UNIVERSITAT ROVIRA I VIRGILI

ASSESSMENT OF FLUID INTAKE AS A DETERMINANT OF LIFESTYLE AND ITS IMPACT ON HEALTH

Címtia Sofia Ferreira Pêgo

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DOCTORAL THESIS

Thesis supervised by Prof. Jordi Salas-Salvadó, and co-supervised by Dr. Nancy Babio

Unitat de Nutrició Humana
Departament de Bioquímica i Biotecnologia
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UNIVERSITAT ROVIRA I VIRGILI
FACULTAT DE MEDICINA I CIÈNCIES DE LA SALUT DE REUS
UNITAT DE NUTRICIÓ HUMANA - DEPARTAMENT DE BIOQUÍMICA I BIOTECNOLOGIA

Jordi Salas Salvadó, Professor of Nutrition and Food Science at the Department of Biochemistry and Biotechnology of Universitat Rovira i Virgili,

I STATE:

That the present study, entitled "ASSESSMENT OF FLUID INTAKE AS A DETERMINANT OF LIFESTYLE AND ITS IMPACT ON HEALTH", presented by Ms. Cíntia Sofia Ferreira Pêgo *for the award of the degree of Doctor, has been carried out under my supervision at the Department of Biochemistry and Biotechnology of this university.*

Reus, 3th of October 2016

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I STATE:

That the present study, entitled "ASSESSMENT OF FLUID INTAKE AS A DETERMINANT OF LIFESTYLE AND ITS IMPACT ON HEALTH", presented by Ms. Cíntia Sofia Ferreira Pêgo *for the award of the degree of Doctor, has been carried out under my co-supervision at the Department of Biochemistry and Biotechnology of this university.*

Reus, 3th of October 2016

Doctoral Thesis Co-Supervisor

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Sabemos muito mais do que julgamos,

Podemos muito mais do que imaginamos.

José Saramago

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ABSTRACT

ABSTRACT:

Water plays a crucial role for well-being, life and health and its consumption remains fundamental for all human tissues to work properly. Assessing total fluid and different types of beverages intake on general population is a real challenge in nutritional epidemiology, but is also fairly a new focus of scientific attention, being the information about it scarce, limited and controversial. One of the aims of the present doctoral thesis is to design and validate a fluid-specific questionnaire for Spanish individuals within the PREDIMED-PLUS (PREvención con DIeta MEDiterranea)-PLUS clinical trial. Further, due to the scarcity about fluid intake data at population level, the consumption of different types of beverages and the total daily fluid intake in adults from Spain and other 12 countries worldwide was assessed. Furthermore, the percentage of population complying with the European Food Safety Agency (EFSA) total water and World Health Organization (WHO) free-sugar recommendations was also analyzed. We described for the first time that approximately 50% of population did not complied with EFSA adequate intake and 44.5% exceeded the WHO energy intake provided by free sugar recommendations, solely by fluids. The beverage pattern and habits of Spanish adult individuals was assessed depending of its level of Mediterranean Diet (MedDiet) adherence and physical activity, recognized variables conditioning health and disease. For the first time, we show that healthy individuals with high scores for MedDiet adherence and physical exercise practice presented the healthiest beverage pattern, with a high consumption of water. Finally, longitudinal and cross-sectional epidemiological studies have suggested some negative associations between healthy diet, including a healthy beverage profile, and Metabolic Syndrome (MetS). However, the effect of sugar- and artificially sweetened beverages and bottled and natural fruit juices on the risk of MetS in a Mediterranean population at high cardiovascular risk had never been investigated before. The results of the present thesis showed that when prospectively examined 1868 participants free of MetS at baseline from the PREDIMED study (during a median of 3.24 years), the consumption of >5 servings per week of different types of sweetened beverages was associated with higher incidence of MetS and some of its components.

In conclusion, the results from the present thesis support the importance of assessing fluid intake and its pattern, and to have a validated tool specifically designed for the evaluation of fluid sources. Besides, the present work provided further evidence of the positive relationship between the frequent consumption of some sweetened beverages and the risk of MetS and its components in a Mediterranean population at high cardiovascular risk.

RESUM:

L'aigua té un paper crucial pel benestar, la vida i la salut, sent també fonamental per a que tots els teixits humans funcionin correctament. El coneixement sobre el consum de líquids i de diferents tipus de begudes a nivell poblacional és un veritable repte en l'epidemiologia nutricional, donat que la informació que tenim sobre el consum dels diferents líquids és escassa, limitada i controvertida.

Un dels objectius de la present tesi doctoral va ser el de dissenyar i validar un qüestionari específic per l'avaluació de consum de líquids per part de la població Espanyola dins del marc de l'assaig clínic PREDIMED-PLUS (PREvención con DIeta MEDiterránea)-PLUS. D'altra banda, a causa de la manca d'informació que existeix sobre la ingesta de líquids per part de la població general teòricament sana, també es va avaluar el consum de diferents tipus de begudes i la ingesta diària de líquids en adults d'Espanya i de 12 altres països d'arreu del món. Es va analitzar el percentatge d'individus que cobrien les recomanacions d'ingesta total d'aigua segons la Agència Europea de Seguretat Alimentària (AESA), així com de sucres senzills segons la Organització Mundial de la Salut (OMS). Es va descriure per primera vegada que al voltant del 50% de la població no cobria les recomanacions d'ingestes adequades de l'AESA, i el 44,5% superava les recomanacions de la OMS en relació al consum d'energia proporcionat pels sucres senzills, només a través de líquids. A més a més, es va avaluar el patró i els hàbits de consum de fluids dels adults espanyols en funció del seu nivell d'adherència a la dieta mediterrània i a l'activitat física, variables reconegudes com condicionants de la salut i la malaltia. Per primera vegada, s'ha descrit que els individus sans que presenten puntuacions més altes d'adherència a la dieta Mediterrània i a la pràctica d'exercici físic, tenen un patró de consum de begudes més saludable, amb un superior consum d'aigua. Finalment, els estudis epidemiològics longitudinals i transversals han suggerit associacions negatives entre la adherència a una dieta saludable, incloent un patró de ingesta de líquids saludable, i la síndrome metabòlica. No obstant, l'efecte de les begudes ensucrades o edulcorades, així com dels sucs de fruites envasats i naturals sobre el risc de síndrome metabòlica en una població mediterrània d'alt risc cardiovascular no ha estat investigat amb anterioritat. Els resultats d'aquest treball demostren que després d'examinar de manera prospectiva 1868 participants lliures de síndrome metabòlica a l'inici de l'estudi PREDIMED durant 3,24 anys, el consum de més de 5 porcions per setmana de diferents tipus de begudes es va associar amb una major incidència de síndrome metabòlica i alguns dels seus components.

En conclusió, els resultats de la present tesi doctoral avalen la importància de l'avaluació de la ingesta de líquids i el seu patró de consum, així com de la necessitat de disposar d'una eina específicament dissenyada i validada per aquest anàlisi. D'altra banda, el present treball proporciona una prova més de la relació positiva que existeix entre el consum freqüent d'algunes begudes endolcides i el risc de síndrome metabòlica i seus components en una població mediterrània d'alt risc cardiovascular.

RESUMEN:

El agua tiene un papel crucial para el bienestar, la vida y la salud, siendo también fundamental para que todos los tejidos humanos funcionen correctamente. El conocimiento sobre el consumo de líquidos y de diferentes tipos de bebidas a nivel poblacional es un verdadero reto de la epidemiología nutricional, no obstante también representa un enfoque nuevo, siendo la información sobre él escasa, limitada y controvertida.

Uno de los objetivos de la presente tesis doctoral fue diseñar y validar un cuestionario específico para la evaluación del consumo de líquidos por parte de la población Española dentro del marco del ensayo clínico PREDIMED-PLUS (Prevención con Dieta Mediterránea)-PLUS. Debido a la escasez de información sobre la ingesta de líquidos en población general teóricamente sana, también se evaluó la ingesta diaria de líquidos y de los diferentes tipos de bebidas en adultos Españoles y de otros 12 países de diferentes partes del mundo. Seguidamente, se analizó el porcentaje de individuos que cumplían con las recomendaciones de ingesta total de agua de la Agencia Europea de Seguridad Alimentaria (AESA), así como de azúcares simples según la

Organización Mundial de la Salud (OMS). Se describió por primera vez que aproximadamente el 50% de la población no cumplía con las recomendaciones de ingestas adecuadas de la AESA, y el 44,5% superaba las recomendaciones de la OMS en relación al consumo de energía proporcionada por azúcares simples aportada únicamente a través de fluidos. Además, se evaluó el patrón y los hábitos de consumo de líquidos de adultos españoles en función de su nivel de adherencia a la dieta Mediterránea y el patrón de actividad física, variables reconocidas como importantes condicionantes de salud y enfermedad. Por primera vez, se ha descrito que los individuos sanos que presentan puntuaciones más altas de adherencia a la dieta Mediterránea y de práctica de ejercicio físico presentan un patrón de consumo de líquidos más saludable, consumiendo más agua. Finalmente, los estudios epidemiológicos longitudinales y transversales han sugerido algunas asociaciones negativas entre el consumo de una dieta, incluyendo el consumo de líquidos, saludable y el síndrome metabólico. Sin embargo, la asociación entre el consumo de bebidas azucaradas o edulcoradas, así como de zumos de frutas embotellados y naturales, y el riesgo de esta patología en una población mediterránea de alto riesgo cardiovascular no ha sido investigado con anterioridad. Los resultados de este trabajo demuestran que después de examinar de forma prospectiva 1868 participantes libre de síndrome metabólico al inicio del estudio PREDIMED durante 3,24 años, el consumo de más de 5 porciones por semana de algunas bebidas se asoció con una mayor incidencia de síndrome metabólico y algunos de sus componentes.

En conclusión, los resultados de la presente tesis doctoral avalan la importancia de la evaluación de la ingesta de líquidos y el patrón de bebidas consumidas, así como de la necesidad de disponer de una herramienta específicamente diseñada y validada para tal efecto. Por otra parte, el presente trabajo proporciona una prueba más de la relación positiva que existe entre el consumo frecuente de algunas bebidas endulzadas y el riesgo de síndrome metabólico y sus componentes en una población mediterránea de alto riesgo cardiovascular.

ABBREVIATIONS

EFSA, European Food Safety Agency

AIs, Adequate Intakes

IOM, Institute of Medicine

FFQ, Food Frequency Questionnaire

SSBs, Sugar-Sweetened Beverages

CHD, Coronary Heart Disease

CVD, Cardiovascular Disease

T2DM, Type 2 Diabetes Mellitus

CKD, Chronic Kidney Disease

AMI, Acute Myocardial Infarction

MetS, Metabolic Syndrome

HDL, High-Density Lipoprotein.

NHANES, National Health and Nutrition Examination Survey

WHO, World Health Organization

BMI, Body Mass Index

RR, Relative Risk

CI, Confidence Interval

MedDiet, Mediterranean Diet

PREDIMED, PREvención con DIeta MEDiterranea

PREDIMED-PLUS, PREvención con DIeta MEDiterranea - PLUS

LDL, Low-Density Lipoprotein

ECG, Electrocardiogram

Liq.In^7, Liquid Intake over 7 days

Uosm, Urine osmolality

USDA, United States Department of Agriculture

FAO, Food and Agriculture Organization

EVOO, Extra Virgin Olive Oil

NCEP, National Cholesterol Education Program

HR, Hazard Ratio

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1. INTRODUCTION

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1.1. Water balance

Water plays a crucial role for well-being, life and health, remaining also fundamental for all human tissues to work properly [1,2]. Water is involved in many body functions, such as homeostasis that is essential for hydro-electrolytic, acid-base and thermal balances, and for transportation of nutrients to the cells and excretion of wastes from the cells [3]. It is also involved in other metabolic and plastic processes [4,5]. Furthermore, water maintains the vascular volume and allows blood circulation, which is essential for the function of all organs and tissues of the body [6]. Furthermore, it is essential for the physiological processes of digestion and absorption, to the structure and function of the circulatory system and has direct action in maintaining body temperature [7].

Total body water is the principal chemical constituent of the human body, since comprises from 75% of body weight in infants to 55% in the elderly [8]. For an average young adult male, total body water represents between 50 and 70% of body weight [9]. Body fluids containing the largest amount of water are the cerebrospinal fluid and bone marrow fluid (99%), blood plasma (85%) and brain (75%) [5]. Total body water is distributed into intracellular fluid and extracellular fluid compartments, which can contain between 34-65% and 26-35% of total body water, respectively [5,10]. However, these volumes may not be static because they represent the net effects of a dynamic exchange [11]. The extracellular fluid compartment is further divided into interstitial liquid, plasma, trans-cellular water and lymphatic liquids.

Variability in total body water is primarily due to differences in body composition, because the amount of water in lean mass (approx. 73%) and in fat mass (approx. 10%) are considerable different [12]. The fact that adult women tend to have lower body lean mass and consequently lower proportion of body water, might explain why water requirements are lower compared to men. Differences in total body water can also be attributable to variations in other modifiable and non-modifiable factors, such as physical activity practice, age, gender, environmental temperature, kidney function, drugs and alcohol consumption [7,10]. Maintaining a constant water and mineral balance requires the coordination of sensitive detectors at different sites in the body linked by neural pathways with integrative centers in the brain that process this information [13]. Most of the components of fluid balance are controlled by homeostatic mechanisms responding to the state of body water. These mechanisms are sensitive and precise, and are activated with deficits or excesses of only a few hundred milliliters of water [13].

