41.2 (389)	<0.01
Secondary education	27.7 (527)	23.7 (227)	31.8 (300)	
Academic or graduate	19.8 (377)	12.6 (121)	27.1 (256)	
Smoking habit, % (n)				
Never smoked	46.1 (877)	71.3 (682)	20.6 (195)	<0.01
Former smoker	41.9 (796)	21.2 (203)	62.8 (593)	
Current smoker	12.0 (229)	7.5 (72)	16.6 (157)	
Sedentary time, h/day	6.1 ± 2.0	5.9 ± 2.0	6.4 ± 1.9	<0.01
Leisure-time physical activity, min/sem.	459 ± 384	385 ± 317	535 ± 430	<0.01
14-item MedDiet Adherence Score	7.9 ± 2.0	7.9 ± 2.0	7.9 ± 2.1	0.96

Abbreviations: BMI, body mass index. MedDiet, Mediterranean Diet.

Data expressed as means ± SD or percentages (n). [a] *P* values for comparisons between groups were tested by Student's t-test or x^2 as appropriate.

[b] BMI (kg/m^2) was divided into the following categories: overweight (BMI between 25-<30 kg/m^2 kg/m^2) and obesity (BMI =>30 kg/m^2).

Table 2. Total daily consumption of various types of beverage (ml/day) in all population and stratified by sex.

Variables	*All population* (*n* = 1902)	*Women* (*n* = 957)	*Men* (*n* = 945)	*P value*[a]
Drinking water	1022 ± 454	1026 ± 445	1018 ± 463	0.70
Hot beverages	236 ± 213	254 ± 221	218 ± 204	<0.01
Coffee	135 ± 118	133 ± 117	138 ± 119	0.38
Tea	101 ± 185	121 ± 193	80 ± 174	<0.01
Milk and derivates	259 ± 213	262 ± 214	255 ± 213	0.47
Soups and vegetable juices	57 ± 94	57 ± 98	57 ± 88	0.92
Sugar-sweetened beverages	117 ± 203	114 ± 206	120 ± 201	0.50
Soda	33 ± 137	30 ± 135	36 ± 139	0.36
Juices	82 ± 149	82 ± 152	82 ± 147	0.95
Isotonic drinks	1.5 ± 18	1 ± 15	2 ± 20	0.40
Energy drinks	0 ± 5	0 ± 3	0 ± 6	0.34
Artificially-sweetened beverages	38 ± 133	32 ± 118	44 ± 146	0.06
Alcoholic beverages	150 ± 267	72 ± 149	229 ± 330	<0.01
Wine	63 ± 106	35 ± 78	92 ± 122	<0.01
Beer	81 ± 222	35 ± 115	128 ± 285	<0.01
Spirits	2 ± 11	0 ± 5	4 ± 15	<0.01
Alcoholic mixed drinks	3 ± 26	0 ± 14	6 ± 35	<0.01
Other beverages	54 ± 143	59 ± 144	49 ± 142	0.13
Total daily fluid volume	1934 ± 617	1876 ± 574	1991 ± 653	<0.01

Data express as means ± SD. [a] *P* values for comparisons by sex were tested by Student's t-test.
Other beverages category include soy drinks, beer without alcohol, sorbets and jellies, and meal replacement shakes.

Table 3. Association (Multivariable adjusted, Odds Ratio, 95% CI.) between different socio-demographic and lifestyle factors and compliance with EFSA recommendations for water intake from fluids and total water intake.