According to the European Food Safety Agency (EFSA), the recommended daily intake of water is the minimum amount required to balance the loss of fluids in the human body [14]. This amount of water would cover the needs related with water losses, such as respiratory, urinary, fecal, sweat and other insensible losses [5,10]. Environmental temperature can also affect these losses, for example exposure to heat and stress may increases it [15]. As environmental temperature increases, dry heat loss (by conduction, convection, and radiation) diminishes and is replaced by heat gain, under these circumstances evaporation of sweat is the only available heat loss mechanism and sweat rate increases markedly. In addition, to air temperature, other environmental factors also modify sweat loss, including relative humidity, air motion, solar load and choice of clothing for protection against environmental elements. Evaporation of sweat is facilitated by air movement and low humidity, keeping conditions comfortable even at high ambient temperatures. However, when humidity is high, sweat runs useless from the skin and soaks clothing, causing discomfort, potential skin disorders, and depleting fluid reserves. Therefore, it is expected that water loss, and water needs, will vary considerably among individuals based on changing extraneous influences. For example, a modest daily exercise sweat loss will increase obligatory daily water requirements even if all the other factors remain constant [10], because physical work increases heat production in the body. An adequate level of hydration is essential to dissipate this heat, with the blood plasma acting both to transport heat to the body surface and as the source of the fluid lost in sweating [2]. Other insensible water loss, like the evaporation of water from the skin and lungs, may also be affected by factors such as environmental conditions and physical activity. Insensible water loss from faeces depends on the amount of water in stools and is greatly increased in cases of diarrhoea. Loss of water in urine normally makes up the largest part of overall water loss and is controlled by the kidneys. The kidneys play a central role in maintaining the balance of water in the body, and also the balance of solutes (sodium, bicarbonate, potassium and chloride) in body fluids [16]. The kidneys are able to conserve water when fluid intake is restricted and to excrete the excess of water when fluid intake is high. However, although the body can minimize water loss by reducing urine excretion, there is an upper limit to the urine concentration that can be achieved, which means that some loss of water as urine, in addition to insensible water losses, is inevitable [17].

Body water contribution is provided from three major sources: intake of water from liquid, intake of water from food and body produced water [18]. Besides exogenous water from food and fluids there is a small amount of water produced by the body that may reach approximately 350mL/day, in response to the introduction of nutritive principles. Metabolic water results from the macronutrients oxidation into water and carbon dioxide. For example, oxidation of 100g of lipids, 100g of carbohydrates or 100g proteins produces about 107mL, 60mL or 40mL of water, respectively. Since endogenous water is not enough to counterbalance the water losses, exogenous water from food and beverages is a necessary nutrient.

Failure to replace fluid losses or even a body water reduction of 2% can decreases plasma volume, alters thermoregulation, impair cognitive functions, alertness and capacity for exercise. This can compromises the ability of the circulatory system to maintain sufficient blood flow to the different body tissues, leading to muscle fatigue, increasing body temperature and the possibility of collapse because blood supply to the brain falters. Subclinical levels of dehydration and core temperature elevation have been shown to affect physical performance and coordination and to impair cognitive function, both potentially contributing to an increase in workplace injuries [2]. A dehydration of 10% may even cause death [5].

Healthy humans regulate daily body water balance with precision despite highly variable stressors on hydration status. So long as food and fluid are readily available, hydration is accomplished by eloquent physiological and behavioral adaptations [10]. Without water, humans may survive only for some days [19].

1.2. Water needs

Despite the well-established importance of water in human body, drinking water is often forgotten in dietary recommendations, and the importance of adequate hydration is not usually mentioned. Therefore, health professionals and dietitians are sometimes confused and they question the necessity of drinking water regularly: how much should we drink? How to know whether patients are well hydrated or not?

Water requirements are not based on a minimal intake because it might lead to a water deficit due to the numerous factors modifying water needs. Instead, water needs are based on experimentally derived intake levels that are expected to meet nutritional adequacy for members of a healthy population [10,18]. Daily water intake comes from both different types of drink and food. However, nowadays there is not a specific and individualized value for water consumption that can be recommended in order to ensure hydration and optimal health [20]. At present, it is thought that food provides approximately 20% of the daily water needs and drinks the remaining 80% [16]. This relationship is not constant and depends on the choice of the type of beverages and foods [14]. Thus, for example the proportion of fruits or vegetables [19], milk or yogurt included in diet provide more amount of water than fast food. Likewise, given healthy individuals have the mechanisms to remove the excess of water and maintain its balance, it has not been established a tolerable maximum level for water intake [21].

1.2.1. Water from foods

Water content is about 10-15% in dry foods (flours, uncooked pasta, dry pulses, etc.) and approximately 90% in fruits and vegetables, but it also depends on the cooking method. Food may provide between 500 and 900mL of daily water [5], which is not sufficient to keep an adult individual well hydrated. In addition, besides to provide water by themselves, as explained before, foods may also stimulate drinking. Some studies have found that 75% of fluid intake occurs during the mealtimes, and may facilitate chewing and swallowing of food, enhance palatability and reduce the effect of irritants [22].

1.2.2. Water from fluids

The human body cannot produce enough water by metabolism or obtain enough water by food ingestion to fulfil its needs, as observed previously. Consequently, we have to pay attention on how much we drink throughout the day in order to meet our daily water requirements and to avoid, negative effects on health. Although drinking water satisfy all hydration requirements, most people usually drink a variety of beverages. All beverages supply water in different concentrations, and some also provide nutrients that are beneficial for health [17]. Therefore, daily fluid intake comes essentially from drinking water and other liquids with a high water content (85 to >90%).

Humans may drink for various reasons, particularly for hedonic ones, but drinking is most often due to water deficiency that triggers the so-called regulatory or physiological thirst [19]. Thirst plays an important role in the day-to-day control of water intake in healthy people living in temperate climates [13]. However, in these regions, people consume liquids not only to quench thirst, but also for pure pleasure, like for example soups, milk, tea or coffee. A common example is alcohol consumption, which can increase individual pleasure and stimulate social interaction [13]. Drinks are also consumed for their energy content and in warm weather for cooling and in cold weather for warming, as soft drinks, milk or tea and coffee [13]. This bias in the way human being rehydrate themselves, may be advantageous because it allows water loss to be replaced before thirst-producing dehydration takes place. Unfortunately, these behaviors also carries some disadvantages. Drinking fluids other than water might contribute to an increased energy intake without nutritional component, or regarding alcohol consumption, in some people, may insidiously bring about dependence [13]. These are some of the reasons why EFSA recommends that water should be the main beverage consumed [23].

1.2.3. Water recommendations

The recommendations for total water, including water contained in food, beverages and drinking water, described by the Food and Nutrition Board of the Institute of Medicine (IOM) were set to 3.7L/day and 2.7L/ day for men and women, respectively. These recommendations may be increased by 0.3L/day in pregnancy and 1.1L/day during lactation. The EFSA set the daily adequate intakes (AIs) for water intake for Europeans at 2.5 liters for men and 2.0 liters for women over 14 years of age, from both food and drink [24]. These recommendations need to be increased by 300ml/day and 700ml/day for pregnant and lactating women, respectively. Further, some authors, also defends that the water needs are related to body weight and caloric intake, and for this reason they recommend a water consumption of 30-35ml/ kg of body weight or 1-1.5ml/ Kcal, respectively [21,25,26].

If only drinks are considered, the EFSA set the daily AI recommendations for water intake for Europeans at 2.0 liters/day for men and 1.6 liters/day for women [24]. These recommendations need to be increased by 300ml/day and 700ml/day for pregnant and lactating women, respectively.

1.3. Methods of water intake assessment

Since water is undoubtedly the most important nutrient and its absence will prove lethal consequences within a few days [13], it is essential to dispose of sensitive tool to better assess the consumption of different types of beverages [19]. Nowadays, estimating the total fluid intake and the real beverage pattern of a population can be considered as a real challenge in nutritional epidemiology. However, the measurement of total water consumption in free-living individuals is a fairly new focus [19]. The associations between hydration, drinking water or beverages intake and health or disease has recently been introduced as an important area of research [27,28].

Information regarding water balance in various population groups is limited. One reason may be that the methodology available for the direct measurement of water intake and loss is rather complicated and therefore not easily applicable in large number of volunteers [29]. The other reason might be the differences in the indirect methodology used. To evaluate total fluid intake (set of drinking water and several beverages categories) it is common to use a food frequency questionnaire (FFQ), multiple-day food record or 24-hour recall [30,31]. However, these questionnaires were designed mainly to evaluate food intake, and not fluid consumption as a whole. Most food records or dietary recalls do not evaluate the consumption of drinking water, because it does not provide calories, and also because fluids are often consumed outside mealtimes and are not perceived or considered as a food. Then, this tends to underestimate fluid intake, both by the individual and the interviewer [18–21]. Food diaries and dietary records that are commonly used to assess intake (food and sometimes fluids) are resource-intensive, time-consuming, burdensome for participants, provide only recent intake data, and are not always feasible in large-scale studies [32,33]. Therefore, it may be difficult to determine habitual intake pattern, as well as changes in food or beverage consumption with these dietary assessment methods [34].

The beverages intake assessment during the last years had been focused mostly in caloric drinks and some specific types of beverages [34,35], but not in the fluid intake as a whole. Nowadays, there is no rapid and efficient method for determining habitual beverages intake in adults, including quantities, frequency of consumption and moment of the day when these are occurred.

In 2009, Neuhouser and coworkers developed a questionnaire to assess the consumption of snacks and beverages, mainly sweetened beverages, in young adolescents [36]. The particular concern was easily assess the consumption of sugar-sweetened beverages (SSBs), salty snacks and sweets. The participants filled the self-reported beverage questionnaire and also a 4-day dietary record, for validation proposes. In 2010, Hedrick and coworkers published a questionnaire designed to assess the consumption of 19 different types of beverages in the American population [37], but once again was mainly focused in energy intake. The same authors, two years after, reduced the previous 19-item questionnaire to one with only 15-items. However the objective was mainly the same: evaluate the intake of SSBs, other energy-containing beverages and total energy from beverages [34]. In same year of 2012, Malisova and colleagues developed a “water balance questionnaire”, designed to evaluate drinking water and also water intake from other beverages, but also from solids sources [29].

The available questionnaires mentioned above were designed in order to measure beverage intake in children and adolescents, and most in fact, do not exclusively measure beverage intake or water from fluids.

To the best of our knowledge, there is no standardized and validated questionnaire, in Spanish language and designed for Spanish adult or elderly population, developed as a research tool for the specific assessment of beverage intake and water only from fluids. A brief, valid and reliable beverages intake assessment tool could greatly enhance nutrition research targeting habitual beverage intake patterns.

1.4. Hydration in health

During the past decade, considerable public attention has been focused on the importance of adequate hydration on health. However, the habitual recommended daily water consumption rate has still unclear scientific basis [10,38]. This might be due, as explained above in the present thesis, to the lack of suitable tools for assessment of hydration status, the effects of hydration on other aspects of day-to-day health and well-being.

A normal hydration status is the condition of healthy individuals to maintain their water balance [18]. Water is vital for survival, and there is currently great interest in the benefits of good hydration for people to function well, and to look and feel good. However, messages surrounding hydration have become increasingly confused. Some sources suggest drinking liters of plain water on top of other fluids, while stories of consumers dying as a result of consuming too much water may leave many in doubt about how to achieve a healthy level of hydration [17].

There is currently no consensus on a "gold standard" for hydration markers, particularly for mild dehydration. As a consequence, the effects of mild dehydration on the development of several disorders and diseases have not been well documented [13]. With regard to physiology, the role of water in health is generally characterized in terms of deviations from an ideal hydrated state, generally in comparison to dehydration. In general, provision of water is beneficial in individuals with a water deficit, but little research supports the notion that additional water in adequately hydrated individuals confers any benefit [19]. Therefore, the effects of body water and water balance on health published in the scientific evidence have been focused on dehydration more than on hydration by itself.

1.4.1. Physical performance

Decrements in the physical performance of athletes have been observed even under lower levels of 2% of hydration [39]. Individuals engaging in rigorous physical activity suffering relatively mild levels of dehydration, will experience decrements in performance related to reduced endurance, increased fatigue, altered thermoregulatory capability, reduced motivation, and increased perceived effort [40,41]. Exercise in hot conditions with inadequate fluid replacement is associated with hyperthermia, reduced stroke volume and cardiac output, decreases in blood pressure, and reduced blood flow to muscle [42]. A good rehydration can reverse some of these deficits and reduce the oxidative stress induced by exercise and dehydration [43].

1.4.2. Neural system and cognition

Hydration or its shortage may influence also neural system and cognition. Mild levels of dehydration might produce disruptions in mood and cognitive functioning. Further, an important evidence body showed that moderate dehydration might also produce alterations in a number of important aspects of cognitive function such as concentration, alertness, and short-term memory in children [6,44], young adults [45–48] and older adults [49]. Some authors, designed a test asking to subjects moderate dehydrated to identify the colour of an object, and increased reaction time was registered [45,46]. However, the number of correct answers was unchanged. As occurred with physical functioning, mild-to-moderate levels of dehydration might impair performance on tasks such as short-term memory, perceptual discrimination, arithmetic ability, vasomotor tracking, and psychomotor skills [45–48]. The same authors also reported a consistent and significant effect of mild dehydration on elevations of subjective mood score, including fatigue, confusion, anger and vigour. Significant and progressive decreases in concentration and coordination have been observed in healthy young males presenting between 2 and 3% of body weight loss of dehydration caused by exercise and heat exposure [50]. However, it is important to highlight that these experiments were conducted in young, fit and apparently healthy adults, and then it is warned further confirmation in other populations. Dehydration was also described as a risk factor for delirium, and for delirium presenting as dementia in elderly or sick individuals [51–53]. Elderly have been reported as having reduced thirst, consequently a reduced fluid intake and hypodipsia compared with younger individuals. In addition, in elderly fluid intake and maintenance of water balance can be complicated by factors such as disease, dementia, incontinence, renal insufficiency, restricted mobility, and drug side effects. Thus, elderly is considered as a risk population for dehydration. In summary, hydration status consistently affected self-reported alertness, but effects on cognition were less consistent. Additionally, relatively little is known about the mechanism of mild dehydration's effect on mental performance. It has been proposed that mild dehydration acts as a physiological stressor that competes with and draws attention from cognitive processes [54]. However, research on this hypothesis is limited and merits further exploration. Water deprivation can also lead to the development of another problem related with neural system: headache [55]. Although this relation is largely unexplored in the scientific literature, some observational studies indicate that water deprivation, in addition to impairing concentration and increasing irritability as noted above, can serve as a trigger for migraine and can also prolong it [56,57]. It was proposed that water deprivation-induced headache is the result of intracranial dehydration and total plasma volume decreased [19]. In this way, a published study reported that the ingestion of water relieved headache in most individuals within 30min to 3h [57]. Recently, another study examined the increased intake of water and its relation with headache symptoms [58]. In this randomized trial, patients with a history of different types of headache, including migraine and tension headache, were assigned either to a placebo or to the group that should increases water intake. As result, water intake did not affect the number of headache episodes, but it was modestly associated with reduction on intensity and duration of the disease. The authors concluded that although provision of water may be useful in relieving dehydration-related headache, the utility of increasing water intake for prevention is yet not well documented.

1.4.3. Gastrointestinal system

Some problems in gastrointestinal function are other negative effects that might be associated with dehydration. Constipation, characterized by slow gastrointestinal transit, small and hard stools and difficulty in passing it, has different causes such as medication use, inadequate fiber intake, poor and unhealthy diet, illness and even dehydration [59]. Inadequate fluid consumption is touted as a common culprit in constipation, and increasing fluid intake is frequently recommended as a treatment. Evidence suggests, however, that increasing fluids is more useful to individuals in a hypohydrated state, and more studies are needed to know the influence in euhydrated individuals [59]. In euhydrated children, a 50% increase in fluid intake had no effect on stool frequency or consistency [6]. In elderly, low fluid intake is a predictor for increased levels of acute constipation [60,61], with those consuming the least amount of fluid having over twice the frequency of constipation episodes than those presenting a higher total fluid intake [19]. In developing countries, another gastrointestinal problem related with hydration or dehydration is diarrheal diseases. This health problem is resulting in approximately between 1.5 and 2.5 million deaths per year [62]. Diarrheal illness results not only in a reduction in body water, but also in potentially lethal electrolyte imbalances. Mortality in such cases may be prevented with appropriate oral rehydration therapy. Many authors consider application of oral rehydration therapy to be one of the significant public health development of the last century [63].

1.4.4. Urinary system

As noted above in the present thesis, kidneys are crucial in regulating water balance. To do this, the kidneys require water for the filtration of waste from the blood-stream and for its excretion via urine. However, a minimum urine volume is mandatory to remove the solute load with a maximum output volume [64]. Under normal conditions, in an average adult, urine volume would be sufficient to clear a solute load. In cases of water restriction, the kidneys are not able to excrete waste and they may overloaded the kidney's maximum output rate, leading to a hyponatremic state or renal dysfunction. However, the effect of hydration or dehydration on kidneys health still remains controversial and more longitudinal studies are needed.

1.4.5. Circulatory system

Heart function and hemodynamic response are also related with water status. Blood volume, blood pressure, and heart rate are closely linked between them. Blood volume is normally tightly regulated by matching water intake and output. In healthy individuals, slight changes in heart rate produces a vasoconstriction to balance the effect of normal fluctuations in blood volume and blood pressure [65]. Decreases in blood volume might occur through loss or donation of blood and/ or changes in body water like for example in cases of exercise sweating. Hypotension can be mediated by drinking water [66,67], because water intake acutely reduces heart rate and increases blood pressure in both normotensive and hypertensive individuals [68]. Water ingestion is also beneficial in preventing vasovagal reaction with brief loss of consciousness in blood donors at high risk for post-donation syncope [69].

In summary, there is strong evidence showing that good hydration reduces the risk of urolithiasis and other kidneys diseases related with water balance. However, less strong evidence links good hydration with reduced incidence of constipation, exercise asthma, hypertonic dehydration in the infant, and hyperglycemia in diabetic ketoacidosis. Good hydration was associated with a reduction in urinary tract infections, hypertension, fatal coronary heart diseases (CHD), venous thromboembolism, and cerebral infarct, but all these effects need to be confirmed by clinical trials. For other conditions such as bladder or colon cancer, evidence of a preventive effect of maintaining good hydration is not consistent [13,70]. However, in order to avoid these problems it is important and convenient to schedule appropriate times to drink water.

1.5. Types of beverages consumption and health

Many foods and all beverages contribute to meet recommended dietary water intake of population and therefore to achieve an optimal hydration status. However, choosing which beverages to consume, it is also important to consider, besides the pleasure sensation, the other health effects, positive and negative, these may have. Some beverages can supply nutrients and plant bioactives, however the content of sugar and energy present in some types of drinks should be also considered.

1.5.1. Water

Drinking plain water, such as tap or bottled water, had the advantage of fulfilling hydration requirements without providing additional energy or adversely affecting health [17,71]. Water cannot be accumulate in the body; therefore, it must be ingested several times during the day. For this reason, the Dietary Guidelines for Americans published in 2015 encouraging individuals to drink more plain water [72]. Previously, in 2010, the same organization had recommended sweetened beverages to be “replaced with water and unsweetened beverages” as a way to reduce added sugar consumption [73]. Plain water intake has been linked to reduced energy-consumption and improved body weight management [74–76]. Water is the beverage by excellence and represents the ideal way of restoring the losses and get hydrated [7].

Water can be regarded both as well an essential nutrient for hydration as a food because it contains several nutrients. Depending on its chemical composition, on the source and the amount consumed, drinking water may provide calcium, magnesium and sodium being a significant source of minerals, although is not its primary source in the diet [17,77,78]. It is recognized that the main source of minerals is food. However some types of water can be an important source of them, contributing to meet its daily recommendations. In this sense, some authors have suggested that the consumption of water with medium-high concentrations of magnesium and calcium and low concentrations of sodium may help to cover the daily recommendations of minerals, and consequently improve some aspects of health [79].

Regarding cardiovascular disease (CVD), it is known that magnesium uses cardiomyocytes to regulate the flow of cations through the calcium and potassium channels. It is also required to maintain normal cardiac electrophysiology [80]. Abnormally low levels of circulating magnesium is a well-known risk factor for cardiac arrest [81]. It is currently thought that the effect of magnesium in the prevention of CVD may be partly mediated through inflammation. An increase in extracellular magnesium concentrations can reduce inflammatory response, while a decrease can activate phagocytes and endothelial cells. It is also thought that the inflammation caused by magnesium deficiency may be the mechanism that induces hypertriglyceridemia and pro-atherogenic changes in the lipoprotein profile [82–84]. The consumption of magnesium has been inversely associated with markers of systemic inflammation and endothelial dysfunction in the general population [85] and post-menopausal women [86]. Likewise, endothelial cells make an active contribution to inflammation in states of magnesium deficiency. At the physiological level, magnesium is regarded as a calcium blocker, so it reduces the release of calcium from and to the sarcoplasmic reticulum, and protects the cells against calcium overload during ischaemia [87–89]. Magnesium reduces systemic and pulmonary vascular resistance, with the resulting decrease in arterial pressure and a slight increase in the cardiac index [90–92]. Any increase in the levels of extracellular magnesium reduces arterial tone, and increases the endogenous dilation (adenosine, potassium and some prostaglandins) and exogenous dilation (isoproterenol and nitroprusside) of some vasodilators [87,89,93,94]. As a result, magnesium slightly reduces systolic and diastolic arterial pressure [95]. The relationship between the intake of both magnesium and calcium from strongly mineralized waters and the effects of these minerals on various aspects of health is controversial. Previous studies suggest an inverse relationship between the intake of magnesium and calcium from drinking water and levels of arterial pressure [96–98]. Since then, according to a recent review by Sengupta, most large-scale studies have reported an inverse relation between the hardness of water and CVD, particularly in relation to the content of magnesium and calcium in drinking water [99–101]. However, other studies have not observed this relation [102,103], making clear that more large-scale and longer-lasting epidemiological studies are required to determine how the consumption of mineral water and its components (mainly calcium and magnesium) affects cardiovascular health.

Cerebrovascular mortality is also another of the main causes of death in developed countries. Some epidemiological studies have shown that calcium from the diet (not taking into account the calcium from mineral water) is inversely associated with levels of arterial tension. The lack of magnesium leads to a decrease in the intracellular concentration of potassium and an increase in calcium levels. It can also increase the contractility of blood vessels. Magnesium causes vasodilation by stimulating the release of endothelial prostacyclin and, *in vivo*, it prevents the vasoconstriction of intracranial vessels after experimental subarachnoid haemorrhage [101]. These results suggest that it is reasonable to expect that the intake of calcium in the diet may reduce the risk of cerebrovascular events [104]. Nevertheless, so far there have been no solid epidemiological studies, or intervention studies, to confirm this relation between the consumption of water and cerebrovascular mortality.

Cancer is one of the diseases that most concerns the general population. Some studies suggested an inverse relation between the intake of calcium from the diet and the risk of colorectal cancer [105]. However, very few studies have examined the relation between the consumption of certain minerals from water or water by itself and the risk of different types of cancer. Therefore, to date, the scientific evidence available is not sufficient to demonstrate a relationship between the intake of calcium and/ or magnesium from mineral water and the risk of suffering from several types of cancer.

Type 2 diabetes mellitus (T2DM) is one of the most extended disease worldwide, and it is known that magnesium plays an important role in its physiopathology. Magnesium deficiency in cells can decrease the insulin secretion through interaction with cell calcium homeostasis [106], and hypomagnesaemia is common in individuals diagnosed with T2DM [107–109]. In this regard, important prospective epidemiological studies [84,110,111] have assessed the relation between the intake of magnesium from the diet and the risk of developing T2DM. Although the relationship between magnesium consumption and diabetes seems to be quite clear, a sufficient number of studies have not proved that there is a relationship between magnesium and/ or calcium from natural mineral waters and the prevalence or incidence of T2DM or glucose metabolism [112–114].

To date, there is general consensus consuming large amounts of fluid can help prevent urinary lithiasis because it decreases the concentrations of elements that might crystallize [115]. However, there is some controversy about the possible impact of the different qualities of natural mineral water, including its hardness, on the risk of renal calculi [116], due to the fact that some authors has been demonstrated no association between the hardness of water, its composition and calcium content, and the formation of urinary calculi [116–119]. Some studies suggest that the consumption of weakly or very weakly mineralized water may be more beneficial for the prevention of renal lithiasis than the consumption of strongly mineralized water, since calcium it is associated with a lower risk of recurrence calculi [20,118]. However, to reduce the risk of the recurring formation of calcium calculi, the European Association of Urology recommends an adequate consumption of calcium and only recommends restriction for important individual health reasons and always following specialist medical advice [115]. The formation of renal calculi is a complex process that has not been fully clarified, and factors such as diet, physical activity, environmental conditions, medicines, supplements and underlying diseases can be important factors [116]. A very recent critical review evaluated the effect of hydration on another urinary parameter: chronic kidney disease (CKD) progression [120]. By reducing vasopressin secretion, increasing water intake may have beneficial effect on renal function in patients at risk and in those that present whichever CKD. This potential benefit may be greater when the kidney is still able to concentrate urine because in contrast, high fluid intake is contraindicated in dialysis-dependent patients. In conclusion, the authors found a positive association between increased water intake (or high urine volume) and preservation of renal function.

Another issue that might be affected by water mineralization is mineral bone density. As it has been pointed out previously, although food are the main source of minerals from the diet and dairy products are the main source of calcium, calcium from natural mineral water can make a valuable extra contribution to cover the recommendations particularly in adult and elderly women who consume little calcium from all sources [121]. Some authors concluded that daily calcium supplement through the consumption of calcium-rich natural mineral water can help to reduce age-related bone loss [122].

Water consumption was also described to reduce meal energy intake among middle-age and older adults, and increasing its consumption is widely recognized as a weight loss strategy in general public, yet there is little data supporting this practice [123]. In a study published in 2010 by Dennis and collaborators, it was found that when combined with a hypocaloric diet, the consumption of 500mL of water prior to each meal leads to greater weight loss than a hypocaloric diet alone in middle-age and elderly [123]. Pan and coworkers also described that plain water was found to be inversely associated with weight gain [124]. Recently in august of 2016, has been published a cross-sectional study including a nationally representative samples of adults (18-64 years) from the NHANES cohort [125]. The authors found a significant association between inadequate hydration and elevated BMI and obesity, even after controlling for confounders. The authors stated that it is possible that obese individuals are more likely to maintain poor hydration or are eating when they are actually thirst, and for this reason, additional investigation and public health education are warranted to examine the relationship between hydration and weight status.

In summary, in accordance with the existing literature on the consumption of calcium or magnesium, or both, from drinking water, it is suggested that there is an inverse relationship with the risk of colorectal cancer, gastric cancer, cerebrovascular and CVD, cardiovascular-cause mortality, diabetes mellitus, nephrolithiasis and even bone diseases. However, the relation between the consumption of drinking water rich in minerals and their effect on various aspects of human health have not been sufficiently elucidated, so it is clear that more population-level epidemiological studies need to be carried out on larger samples and for longer periods before any recommendations can be made to the general population [121,122,126].

1.5.2. Hot beverages

Tea and coffee in its different versions are the most commonly consumed hot beverages in the world, and mainly in Mediterranean countries.