	TOTAL WATER INTAKE FROM FLUIDS			TOTAL WATER INTAKE		
Variables	*All population* (*n* = 1902)	*Women* (*n* = 957)	*Men* (*n* = 945)	*All population* (*n* =1902)	*Women* (*n* = 957)	*Men* (*n* = 945)
Population complying with EFSA recommendations, n (%)	965 (51.70)	592 (61.90)	373 (39.50)	1,523 (80.10)	875 (91.40)	648 (68.60)
Sex	-	3.02 (2.40 - 3.80)**	1 (ref.)	-	5.34 (3.85 - 7.42)	1 (ref)
Age [a]	0.96 (0.94 - 0.98)**	0.97 (0.94 - 1.00)	0.95 (0.93 - 0.98)**	0.99 (0.97 - 1.02)	1.03 (0.97 - 1.09)	0.99 (0.96 - 1.02)
Education						
Primary education	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Secondary education	1.01 (0.80 - 1.27)	1.09 (0.78 - 1.51)	0.96 (0.69 - 1.32)	1.16 (0.86 - 1.55)	1.07 (0.59 - 1.95)	1.23 (0.88 - 1.72)
Academic or graduate	0.96 (0.74 - 1.27)	0.71 (0.46 – 1.09)	1.14 (0.80 – 1.61)	1.06 (0.76 - 1.46)	0.55 (0.29 -1.07)	1.28 (0.90 - 1.84)
Smoking habit						
Never smoked	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Former smoker	0.99 (0.79 - 1.26)	1.15 (0.80 - 1.64)	0.99 (0.70 - 1.39)	0.92 (0.68 - 1.25)	0.80 (0.43 - 1.49)	1.13 (0.80 - 1.60)
Current smoker	0.91 (0.66 - 1.27)	0.72 (0.43 - 1.20)	1.07 (0.69 - 1.66)	0.73 (0.48 - 1.09)	0.39 (0.19 - 0.81)*	1.03 (0.65 - 1.61)
Sedentary time, h/day [a]	1.06 (1.01 - 1.12)*	1.09 (1.02 – 1.17)*	1.03 (0.96 - 1.11)	1.11 (1.04 - 1.18)	1.18 (1.06 - 1.31)*	1.08 (1.01 - 1.17)*
Leisure-time physical activity, 30min/day. [a]	1.07 (1.02 - 1.13)*	1.09 (0.99 - 1.19)	1.07 (0.99 - 1.15)	1.07 (1.00 - 1.15)	1.08 (0.99 - 1.27)	1.08 (0.91 - 1.16)
MedDiet Adherence 14items [a]	1.07 (1.02 - 1.12)*	1.08 (1.01 - 1.16)*	1.07 (0.99 - 1.14)	1.06 (1.00 - 1.13)	1.16 (1.02 -1.31)*	1.04 (0.97 - 1.11)

Multivariable results (simultaneous adjustment). In addition, model was adjusted by recruitment center (in quartiles by number of recruited participants). All analyses were conducted with robust estimates of the variance to correct for intra-cluster correlation. Data expressed as ORs (95% CI). * $P < 0.05$; ** $P < 0.001$; compared to the reference category. [a] Variable express as continues.

Total water intake from fluids was defined as water consumed through fluids sources. Total water intake was computed as the sum of water content in the consumed beverages and foods.

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Supplementary Table 1. Energy and nutrient intake from fluids in all population and stratified by sex.

Variables	*All population* (*n* = 1902)	*Women* (*n* = 957)	*Men* (*n* = 945)	*P value*[a]
Energy (kcal/d)	420 ± 257	391 ± 258	450 ± 252	<0.01
Water (mL/d)	1,819 ± 558	1,778 ± 536	1,861 ± 577	<0.01
Carbohydrate (g/d)	51 ± 39	50 ± 41	51 ± 35	0.74
Sugar (g/d)	36 ± 25	34 ± 24	38 ± 27	<0.01
Proteins(g/d)	23 ± 15	23 ± 16	23 ± 15	0.36
Lipids (g/d)	7 ± 6	7 ± 6	7 ± 6	0.38
Alcohol (g/d)	8 ± 13	4 ± 8	12 ± 15	<0.01
Sodium (mg/d)	340 ± 284	338 ± 296	342 ± 269	0.78
Potassium (g/d)	2.6 ± 2.9	2.4 ± 2.7	2.8 ± 3.0	<0.01
Calcium (mg/d)	535 ± 273	541 ± 270	530 ± 277	0.38
Vitamin C (mg/d)	32 ± 56	32 ± 56	31 ± 55	0.85

Data expressed as means ± SD. [a]P values for comparisons by sexes were tested by Student's t-test.

Supplementary Table 2. Daily contribution of water (mL/day) from various food groups in the whole population and stratified by sex.

Variables	*All population* (*n* = 1902)	*Women* (*n* = 957)	*Men* (*n* = 945)	*P value*[a]
Vegetables	301 ± 127	313 ± 127	288 ± 125	<0.01
Fruits	317 ± 177	332 ± 187	302 ± 166	<0.01
Legumes	1 ± 0.6	1 ± 0.6	1 ± 0.6	0.27
Cereals	47 ± 24	43 ± 22	50 ± 25	<0.01
Dairy drinks	92 ± 73	100 ± 76	84 ± 70	<0.01
Meat and poultry	102 ± 40	98 ± 38	106 ± 41	<0.01
Fish/seafood	82 ± 38	83 ± 38	80 ± 38	0.07
Fats	0.5 ± 0.7	0.5 ± 0.8	0.5 ± 0.7	0.70
Nuts	2 ± 2	2 ± 2	2 ± 2	0.71
Other foods	24 ± 10	22 ± 8	25 ± 11	<0.01

Data express as means ± SD. [a]P values for comparisons by sex were tested by Student's t-test.