Black, oolong and green teas are all produced from the leaves of the plant *Camellia sinnsis* using different processing methods. Black tea was found to be the most commonly consumed type of tea in some countries, like United Kingdom [17]. Black tea infusions contain small amounts of potassium, magnesium, fluoride and phosphorus, and if consumed with milk provide a range of additional nutrients in small amounts, including some calcium, complex B vitamins and energy. Some types of tea also contains caffeine and a variety of polyphenolic compounds [127]. Drinking tea was associated with a decreased risk of CVD, and this may be because of its polyphenol content [128,129]. Tea has also been associated with reduced risk of cancer, dental caries and bone loss, although the evidence for these associations is weaker than for CVD [128]. Pancreatic cancer, which is currently the fourth leading cause of cancer death in men and women, is an aggressive malignancy characterized by poor prognosis and patient survival, with a 5-year survival rate of less than 5% [130]. A meta-analysis summarizing published case-control and cohort studies was performed to evaluate the associations of green tea consumption with risk of pancreatic cancer [131]. The authors concluded that cumulative evidence suggests that green tea is not associated with pancreatic cancer, and that the results of lower risk associated with high consumption among Chinese population previously published, were mainly derived from case-control studies, and so further confirmation are warrant.

In contrast, there has been concern that some polyphenols (tannins) present in tea might inhibit the bioavailability of non-haem iron, increasing the risk of sub-optimal iron status in at-risk groups [17]. A review of the scientific evidence available, suggested that those at risk of low iron status should avoid drinking tea at mealtimes, while there is no need to restrict tea consumption in those at no risk [132]. However, a report on iron from the Scientific Advisory Committee on Nutrition in 2010, found that in practice, consumption of tea appeared to have a little effect on iron status in developed countries population, and concluded that polyphenols in tea, and other potential inhibitors of iron absorption, were unlikely to be of importance in determining iron status [133]. If tea is consumed with added sugar, this increases its energy content and may influence the risk of some diseases, like overweight or obesity. Some types of teas and infusions provide hydration without caffeine for those who wish to avoid it, and, if taken unsweetened, they do not provide extra energy to diet, being a good and appetizing alternative to water. Due to few scientific evidence available regarding the consumption of tea and health, more epidemiological and prospective studies are needed for confirm these conclusions.

Coffee is another of the most widely beverage consumed worldwide [134–136], mainly by the adult population. Coffee is the primary dietary source of caffeine in many populations, but also contains hundreds of other compounds, like some minerals (such as potassium, calcium and phosphorus), and a considerable number of antioxidants, phenolic compounds (such as chlorogenic, caffeic, ferulic, and cumaric acids) and milanoidins and diterpenes (such as cafestol and kahweol) [137]. As with tea, when consumed with milk, coffee provides small amounts of a range of additional nutrients, like calcium [17]. For this reason, the biological effects of coffee cannot be reduced to the isolated effects of the caffeine that it contains [138]. Due to the high prevalence of coffee consumption and its popularity, even small effects on health could have a large impact on public health.

Hypertension is a strong independent risk factor for stroke or CHD [138]. Coffee consumption has been associated with acute increases in blood pressure in caffeine-naïve people, but exerts negligible effects on the long-term levels of blood pressure in habitual coffee drinkers [139]. The acute effects of coffee are transient, and, with regular intake, tolerance develops due to the hemodynamic and humoral effects of caffeine [140]. A recent meta-analysis of ten randomized controlled trials and five cohort studies assessed blood pressure and the incidence of hypertension in coffee consumers [141]. Non-significant mean changes in systolic blood pressure and diastolic blood pressure were noted in coffee drinkers compared with the control group. Evidence analyzed from this large study showed no clinically important effects of long-term coffee consumption on blood pressure or risk of hypertension. Similar results were found in the Nurses' Health Study with 1.4 million person-years of follow-up, demonstrated that daily intake of up to 6 cups of coffee was not associated with an increased risk of hypertension [142].

There was also described some associations involving boiled-unfiltered coffee consumption and an increased risk of high cholesterol levels [143,144]. However, moderate consumption of coffee prepared by other methods (instant or filter) does not appear to increase risk of CVD [17], showing that these results might be related to the coffee brewing method [145,146]. Coffee contains cholesterol-increasing compounds classified as diterpenes, including cafestol and hahweol [147].

Importantly, the concentrations of these compounds depends on how coffee is prepared: boiled coffee has higher concentrations (because diterpenes are extracted from the coffee beans by prolonged contact with hot water) and in contrast brewed/ filtered coffee has lower levels (because of the short contact with hot water) [138].

CVD and mortality appear to be the most described relation in the scientific literature, involving coffee consumption. A systematic review and a dose-response meta-analysis of prospective cohort studies from 2013, was performed to assess the relationship of long-term coffee consumption and CVD risk. The authors found a nonlinear inverse association between a moderate intake of coffee and CVD risk. The lowest CVD risk was described at 3 to 5 cups per day, but heavy coffee consumption was not associated with elevated CVD risk [135]. A very recent meta-analysis, described that drinking coffee habitually (heavy and light) following an acute myocardial infarction (AMI) was associated with a reduced risk of mortality [148]. Furthermore, another systematic review with meta-analysis performed in twenty prospective cohort studies, found that coffee consumption was associated with a reduced risk of total death. Similar results were also described regarding the intake of decaffeinated coffee, but the data was limited [134]. Similar results were found by Malerba and coworkers in 2013 in another meta-analysis, that, according to the authors, provides quantitative evidence that coffee intake is inversely related to all cause and, probably, CVD mortality [149]. In 2014, another meta-analysis confirmed these results, indicating that coffee consumption (3-4 cups/day) is inversely associated with all-cause and CVD death, but not with cancer mortality [136]. A growing body of evidence has shown that habitual coffee consumption is associated with a decreased risk of heart diseases [150], such as stroke [151], some types of cancer [152–158] and T2DM [159], which are major causes of death nowadays.

The prevalence of T2DM increased from 153 million of people in 1980 to 347 million in 2008 [160], and is estimated to reach 366 million by the year 2030 [161]. Globally, 12% of the health expenditures are estimated spent on diabetes in 2010 [162]. Furthermore, those with T2DM have two to five times higher risk of AMI and two to three times higher risk of stroke [163]. For this reason, a meta-analysis was conducted in 2014 to assess the relation between coffee consumption and this disease, and also for evaluating its possible dose-effect relationship [164]. The authors concluded that coffee and caffeine are significantly associated with reduced risk of T2DM incidence. Similar results were found by Ding and coworkers in another published systematic review and a dose-response meta-analysis [165]. The findings from this analysis, based on 1,109,272 study participants and 45,335 cases of T2DM, demonstrated that the consumption of both caffeinated and decaffeinated coffee was found to be inversely associated with the risk of T2DM, in a dose-response manner.

If the consumption of coffee was inversely related with some compounds of Metabolic Syndrome (MetS) (impaired fasting glucose, abdominal obesity, high blood pressure, high serum triglycerides, and low high-density lipoprotein [HDL]-cholesterol), as it was previously mentioned, it should be expected to observe the same relation with MetS as a whole. Although this inverse relation occurred in some studies [166–168], these results are not consistent in all the manuscripts published [169,170]. The findings suggest that the association between coffee intake and MetS may differ according to the type of coffee consumed and the coffee additives that are used (sugar, powder creamer, etc.) [169]. Two recent meta-analysis published in 2016, have confirmed the same conclusion that coffee consumption is associated with a low risk of MetS [171,172]. Further observational studies and randomized trials are required in order to identify definitively the health benefits and risks of coffee and MetS, because it is known that individuals presenting MetS also have a greater cardiovascular risk [173,174].

Caffeine, that is present in some types of teas and coffee, has a mild diuretic effect. However, a moderate caffeine consumption (up to about 500 mg/day) does not appear to cause dehydration [175,176], as previously it was thought. In the majority of the cases, the fluid in a caffeinated drink compensates for the short-term diuretic effect it produces. Some years ago, Stookey suggested that each milligram of caffeine consumed stimulates the formation of 1.1 mL of urine [177]. However, the evidence suggests that the relationship is not so linear, but rather there is a threshold level below which little or no effect on urine production is observed [178]. Some authors defend that the level of caffeine consumption below which hydration status will not be compromised is 300mg per day [178], although others indicates a different result of 500mg/day [175,176].

In addition, there has been suggestive evidence of a lower risk of suicides [179], Parkinson's disease [180], Alzheimer's disease [181] and gallstones [182,183] among coffee drinkers. Overall, habitual coffee drinkers appear to develop tolerance to the acute effects of caffeine, like those were explained above, and may experience the beneficial effects of the other compounds of coffee (e.g. phenolic compounds and antioxidants) that protect against oxidative damage [184], improve insulin sensitivity [185] or decrease insulin resistance [186] and have some anticarcinogenic properties [187].

1.5.3. Sugar-sweetened beverages

SSBs are known to be significant sources of additional caloric intake, such as sucrose, high-fructose corn syrup or fruit-juices concentrates, all of which result in similar metabolic effects [188]. The adjusted prevalence of SSBs consumption was set in 73% for young adults and 50% among adults older than 35 years, and according to the 2007-2008 US National Health and Nutrition Examination Survey (NHANES) data, the mean adjusted SSBs energy intake for young people and adults was 338 and 236kcal/day, respectively [189]. Given the recent attention of SSBs contribution in the development of several chronic diseases different publications were performed focusing on the impact of these beverages on weight and the risk of obesity, diabetes, MetS, hypertension, CVD and other disorders [19,190,191]. All of these chronic diseases impose a significant burden to public health [191].

In recent decades, the world has seen an unprecedented rise in the prevalence of overweight and obesity, as global shifts in diet and lifestyle increasingly promote positive energy balance [188]. The World Health Organization's (WHO) latest projections indicate that globally in 2014 approximately 1.9 billion adults were overweight (body mass index [BMI] ≥ 25Kg/m^2) and at least 600 million were obese (BMI ≥ 30 Kg/m^2), numbers that more than doubled since 1980 [192]. Given that SSB consumption may alter taste preferences and quality of the diet, caloric intake may in fact mediate the effect of SSB consumption and health outcomes, such as overweight or obesity [191]. An important systematic review and meta-analysis from 2013, described that each serving per day increased in SSBs was associated with an additional weight gain of 0.22 Kg over 1 year in adults [193]. The same publication observed similar results in children, providing scientific evidence that SSBs consumption is associated with weight gain in both, adults and children. After this review being published, several original research manuscripts and other reviews were performed, demonstrating similar results in adults [194–196]. Some authors defend that patients and also general population should be counselled to reduce SSB consumption, for trying to avoid this weight gain [194]. For this reason, a detailed meta-analysis of the effects of water intake alone as a replacement for SSBs was published [197]. In general, the results of this review suggest that water, when consumed in place of SSBs is linked with reduced energy intake, and thereafter may influence on body weight. More recent studies, tried to confirm these results, reporting that the replacement of SSBs by plain water was related to body weight losses [76,124]. It is thought that SSB consumption contribute to weight gain in part because of the high added sugar content and low satiety of these beverages and incomplete compensation for total energy at subsequent meals following intake of liquid calories [198].

Given MetS is a cluster of metabolic alterations associated with visceral obesity including atherogenic dyslipidaemia, high fasting plasma glucose, and increased blood pressure [199], this disorder entails an increased risk of CVD and cause-specific mortality [199–201]. In recent decades, the relationship between the consumption of sweetened beverages and the development of MetS has been investigated in epidemiological studies. However, most of these are cross-sectional [202–207], so their potential for discerning relationships is limited. To date, only four prospective studies have investigated the association between the consumption of sweetened beverages and MetS incidence, with contradictory results [208–211]. Three of them were part of a meta-analysis [212], published in 2010 by Malik and coworkers, concluding that the highest quartile of SSB consumption was associated with the development of MetS (relative risk [RR]:1.20; 95% confidence interval [CI]: 1.02-1.42). The fourth, not included in the aforementioned meta-analysis, was conducted in a Mediterranean population [208] and suggested a positive association between changes in the consumption of SSBs and incident MetS in university graduates.

T2DM, with the rapid increased prevalence worldwide and substantial economic burden, as explained before, has become a global public health concern [213,214]. Consequently, it is of great importance to identify related factors to reduce the risk of developing T2DM. In 2015, Wang et al, performed a meta-analysis to estimate the association between SSB intake and risk of T2DM. The authors provided updated evidence that a greater intake of this type of beverage was positively associated with a 30% higher risk of developing T2DM [215]. In the meta-analysis of 11 prospective cohort studies from Malik (the same where SSBs were associated with an increased risk of MetS) the authors also observed that the highest category of SSB consumption (1-2 servings/day) was associated with a statistically significant increased risk of developing T2DM (RR:1.26; 95%CI: 1.12-1.41) in adults [212]. Recently, a systematic review and meta-analysis has confirmed these previous results, showing that the consumption of SSB is associated with incident T2DM, independently of adiposity and taking into account as population characteristics, potential residual confounding as publication bias [216]. The high amount of rapidly absorbable carbohydrates such as sucrose or high-fructose corn syrup, coupled with the large quantities of often consumed, suggest that SSBs may increase the risk of T2DM regardless of obesity and adiposity, particularly around the abdominal area. These types of beverage and its components may act as a potential contributor to increase the dietary glycemic load leading to inflammation, insulin resistance, and impaired β-cell function [188,217–219].

Hypertension is the most prevalent condition in primary care [220], is a major risk factor for CVD and accounts for 9.4 million deaths annually, worldwide [221]. According to a recent report from the American Heart Association, the prevalence of hypertension is increasing [222], and the number of adults with this disease has been predicted to increase worldwide by about 60% in the next years [223]. Nevertheless, hypertension risk remains highly modifiable through dietary and lifestyle interventions [224]. Recent attention has implicated SSB intake in the pathogenesis of hypertension [225]. A systematic review and meta-analysis of six prospective cohorts was performed to quantify the association between SSBs and the risk of hypertension [226]. The authors observed a harmful effect of the consumption of this types of beverages on hypertension (RR: 1.12; 95%CI: 1.06-1.17; P<0.001), in the highest compared with the lowest quantiles of SSB intake, in individuals with no history of hypertension. These results confirm those observed previously in two published meta-analysis from 2015 [227,228] by Cheungpasitporn et al, (RR: 1.12; 95%CI: 1.03-1.23) and by Xi and coworker (RR: 1.08; 95%CI: 1.04-1.12). Similar results were confirmed by Kim and Je in a recent systematic review and meta-analysis [229] published in 2016 (RR: 1.12; 95%CI: 1.07-1.17). It has been suggested that fructose, through the depletion of ATP leads to an elevation of uric acid, inducing vascular oxidative stress, endothelial dysfunction, and aggravates the renin-angiotensin axis, consequently elevating blood pressure [230]. Although, SSBs has been associated with a higher risk of hypertension, there is a need for high-quality randomized trials to assess the role of SSBs in the development of this disorder and its complications.

Moreover, an increased risk of CHD (RR: 1.17; 95%CI: 1.10-1.24) for every serving/day of SSBs was also observed, but no relationship between this intake and stroke was found (RR: 1.06; 95%CI: 0.97-1.15) [228]. A meta-analysis of prospective studies was performed to summarize the evidence with respect to the consumption of SSBs and risk of CHD [231]. The authors found a RR: 1.17 (95%CI: 1.07-1.28) in the highest category of SSBs consumption in comparison with the lowest category. This meta-analysis of four prospective studies, published in 2014, suggests that consumption of SSBs may increase the risk of CHD, especially among men. However, these findings were based on limited data, and further studies are warranted to critically evaluate this relationship.

The consumption of SSB was also related with CKD. A systematic review and meta-analysis evaluated this association, and demonstrates a statistically significant increased risk of CKD (RR: 1.58; 95%CI: 1.00-2.49) in subjects consuming SSBs versus control subjects [232]. These results have special importance because in 2010, greater than 10% of adults in the United States (over 20 million people) were estimated to have CKD, and prevalence worldwide is estimated at 8-16% [233]. The increasing rates of T2DM and obesity have contributed to rise in prevalence of this disorder [232].

In summary, the consumption of SSBs may increase the risk of T2DM and CVD as a contributor to a high dietary glycemic load leading to inflammation, insulin resistance and impaired β-cell function. Additional metabolic effects from the fructose fraction of these beverages may also promote accumulation of visceral adiposity, and increased hepatic *de novo* lipogenesis, and hypertension due to hyperuricemia. Consumption of SSBs should therefore be replaced by healthy alternatives such as water, to reduce risk of obesity and other chronic diseases. It was observed that a good tool for increasing water consumption and replace SSBs intake is providing water and making it more affordable [234].

1.5.4. Artificially sweetened beverages

The negative impact of consuming SSBs on weight and other health outcomes has been increasingly recognized, as explained above in the present thesis. Therefore, many people have turned to artificially sweetened beverages (also known as “diet beverages”), which are sweetened with high-intensity sweeteners like aspartame, sucralose, and saccharin as a way to reduce the risk of these health consequences. The artificial sweeteners used in beverages are also common in many foods, and are also used as substitute of table sugar. They are also potent stimulators of the taste receptors for sweetness, being 100 or more times sweeter than sucrose [235]. However, accumulating evidence suggests that frequent consumers of these sugar substitutes may also be at risk of excessive weight gain, MetS, T2DM, and CVD [236].

MetS, as defined before, is characterized by a clustering of cardiometabolic risk factors within an individual, namely abdominal obesity, hypertension, hypertriglyceridemia, low levels of HDL-cholesterol and impaired glucose [199]. The prevalence and trends of MetS in American adults over 20 years old from the NHANES study is showed in **Figure 1**.

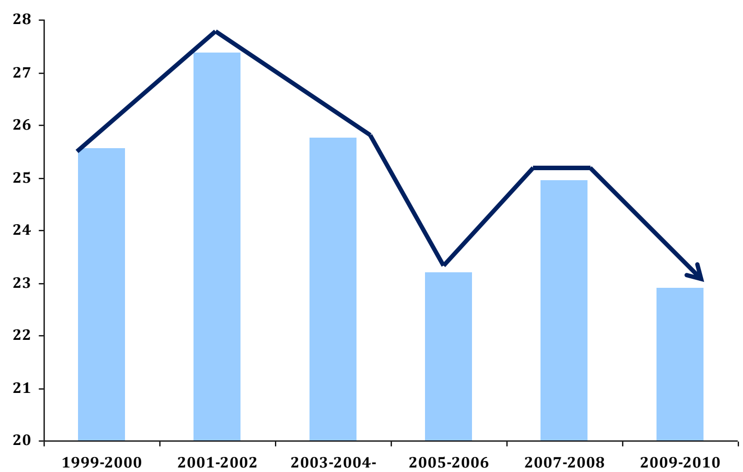

Figure 1. Prevalence and trends of metabolic syndrome in American adults (≥20 years) from the NHANES cohort study (1999–2010).

Some of the MetS components were related with the consumption of artificially sweetened beverages.

Hypertension is associated with increased risk of mortality from CVD, such as coronary artery disease, congestive heart failure and AMI, as the risk of other disorders including CKD [229]. In the same systematic review and meta-analysis that related the consumption of SSBs with an increased risk of hypertension, its association with artificially sweetened beverages was also assessed [229]. Similar results were described (RR: 1.14; 95%CI: 1.10-1.18), founding a positive association between the intake of artificially sweetened beverages and increased levels of blood pressure.

An increases in waist circumference was found to be particularly troubling because they reflect disproportionate increases in visceral fat [237], which is associated with greater cardiometabolic risk [238,239]. For this reason, a prospective cohort study examined the relationship between diet soda intake and long-term waist circumference change in middle-age and elderly (>65 years) [240]. The authors found a striking and positive dose-response relationship between the increased intake of this beverage and escalating abdominal obesity. More studies are needed for stronger conclusions, however these results raise concerns health effects of artificially sweetened beverages in middle-age and elderly individuals.

Artificially sweetened beverages are considered healthy alternatives to SSB, but their prospective associations with T2DM have not yet been well established because only a few studies have examined the associations, of which potential bias has been debated [241–243]. A recent meta-analysis from Imamura and coworkers related the habitual consumption of SSBs with a greater risk of T2DM [216]. The same publication also evaluated the association between this disorder and the intake of artificially sweetened beverages, being the results very similar (RR: 1.81; 95%CI: 1.332.47). The authors concluded that artificially sweetened beverages were unlikely to be a healthy alternative to SSBs for the prevention of T2DM. A different population previously published (2010) had also reached the same conclusions [209]. Nevertheless, besides the relation with T2DM, the authors also determined the association between the consumption of artificially sweetened beverages and MetS. At least daily consumption of diet soda was associated with a 36% RR of incidence MetS compared with no consumption [209]. A more recent scientific article assessed the intake of artificially sweetened beverages in relation to the prevalence of MetS in United States and Europe [202]. In spite of, the author found that individuals who consumed at least one drink per day had a higher prevalence of MetS compared to non-consumers, in both assessments. However, these finding comes from a cross-sectional study, which is not enough for concluding causal relations. Further prospective studies with a large follow-up and sample are needed for better conclusions regarding the association of artificially sweetened beverages on MetS.

Low-calorie sweeteners are commonly used as substitutes for caloric sugar, such as high-fructose corn syrup, because they contribute no or few calories neither glycemic index, while maintaining palatability [244,245]. Yet their role in weight management and obesity remains a topic of continued controversy [236]. In 2013, it was published a review including the most methodologically rigorous studies, that have taken into account many confounding factors, such as changes in beverages habits over time and whether or not the participants claim they are attempting to lose weight [235]. These higher-quality studies suggest either no effect of artificially sweetened beverages on weight change or obesity risk, or perhaps, a protective effect due, possibly, to replacing calorically-dense alternatives. One year after (2014), 303 men and women were assigned to a prospective randomized trial to compare the efficacy of artificially sweetened beverages for weight loss during 12-week [246]. The authors found that the patients included in the group consuming artificially sweetened beverages loss significantly more weight compared to the water group. In addition, the participants drinking artificially sweetened beverages reported significantly greater reductions in subjective feelings of hunger compared to the other intervention group. Therefore, the authors concluded that artificially sweetened beverages might be part of an effective weight loss strategy. To the best of our knowledge, only one prospective cohort study performed in adults found a positive association between the consumption of artificially sweetened beverages and long-term body weight changes [247]. The authors found that consuming >21 servings/week of artificially sweetened beverages (vs. no consumers) was associated with almost-doubled risk of overweight among normal-weight individuals, and doubled risk of obesity among individuals with BMI<30Kg/m^2. A very recent systematic review, including some of the studies presented in this paragraph, concluded that results regarding the relationship between artificially sweetened beverage consumption on body weight changes, were inconclusive, and future research is needed [248].

The paradoxical association between consuming artificially sweetened beverages and metabolic outcomes might be explain through at least three hypothesis, not mutually exclusive:

1) Reverse causation, i.e. individuals who are likely to develop metabolic disease or have increased their body weight choose to consume this type of beverages as a strategy to reduce sugar and caloric intake;

2) A perception that artificially sweetened beverages don't satiate and may have the opposite effect of increasing hunger, leading to immediate or delayed energy compensation;

3) Artificially sweetened beverages are not physiologically inert but affect biological processes involved in regulating energy and glucose homeostasis, such as interactions gut microbiota and induce glucose intolerance [249,250].

1.5.5. Fruit juices

Fruit juices are extracted from fruit, with most of the fruit pulp and hence the fiber removed. Smoothies typically contain a mixture of fruit juices and puréed fruit, and may also blended with yogurt or milk [17]. Fruit juices contain vitamins, such as vitamin C, and plant bioactives, such as carotenoids and polyphenols, depending on the fruits used [251]. Although juices supply water and some nutrients, they do not provide equivalent amounts of fiber to whole fruit. Nevertheless, it is universally accepted that fruit and vegetable intake has a protective effect on health, there is no clear consensus about the effects of consuming the juices that are extracted from them [129,252]. In addition, their relatively high sugar content (naturally present at the fruit) means that they provide energy, and frequent consumption may be detrimental to health [17]. Because of that, some researchers have suggested that fruit juices intake should be limited as a poor substitute for fruit and also that fruit juice is comparable to SSBs [253].

A review and critical analysis published in 2015, assessed the effects of apple, cranberry, grape, grapefruit, orange and pomegranate on outcomes related with health and bodyweight regulation [253]. The authors, concluded that the potential clinical benefits of pure fruit juices on oxidation and related markers, vascular reactivity and inflammation, lipids and related metabolism, hypertension, cancer, cognitive function, memory decline, and Alzheimer's disease and urinary tract infection remains unclear. Being impossible making any public health recommendation regarding the consumption of fruit juices.

Weight gain and nutrient displacement have been cited as a potential concerns associated with high consumption of fruit juice intake, especially in children. Although, importantly some studies in this area have not distinguished between fruit juice-containing drinks and pure fruit juices [254,255]. However, other studies found and inverse relation between BMI and fruit juice intake, in children and adults [256–259], reporting that the mechanisms are not fully understood and well-controlled prospective intervention studies are need to determine the true impact of pure fruit juices on human bodyweight.

Fruit juices are considered by the general population, as healthy alternatives to SSB, but their prospective associations with T2DM have not yet been well established because only a few studies have examined the associations, of which potential bias has been debated [252,260]. According to a systematic review and meta-analysis published in 2014, the intake of pure fruit juice was not significantly associated with risk of developing T2DM (RR:1.03; 95%CI: 0.91-1.18) [260]. However, in a more recent systematic review and meta-analysis published by Imamura, the higher consumption of fruit juices was associated with a higher risk of T2DM, after adjusting for adiposity (RR: 1.07; 95%CI: 1.01-1.14) [216]. Although the different results, both authors agree that current evidence is limited to answer whether or not consumption of fruit juice is associated with risk of T2DM, and further large population-based prospective studies are needed.

While it is widely accepted that fruit and vegetables lower the risk of cancer and CVD, the role of its pure juices is often downplayed [129]. A review of the evidence published by Ruxton and coworkers, evaluated if pure fruit juices are protective against cancer and CVD [129]. The authors concluded that the impact of pure fruit juices on cancer risk was weakly positive, although a lack of human data and contradictory findings hampered conclusions. In relation to CVD, there was convincing evidence from epidemiological and clinical studies that pure fruit juices reduced risk via a number of probable mechanisms. Another published review support the need of more preclinical tests with pomegranate and citrus fruit juices and their constituents, in different colorectal cancer cell lines and also some epidemiological studies, since in the current scenario there are no human clinical trials that have been done to study the effect of these juices on colon cancer [261].

MetS is a cluster of physiologically deregulated cardiometabolic parameters, which substantially increase the risk of T2DM and CVD [262], both described above. As noted in the present thesis, SSB consumption was associated with an increased risk of MetS. In contrast, studies on the role of fruit juice intake on MetS, at the best of our knowledge, are inexistent. In general-population, fruit juices are considered as one healthy option to SSBs, and for this reason one original research manuscript determined the prevalence ratio of MetS for different types of beverage, and also the Odds Ratio by substituting one serving of homemade fruit juice for one of SSBs [263]. Fruit juices were not significantly related with MetS in any category of consumption, but when the consumption of different sweetened beverages (instant drink, regular soda and SSB) was replaced by homemade fruit juices intake, a lower odds for MetS was observed. In conclusion, the authors reported that reducing the consumption of SSBs and substituting them with homemade fruit juices, in a moderated level, might be an approach to reduced MetS among adults.

The escalating prevalence of dementia and an increasingly aging population likely to experience age-related cognitive decline have generated extensive interest in dietary components that may offer protection against neurodegenerative diseases and may be able to preserve or even enhance cognitive function in normal healthy populations [264]. A review from 2014, tried to relate 100% fruit juice with cognitive function and a clinical diagnosis of neuropsychological disease [265]. The authors found that 17 of 19 epidemiological studies and 3 of 6 intervention studies reported significant benefits of 100% fruit juices for cognitive performance. The limited data from acute interventions indicate that consumption of fruit juices can have immediate benefits for memory function in adults with mild cognitive impairment; however, acute benefits have not been observed in healthy adults. This suggests that chronic consumption of fruit juices may attenuate the onset of age-associated cognitive decline, but longitudinal and acute studies examining dietary habits and cognitive outcomes in healthy adults must be conducted.

Oxidative stress may lead to overproduction of reactive species and a decrease in antioxidant defences, resulting in some chronic diseases explained above, such as diabetes or cancer [266]. The consumption of natural compounds with an antioxidant power, as fruit juices, may be a preventive alternative. A systematic review and meta-analysis published by Tonin et al, in 2015, was performed to obtain evidence from randomized controlled trials, regarding the potential antioxidant activity of fruit or vegetable juices compared to placebo or other beverages [266]. The authors concluded that natural fruit juices are possible candidates for the management of oxidative stress, and its antioxidant capacity can be the responsible of some of the protective health effects described previously. However, the effects of fruit juices should be further investigated by conducting larger and well-defined trials of longer duration.

1.5.6. Alcoholic beverages

During the past decades, total per capita alcohol intake has increased rapidly in some countries, mainly in western cultures, where alcohol is currently consumed by many, if not most, people [267]. Due to this large consumption in some populations, investigating whether alcohol consumption is associated with the risk of chronic diseases has important public health implications [268,269]. Alcoholic beverages vary in their water and alcohol content, with a standard measure of beer containing much more water than a standard measure of spirits. Alcohol has a diuretic effect, and so the effect of consuming alcoholic beverages on overall water balance depends on the amount of alcohol and water consumed. Consumption of strong alcoholic drinks without additional fluids may cause dehydration [270]. Alcohol provides seven Kcal/g, and so alcoholic drinks contribute to energy intake. As occurs with other energy-containing drinks, consumption of energy from alcohol does not appear to reduce subsequent energy intake from foods, resulting in an overall increased energy intake in the whole diet. When consumed as a preload shortly before an intake test, alcohol has been reported to either have no effect on the amount consumed or to result in an increase in voluntary intake [271]. This lack of any compensatory reduction in subsequent intake in any study providing energy as an alcohol preload clearly suggest that alcohol fails to generate effective short-term satiety cues. This can be due to that alcohol may release inhibitions, and in particular may increase food intake through disinhibition of restrained eating or might be that alcohol enhances the palatability of food [271]. In addition, alcohol may actually increase appetite through an aperitif effect in the short-term [271,272]. Given the increased incidence of obesity, an important question is the extent to which energy from alcohol consumption has contributed to the excess energy intake associated with weight gain. While some data might suggest that alcohol is a risk factor for obesity, epidemiological data suggests that mild to moderate alcohol intake may be more likely to protect against obesity, especially in women [273]. In contrast, higher intakes of alcohol, in the absence of alcohol dependence, may increase the risk of obesity, as may bingedrinking, however these effects may be secondary to personality and habitual beverage preferences [273]. A review published in 2011, confirm the need of more scientific evidence, however positive findings between alcohol intake and weight gain were reported, mainly from studies with data on higher levels of drinking. It is, therefore, positive that heavy drinkers may experience such an effect more commonly that light drinkers [267]. The same authors concluded that light-to-moderate alcohol intake, especially wine, might be more likely to protect against weight gain, whereas consumption of spirits has been positively associated with its gain.

With the increasing incidence of obesity and overweight, some disorders as T2DM also increases. T2DM, as explained above, is an epidemic worldwide, and is a major cause of premature illness and death [274]. A very recent (2016) systematic review and dose-response meta-analysis explored the evidence on the strength of the association between alcohol consumption and the subsequent risk of T2DM [274]. The authors analyzed 706,716 individuals from 26 different studies with 31,621 T2DM cases, and concluded that light and moderate consumption was associated with a lower risk of T2DM, whereas heavy alcohol consumption was not related with risk of this disorder.

A meta-analysis from 2016 published by Vancampfort et al, assessed pooled rates of MetS and its components in people with alcohol use disorders [275]. The authors concluded that 1 in 5 people with alcohol use disorders were found to have MetS. However, more studies regarding a moderate consumption of alcohol without any dependence are needed. Yoo and coworkers in 2004 didn't find any significant relation between grams of alcohol consumed and the number of MetS components in the Bogalusa Heart Study [276].

Alcohol has beneficial and harmful effects at the same time, as observed. An example of this affirmation is the French paradox: a few cardiac deaths in spite of high animal fat intake [277]. Some authors defends that this reaction can be due to alcoholic drinks, and mainly wine intake. At the best of our knowledge, the first systematic review regarding the consumption of alcoholic beverages and risk of AMI was performed by Cleophas in 1999. The authors concluded in that moment that small doses (1-4 drinks/ day) of alcohol, independently if was from wine, beer and spirits reduced the risk of mortality and CHD. Doses of ≥5 drinks/ day were not associated with a reduced risk of death or CHD. At the same year a meta-analysis confirmed those results regarding CHD [278]. The authors found that the intake of 30g of alcohol per day (from beer, wine and spirits) would cause an estimated reduction of 24.7% in the risk of CHD. These results can be due to the changes in lipids and haemostatic factors. The same amount of alcohol was related with an increased concentrations of HDL-cholesterol, apolipoprotein A and triglycerides, and modestly affected several haemostatic factors related to a thrombolytic profile. In 2015 was published a systematic literature review and meta-analysis investigating the risk of all-cause mortality in alcohol-dependent subjects [279]. The authors identified a significant increase in mortality for alcohol-dependent compared with general population (RR: 3.45 95%CI: 2.96-4.02). However, it seems that the effect of alcohol is dose-response, because those subjects continued drinking heavily had significantly greater mortality than alcohol-dependent subjects who reduced alcohol intake (even if abstainers were excluded). It seems that alcohol has biphasic and complex physiological effects that result in both higher and lower cardiovascular risk depending on the amount consumed, drinking frequency and the outcome under study [280,281]. A very recent systematic review and dose-response meta-analysis reported that appears to be a consistent finding of an immediately higher cardiovascular events risk of following any alcohol consumption. However, after 24 hours there is a lower risk of AMI and haemorrhagic stroke, and within 1 week, there is a lower risk of ischemic stroke, whereas heavy alcohol drinkers conferred continued risk even after 24 hours [282]. However, it is still need to know if these results are due to the alcohol or antioxidants and phytochemical content.

Cancer is still one major public health concern worldwide, and its relation with alcohol consumption was assessed in some meta-analysis [283–285] and epidemiological studies [286]. The consumption of 2 glass of alcoholic beverages daily, was demonstrated to increase the risk of colorectal (RR: 1.10; 95%CI: 1.05-1.14) in both men and women [283]. However, the authors state that the findings regarding a causal role of alcohol were inconclusive. Compared to non-drinkers, a strong effect of alcohol consumption (particularly beer and liquor, but not wine) on gastric cancer risk was observed in a recent systematic review and dose-response meta-analysis of prospective cohort studies [285]. The authors also found that per 10g/day increment of alcohol consumption increases the risk of gastric cancer in 5%. Another meta-analysis, including most published information, from 2001 published by Bagnardi et al, found that alcohol intake mostly strongly increased the risks of cancer of the oral cavity, pharynx, oesophagus, and larynx [284].

Statistically significant increases in risk also existed for cancers of the stomach, colon, rectum, liver, female breast and ovaries. The authors were unable to identify a threshold level of alcohol consumption below no increased risk for cancer is evident. However, this analysis found that alcohol consumption of at least 50 grams (i.e., 4 standard drinks) per day significantly increased the risk of developing any type of cancer, while lower levels of consumption result in a moderately increased risk for various cancers.

Pancreatitis is a prevalent inflammatory disorder of the pancreas that is associated with high mortality and is a source of significant global socioeconomic burden [287]. For this reason a systematic review and a series of meta-analysis was performed to assess the association between alcohol consumption and pancreatitis [288]. The authors concluded that alcohol consumption below 40 g/day was associated with reduced risk of acute pancreatitis in women; however, consumption beyond this level was increasingly detrimental for any type of pancreatitis.

The ethology of Parkinson's disease has both genetic and environmental factors, but the known Parkinson's genes account for only a small proportion of all Parkinson's at population level [289]. A meta-analysis of observational studies related the intake of alcohol with the risk of Parkinson's disease, and concluded that alcohol intake, mainly beer, might be inversely associated with risk of this disease [290]. However, more studies regarding this disease are needed.

Alcohol consumption, particularly low and moderate, was also inversely related with later onset menopause [291], although the magnitude of the association was low. Sarcopenia, a loss of muscle strength and mass very typical in elderly, was not related with the consumption the consumption of alcohol, in a very recent meta-analysis [292].

When consumed in excess, alcohol can damage to every system in the body as well as having negative personal and social consequence for those concerned [293]. However, the effects of moderate alcohol consumption are unclear and it depends on drinking patterns and the type of alcoholic beverages consumed, as well as age, gender, risk of CVD and other lifestyle factors [17]. Risk consumption of alcohol is also an important economic and financial problem, impacting significantly the health system and society [294]. For this reason, it is important to increase consumer understanding about the safe consumed amount of alcohol. In this regard, most of non-drinkers that abstain for any reason (religion, previous health conditions, family history of alcoholism), should not be advised to start drinking.

2. RATIONALE AND JUSTIFICATION

2. RATIONALE AND JUSTIFICATION

Water plays a crucial role for well-being, life and health and its consumption remains fundamental for all human tissues working properly. Water is involved in many body functions, such as homeostasis that is essential for hydro-electrolytic, acid-base and thermal balances and for transportation of nutrients to the cells and excretion of wastes from the cells. Total body water is the principal chemical constituent of the human body, since comprises from 75% of body weight in infants to 55% in the elderly. These variations in total body water are primarily due to differences in body composition. According to EFSA, the recommended daily intake of water is the minimum amount required to arrive to a balance between the losses of fluids (respiratory, urinary, fecal, sweat and other insensible losses) and the inputs (beverages, food and self-production). The EFSA set the daily recommendations for water intake for Europeans, only from drinks, at 2.0 liters/day for men and 1.6 liters/day for women.

Assessing total fluid and different types of beverages consumed on general population is a real challenge in nutritional epidemiology. The knowledge about fluid intake and its patterns is very important for the creation of public health messages and policies. The scarcity and the inconsistency of the evidence available about beverages intake, led us to examine the consumption of different types of beverages and also total daily fluid intake in Spanish adults but also in other 12 countries worldwide. Furthermore, the percentage of population complying with the EFSA total water and WHO free-sugar recommendations was performed. This information is very important for public health and for a better understanding about beverage intake patterns and if people are following the recommended values.

Lifestyle is one of the most important factors conditioning health. Physical activity and adherence to a healthy diet, including a healthy beverage pattern, are considered essential components of a healthy lifestyle that can reduce the risk of several non-communicable chronic diseases. One of the recognized healthy dietary patterns is the so-called Mediterranean diet (MedDiet), which has been associated with several health benefits like for example the reduction of the MetS risk. However, little is known about the association between MedDiet adherence and physical activity practice, and beverage pattern at a population level. This lack of information motived us to assess the beverage pattern and habits of adult Spanish individuals, depending of its level of MedDiet adherence and physical activity.

Longitudinal and cross-sectional epidemiological studies have suggested some negative associations between healthy diet and MetS. However, the results published regarding the association of beverages, mainly sweetened beverages, and MetS are inconsistent. Even though there is accruing data on the negative relationship of the different types of sweetened beverages on MetS, further investigation was required to confirm the associations in middle-age and elderly population at high CVD risk and to explore new research areas. Moreover, the effect of SSBs, artificially sweetened beverages and bottled and natural fruit juices on the risk of MetS new cases in a Mediterranean population and context had never been investigated before and remained to be elucidated. Due to the actual inconsistency and the lack of knowledge in the available scientific evidence in the matter of sweetened beverages and MetS, we decided to evaluate this matter in the framework of the PREDIMED (PREvención con DIeta MEDiterranea) study, a cohort of individuals at high CVD risk.

Finally, the measurement of total water and beverages intake in free-living individuals is fairly a new focus and the information about it is scarce and very limited. One reason may be that the methodology available for the direct measurement of water intake and loss is rather complicated and therefore not easily applicable in large number of volunteers. The other reason can be the methodology used, due to the fact that different authors use different methodology: FQQ, multiple-day food records or 24-h dietary recall, etc. Nevertheless, these questionnaires were mainly designed to evaluate food intake, and not fluid consumption as a whole. After evaluate the consumption of different types of beverages in several populations, its relation with MedDiet and physical activity and its association with MetS, we found a terrible difficulty in the assessment of fluid intake. For this reason, our aim was to design a fluid-specific questionnaire for Spanish population. We also proceeded to validate this questionnaire in Mediterranean middle age and elderly individuals presenting MetS and with high risk of CVD, within the PREDIMED-PLUS (PREvención con DIeta MEDiterranea - PLUS) trial. Although, the validation of this fluid-specific questionnaire was the last work to be published, actually it was one of the firsts to be planned and performed. The time need to design the questionnaire, to recruit all the participants and follow them during 1 year made that the publication takes a little longer compared to the other projects. This is the reason why in the present thesis the questionnaire validation and project is the first presented followed by the fluid intake assessments and at last by the relation of sweetened beverages and MetS incidence.

3. HYPOTHESIS

3. HYPOTHESIS

A new fluid-specific questionnaire designed to measure habitual consumption of drinking water and different types of beverage of a Spanish population is considered reliable and relatively valid, in a middle age and elderly population presenting MetS.

Spanish healthy adults are not complying with the WHO free-sugar and EFSA total fluid intake recommendations.

A higher adherence to the MedDiet and physical exercise is associated with having a healthier fluid intake pattern.

Adults from different countries in three continents are not complying with the AI from EFSA of water from different types of beverages, neither with the WHO recommendations on free sugars intake only coming from beverages.

A greater consumption of SSBs, artificially sweetened beverages, natural fruit juices and bottled fruit juices is associated with an increased risk of MetS development or any of its features in a cohort of participants at high cardiovascular risk.

4. OBJECTIVES

4. OBJECTIVES

To assess the repeatability and the relative validity of a new fluid-specific questionnaire designed to measure habitual consumption of drinking water and different types of beverage in Spanish population with MetS.

To evaluate the total fluid and sugar intake provided by different types of beverages in Spain and to assess the percentage of individuals complying with the EFSA recommendations for total fluid intake and the WHO recommendations for sugars coming from total diet.

To evaluate the association between adherence to the MedDiet and physical exercise practice and fluid intake pattern in Spanish healthy adults.

To evaluate the total fluid intake from beverages in adult populations from 13 countries in three continents and to assess the percentage of individuals complying with EFSA AI of water from fluids.

To describe drinking water intake and all other type of beverages in adults from 13 countries in three continents including Europe, Latin America and Asia and to report energy intake from beverages and the percentage of adults exceeding the WHO recommendations on free sugars intake.

Analyze the relation between the consumption of SSBs, artificially sweetened beverages, natural fruit juices and bottled fruit juices and MetS and its components incidence, in a cohort of participants at high cardiovascular risk.

5. MATERIAL AND METHODS

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5.1. The PREDIMED-PLUS study

Study design

The PREDIMED-PLUS study is a randomized, multicentre field trial which main aim is the primary prevention of CVD in overweight and obese adults presenting MetS. The program is based in an intensive intervention on an energy-restricted MedDiet, increased physical activity and behavioural therapy, compared with a control group given dietary advice also about MedDiet for the prevention of cardiovascular morbidity and mortality, but no restricted in energy. The main objective of PREDIMED-PLUS is to evaluate the effect of an intensive lifestyle intervention comprising an energy-restricted MedDiet, increased physical activity and behavioral therapy on:

- The incidence of cardiovascular events (non-fatal AMI, non-fatal stroke, or cardiovascular death).
- Weight change (weight loss and long-term weight-loss maintenance).

The secondary objectives are to determine whether an intensive weight-loss-oriented lifestyle intervention program has a beneficial effect to reduce waist circumference and some of the following overweight- and obesity-related conditions:

- Total mortality.
- Myocardial infarction.
- Stroke.
- Heart failure.
- Atrial fibrillation.
- Peripheral artery disease.
- T2DM and its complications.
- Overall incidence of cancer and specific types of cancers in main sites (breast, colorectal, prostate, lung and stomach).
- Osteoporotic fractures.
- Cholelicistechtomy.

- Cataracts.
- Neurodegenerative disorders (dementia and Parkinson's disease), unipolar depression and eating behavior disorders.

Study population

The recruitment of individuals started in October of 2014, only in Reus and Navarra centers and is still going on. The end of the recruitment process is planned to occur in October 2016 for all the participating centers (Málaga, Sevilla, Islas Baleares, Barcelona, País Vasco, Valencia, Gran Canaria, Granada, Madrid, Córdoba, Alicante, Jaén). Individuals who participated in the PREDIMED trial are not eligible to participate in PREDIMED-PLUS study. Intervention will be maintained for 6 years and average follow-up time for clinical events will be 8 years.

The study participants were community-dwelling adult men aged 55–75 and women aged between 60 and 75 with a BMI ≥27 and <40 kg/m^2, free of CVD at baseline and who meet three or more criteria for MetS, which was defined in accordance with the updated harmonized criteria of the International Diabetes Federation and the American Heart Association and National Heart, Lung and Blood Institute [199].

The PREDIMED-PLUS study is still recruiting individuals and diabetic participants should not exceed the 25% of the final population.

Individuals may be excluded if they meet any of the following criteria:

- Illiteracy or inability/unwillingness to give written informed consent or communicate with study staff.
- Institutionalization (the participant is a permanent or long-stay resident in a care home).
- Documented history of previous CVD, including: angina; AMI; coronary revascularization procedures; stroke (ischemic or hemorrhagic, including transient ischemic attacks); symptomatic peripheral artery disease that required surgery or was diagnosed with vascular imaging techniques; ventricular arrhythmia; uncontrolled atrial fibrillation; congestive heart failure (New York Heart Association Class III or IV); hypertrophic myocardiopathy; and history of aortic aneurism >=5.5 cm in diameter or aortic aneurism surgery.

- Active malignant cancer or history of malignancy within the last 5 years (except non-melanoma skin cancer).
- Inability to follow the recommended diet (for religious reasons, swallowing disorders, etc.) or to carry out physical activity.
- A low predicted likelihood to change dietary habits according to the Prochaska and DiClemente Stages of Change Model [295].
- Inability to follow the scheduled intervention visits (institutionalization, lack of autonomy, inability to walk, lack of stable address, travel plans, etc.).
- Inclusion in another program that provides advice on weight loss (> 5 kg) in the six months before the selection visit.
- History of surgical procedures for weight loss or intention to undergo bariatric surgery in the next 12 months.
- History of small or large bowel resection, or inflammatory bowel disease.
- Obesity of known endocrine origin (except for treated hypothyroidism).
- Food allergy to any component of the MedDiet.
- Immunodeficiency or HIV-positive status.
- Cirrhosis or liver failure.
- Serious psychiatric disorders: schizophrenia, bipolar disorder, eating disorders, or depression with hospitalization within the last 6 months.
- Any severe co-morbidity condition with less than 24 months' life expectancy.
- Alcohol abuse or addiction (or total daily alcohol intake >50 g) or drug abuse within the past 6 months.
- History of major organ transplantation.
- Concurrent therapy with immunosuppressive drugs or cytotoxic agents.
- Current treatment with systemic corticosteroids.
- Current use of weight loss medication.
- Concurrent participation in another randomized clinical trial.
- Patients with an acute infection or inflammation (e.g. pneumonia) will be allowed to participate in the study 3 months after resolution of their condition.

- Any other condition that may interfere with adherence to the study protocol.

Medical doctors from primary care centers associated with the recruitment centers were the main responsible of recruiting participants. Individuals' eligibility criteria and demographic data were collected from the medical records at the primary care centers, which are entirely computer-based. Potential participants were contacted through a telephone call or during the routine clinical visits. If they were interested in participating, a face-to face interview was scheduled. When the first screening visit was taken place, the purpose and characteristics of the study were explained to the candidates and, if they agree with participating into the study, an informed written consent form were signed. All participants provided two written informed consent, one for the general PREDIMED-PLUS study and other for a genetic sub-study. The Institutional Review Board of each participating center approved all the procedures of the study protocol.

Intervention

The participants of the PREDIMED-PLUS Study were randomly and equally assigned (1:1) to one of two intervention groups (**Figure 2**):

- Intensive intervention on an energy-restricted MedDiet, increased physical activity and behavioural therapy (intervention group).
- Dietary advice about MedDiet for the prevention of cardiovascular morbidity and mortality, but no restricted in energy (control group).

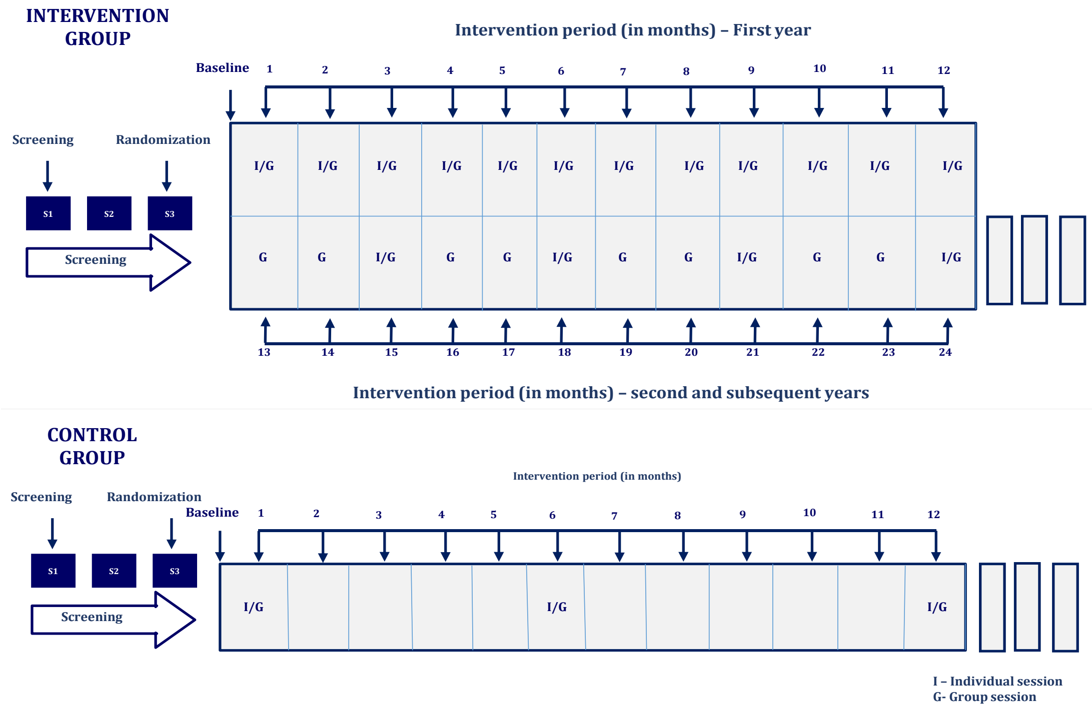

Figure 2. Design of the PREDIMED-PLUS study

A run-in period of three different visits (one of them was a telephone call) with a duration of 4 weeks was performed before the baseline visit.

In the first visit of the run-in period, participants were screened in order to ensure that the eligibility criteria are met, and also to evaluate the probability that they will attend the scheduled sessions, complete the protocol's assessment tools, and finally change their dietary habits, in accordance with the Stages-of-Change model [295]. This screening visit will comprise:

- The administration of a general questionnaire including the meeting of inclusion and exclusion criteria.
- Explanation of the study and completion of the informed consent forms.
- Performance of electrocardiogram (ECG) and anthropometric (height, weight, waist circumference) and blood pressure measurements.

- Distribution of a 3-day food record sheet (2 working days and 1 weekend day), and a leisure-time physical activity questionnaire (**Appendix 1**).

All these questionnaires, except the general questionnaire, were filled at home by the participant and returned in the last run-in visit. The objective of the initial interview of the trial was to evaluate the willingness of each candidate to participate in the study, comply with the proposed intervention, and lose weight.

After 2 weeks, the participants received a telephone call, agreeing with the second visit of the run-in period, to assess if they want to maintain its participation in the study, and remind them to bring to the next screening visit all the records filled.

At week 4 of the run-in period, the third visit was performed with the objective of:

- Collection of the participants' record, by the dietitian.
- Measurement of the participants' weight and hip circumferences.
- Administration and completion of a 143-item FFQ.
- Explanation of nighttime fasting for in situ extraction of blood sample performed in the next visit (baseline visit), and how to collect the first morning urine sample.

The participants were randomly assigned to one of the two intervention groups if they satisfy all the following criteria:

- Full attendance at the two previous sessions (including having answered the telephone call) at the scheduled times.
- Correct completion and delivery of all the records and questionnaires.

After one week of the participant's inclusion in the study and their randomization to one of the two intervention groups, the baseline visit was performed. In this visit, the general questionnaire was completed by the PREDIMED-PLUS personnel. This general questionnaire included questions about medical conditions, risk factors, medication use, MedDiet adherence questionnaires (14- and 17-items [**Appendix 2** and **3,** respectively]) and physical activity practice including the chair test.

Participants in the intensive intervention group received counselling to help them progressively increase their compliance with the following 17 objectives (the 17-item questionnaire on adherence to the energy-restricted MedDiet **- Appendix 3**).

One point would be awarded for each objective met:

1. Use only extra-virgin olive oil for cooking, salad dressings, and spreads.

2. Consume ≥3 portions of fruit per day.

3. Consume ≥ 2 portions of vegetables/garden produce per day (at least 1 portion raw or in a salad).

4. Reduce consumption of white bread to ≤1 serving/day (1 serving = 75 g).

5. Consume whole grain cereals and pasta ≥5 times per week.

6. Consume ≤1 serving (1 serving = 100-150 g) of red meat, hamburgers, or meat products (ham, sausage, etc.) per week.

7. Consume less than 1 serving of butter or cream per week (1 serving = 12 g).

8. Consume less than one sugary beverage or sugar-sweetened fruit juice per week.

9. Consume ≥3 servings of legumes per week (1 serving = 150 g).

10. Consume ≥3 servings of fish or shellfish per week (1 serving = 100-150 g fish, or 4-5 units or 200 g shellfish).

11. Consume < 3 sweets or pastries, such as cakes, cookies, sponge cake, or custard, per week.

12. Consume ≥ 3 servings of nuts (including peanuts) per week (1 serving = 30 g).

13. Consume chicken, turkey or rabbit meat instead of beef, pork, hamburgers or sausages.

14. Use *sofrito* (sauce made with tomato and onion, leek or garlic, simmered in olive oil) ≥ 2 times per week.

15. Do not add sugar to beverages (coffee, tea); instead, replace sugar with non-caloric artificial sweeteners.

16. Reduce consumption of pasta or rice <3 servings per week (unless the pasta or rice are whole grain products).

17. Consume 2-3 glasses of wine (200 mL) per day (men) or 1-2 glasses of wine per day (women).

Although, the 17-point MedDiet adherence questionnaire was used in both of the intervention groups, the intervention tool for the control group, was the 14-item adherence non-energy-restricted MedDiet questionnaire (**Appendix 2)**, used in the PREDIMED cohort [296].

Intensive lifestyle intervention group

Participants in the intensive lifestyle intervention group received traditional MedDiet recommendations, with an energy restriction. Dietary intervention was accompanied by an increasing in physical activity practice and behavioral therapy program. Participants in this group took monthly an individual interview and a motivational group session during the first year of the intervention, and once every three months thereafter. In the PREDIMED-PLUS study, extra-virgin olive oil (one liter per month) and nuts (500g per month) were provided to the participants freely. The participants' degree of compliance with the intervention was monitored periodically, so that the intervention can be adjusted if it was necessary. For the intensive intervention group, the specific weight-loss objectives are to achieve an average reduction in baseline body weight of over 8% and an average reduction in waist circumference of over 5% in the first six months and to maintain these figures over an additional period of seven and a half years. The final objective is to obtain a between-group average absolute difference in weight loss and waist circumference reduction of over 5%.

Control intervention group

The control group received usual primary healthcare from medical professionals, all the written material, instructions on following a MedDiet—which was used in the PREDIMED study and has been shown to have benefits for the prevention of cardiovascular morbidity and mortality [297]—and general lifestyle recommendations for managing the MetS. Every six months, the control group participants received group sessions led by trained personnel and a free supply of EVOO (6 liters every 6 months) and nuts (3kg every 6 months) in order to promote the MedDiet and encourage compliance with the trial.

Group sessions

At the group sessions (maximum of 20 participants per group), a shopping lists, menus, recipes, descriptions of typical components of the MedDiet and advice on lifestyle changes were provided. The PREDIMED-PLUS trained dietitians led these sessions. Group sessions, for the intervention group, were split in three different topics:

- Dietary advice (weight loss, main aspects of the MedDiet, recipes, etc.).

- Physical exercise practice.
- Behavioral strategies for a better compliance.

In the control group sessions, only recommendations for a better adherence to the MedDiet or tips about typical foods were delivered. EVOO and nuts were delivery freely to the participants in the group sessions.

Data assessment

In the PREDIMED-PLUS study, a general questionnaire about CV risk factors, history of illnesses, medication use, family history of disease, smoking and alcohol use, educational achievement, occupation and socio-economic status were administered to the participants at baseline and yearly during the follow-up. Anthropometric and biochemical evaluations were also performed and registered in the general questionnaire. Dieticians also completed a validated 14-item (for control group) and 17-item (for intervention group) questionnaire of adherence to the MedDiet (**Appendix 2** and **3,** respectively). Trained dieticians completed a 143-item semi-quantitative FFQ in a face-to-face interview with the participant, at baseline, six months and annually thereafter. The objective of the present questionnaire is to estimate average daily nutrient intake over the previous 12-month period. It has a design semi-quantitative in order to evaluate the consumption frequency of the food items. It considers an incremental scale with nine levels (never or almost never; 1–3 times per month; once per week; 2–4 times per week; 5–6 times per week; once per day; 2–3 times per day; 4–6 times per day; more than six times per day). This questionnaire it was adapted from the one that has been validated previously in elderly population at high cardiovascular risk from Spain [298]. Energy and nutrient intake were estimated using Spanish food composition tables [299,300]. Physical activity was assessed using the validated Spanish version of the Minnesota Leisure-Time Physical Activity questionnaire (**Appendix 1**) [301]. Weight (kg) and height (m) were measured with light clothing and no shoes, using calibrated scales and a wall-mounted stadiometer, respectively. BMI (kg/m^2) was calculated after, using weight and height values. Waist circumference (cm) was measured midway between the lowest rib and the iliac crest using an anthropometric tape. Blood pressure was measured using a validated oscillometer [Omron HEM705CP, Hoofddorp, Netherlands] in triplicate with a five minutes interval between each measurement, and the mean of these three values was considered as the final record.

Blood and urine samples were collected by trained personnel. Blood samples were obtained in fasting conditions and serum lipid concentrations (total, HDL- and LDL [low-density lipoprotein]-cholesterol, and triglycerides), fasting plasma glucose, haemogram, sodium, potassium, calcium, uric acid, urea, creatinine, albumin, C-reactive protein, erythrocyte sedimentation rate, hemoglobin A1C, liver function tests (serum bilirubin, alkaline phosphatase, and aminotransferases: alanine transaminase, aspartate aminotransferase and gamma-glutamyltranspeptidase) were performed. Participants were considered to be diabetic, hypercholesterolemic or hypertensive if they had previously been diagnosed as such, and/or they were being treated with antidiabetic, cholesterol-lowering, or antihypertensive agents, respectively. Samples of foot nails and a morning spot urine were also collected in situ. Conventional urine analyses, such as albumin and creatinine were performed. The nursing staff of each recruiting centers was the responsible for collecting, processing, delivering, storing (in freezers at a temperature of -80ºC), preserving the samples, digitizing the information, and keep updated the registry and database for all samples and analyses. All the biochemical procedures performed at the baseline visit were repeated again at 6 months and 1 year visits, and will be performed yearly during the follow-up.

Assessment of total water intake and collection of 24-hour urine sample

A fluid-specific questionnaire (**Appendix 4**) was designed to record the frequency of consumption of different types of beverages, including drinking water in a Spanish population. This questionnaire was not self-reported, given that was filled by trained dietitians at baseline and in each follow-up visit. Average daily fluid intake from beverages was estimated based on servings of consumption 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 200cc), milkshakes, vegetable drinks, soups, jellies and sorbets, SSBs (200 and 330cc), artificially-sweetened beverages (200 and 330cc), espresso (sweet and unsweetened), coffee with milk (sweet and unsweetened), tea (sweet and unsweetened), other infusions (sweet and unsweetened), beer (200 and 330cc), non-alcoholic beer (200 and 330cc), wine, sprits, mixed alcoholic drinks, energetic drinks, sports drinks (200 and 330cc), meal replacement shakes and other beverages. Total fluid intake was considered as the sum of all types of beverages. The amount of water in each beverage was estimated using the percentage of water values from the USDA online database [302]. All the analyses were performed taking into account the mL of water content in each beverage, referring thereafter as total water intake. Participants provided a 24-hours urine sample, and trained personnel registered the volume, the day provided and the mean environmental temperature of the collection day. Participants were advised that in the morning, the first urine of the collection day should be discarded, and the first urine sample of following day included, thus concluding the 24-hour cycle. After receiving the urine sample, the trained personnel aliquoted the samples and keep it at -80 ºC. Urine osmolality (Uosm) using refractive index method was measured before 31 weeks of freezing using the osmometer *ARKRAY OM6050 Osmo Station*.

5.2. The LIQ.IN^7 study

Study design

The LIQ.IN^7 is the acronym of *Liquid Intake over 7 days* study which is an international cross-sectional study conducted between 2008 and 2014 in children, adolescents, adults and elderly individuals from 13 different surveys. It was conducted in Latin America (Mexico, Brazil and Argentina), Europe (Spain, France, United Kingdom, Germany, Poland and Turkey) and Asia (Iran, China, Indonesia and Japan), by public (Iranian National Nutrition & Food Technology Research Institute, NNFTRI; and Chinese Centre for Disease Control, CDC) and private organizations. The primary objective of these surveys was to assess the sources of fluid consumption, including drinking water and different types of beverages.

Study population

The participants were recruited either randomly from a database of volunteers for population surveys, or via systematic door-to-door method until the quotas for age, gender, region, habitat and/or socioeconomic characteristics in relation to the total country population were met. All the individuals included in the analysis were apparently healthy.

Participants were excluded if they met any of the following criteria:

- Working in company advertising, marketing, market research, media or manufacture, distribution and sale of water and all kind of beverages.
- Not being able to read and write in the language of the questionnaire.
- Specific diagnosed disease.
- A medically prescribed diet (exclusion criteria in United Kingdom, Iran and China).
- Participating in a survey about non-alcoholic drinks in the previous 6 months (exclusion criteria in Argentina, Poland and Japan).
- Do not complete the full fluid intake record.
- Reporting a mean total daily fluid intake below 0.4L/day or higher than 6L/day.
- Participating in a market research study in the previous 6 months.
- Pregnancy or lactation (exclusion criteria in Iran and China).

In the present thesis, only adults and elderly individuals (≥ 18 years) were included, for this reason the selective sample size was 16,276 participants. Individuals who agreed to be part of the survey received detailed information about the study's objectives; what was expected of them; information about the study's provisions to preserve confidentiality, risks and benefits; and a clear explanation about their option to participate voluntarily or not in the study. After being given a fully informed description of the study, following the principles of informed consent, participants were asked for their oral approval to participate. No monetary incentive was offered for taking part in the study. All data were recorded anonymously. Therefore, subjects included in the dataset cannot be identified, either directly or through identifiers. The survey protocol of the unpublished surveys was reviewed and approved by the University of Arkansas Review Board (ref. 14-12-376).

The Spanish survey took place between March and May 2012 in all regions of Spain (except Ceuta, Melilla and Canary Islands). The final sample size for the Spanish analysis was 1262 adults and elderly participants whom provided their informed consent. The present study was submitted to the Ethics Committee of the University Hospital of Sant Joan de Reus (ref. C.E.I.C-012), was reviewed, was found to be less than minimal risk and non-invasive, and was approved without requiring signed informed consent.

Assessment of total fluid intake

All participants were provided with seven copies of the 24h fluid-specific record (**Appendix 5**) so that they could collect information on their fluid intake over seven consecutive days. The 7-day fluid specific record was always presented in the official language of the country. In all countries except for France, Germany and Japan, a paper version of this 7-day fluid specific record was delivered and explained to the participants during an initial interview at home. After a period of seven days, the fluid record was collected from the participant's home and reviewed by the researcher with the participant. Individuals from France, Germany and Japan completed 7-day fluid specific record online. On the morning of the first day, the participants received an electronic reminder with written instructions on how to fill the fluid record. Paper memory cards were made available to the participants so that they could make notes during the day, and subsequently complete the fluid record online. Both the paper and online records had the same structure: the participants were asked about the type and temperature of the beverage, the volume of the intake, the reason for the intake, and where and when it was consumed. The questionnaire also asked whether the fluid was consumed by itself or accompanied by some food, but did not record the food consumed. To assist the participants in estimating how much fluid was consumed, a photographic booklet of standard fluid containers (**Appendix 6**) supported the records. The questionnaire items on different types of fluids included: water (tap water, still bottled water and sparkling bottled water); hot beverages (coffee, tea and other hot beverages); milk and derivatives; regular sweet beverages (carbonated soft drinks, non-carbonated soft drinks, juices, energy drinks, sports drinks, other sugared soft drinks); artificially sweetened beverages (diet carbonated soft drinks, diet non-carbonated soft drinks, other diet soft drinks); and alcoholic drinks. Total fluid intake was defined as the sum of all these categories. In UK, Poland, Indonesia and Japan the intake of artificially sweetened beverages was very small, and therefore they were included in the "regular sweetened beverages" category, during the first data treatment. In

Argentina, Iran and Indonesia only non-alcoholic beverages were recorded. In Spain and France no fluids were classified into the group "Other beverages".

Data assessment

Socioeconomic level was assessed using a self-administered questionnaire in the most of the countries, and was categorized using the Market Research Society classification [303,304].

Height in metres (m) and weight in kilograms (kg) were self-reported by participants, except in Poland, Iran and China where these variables were measured by the researchers. The BMI was calculated (kg/m^2). In Mexico, Brazil, Argentina, Indonesia and Japan no anthropometric data were available.

In the Spanish survey, physical exercise practice of more than thirty minutes a day (active walking, swimming, cycling, aerobics and team or individual sports) was evaluated with a self-reported questionnaire. There were four possible responses: five times a week or more, between three and four times a week, between once and twice a week, and once every two weeks or less. Besides, in order to assess the adherence to the MedDiet, the participants filled a 14-points questionnaire validated in a Spanish population [27, 28] (**Appendix 2**). The questions were based on number of servings and frequencies of consumption for the typical foods or food groups of the MedDiet. Each positive point means an increase in compliance with the MedDiet. We classified the MedDiet adherence score into 3 categories: poor (< 5 points), average (6-7 points) and good adherence (> 8 points). In addition, variables such as marital status, region, habitat (urban or rural) and education level were also recorded.

Estimation of energy and free-sugar intake from fluids

In the Spanish survey, the number of sugar teaspoons added to the different beverages was registered, and it was used to estimate the addition by hand of free sugars to each beverage. Furthermore, sugar naturally present in beverages was calculated using a Spanish food composition table [305].

In the rest of the surveys, energy and sugar intake from different types of beverages was calculated using the updated United States Department of Agriculture (USDA) international food composition tables [306]. Because the quantity consumed of beverages classified as "Other beverages" was very low and these fluids frequently had an unknown or unregistered food composition, this category was discarded for the energy and sugar analysis. Hereinafter, we used as free-sugar according definition from the 2002 Joint WHO/ Food and Agriculture Organization (FAO) Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases [307,308]. The percentage of individuals consuming more than 10% of energy requirements as free-sugar, as recommended by WHO, was calculated [308]. This organization strongly recommends the intake of free sugars to less than 10% of total energy intake, and recently even suggested under conditions a further reduction of the intake of free sugars below 5% of total energy intake [308]. Total energy requirement could not be calculated due to missing data of participants' weight and height in some countries. Therefore, the Food Balance Sheets from the FAO were consulted to retrieve the mean energy intake (kcal/capita/day) of the adult population of the countries included in this analysis, which is accepted for ecological studies [309]. This source, however, contained the mean energy intake for total population, not separated by gender.

In order to assess the differences in adherence to the WHO recommendation on free sugar intake between genders, the theoretical recommended daily energy requirement published by the IOM were used for total population, but not for each country [310]. In the Spanish analysis, the IOM equations were used to estimate the total energy expenditure of each individual [311], since values of age, weight, height and physical exercise practice were available.

Estimation of individuals meeting the EFSA recommendations

The percentage of individuals following the EFSA AI of water from fluids was calculated. The EFSA set an AI of total water for men and women at 2.5L and 2L, respectively. The sources of this water can be food moisture, drinking water and different types of beverage. The EFSA assumes that foods usually contribute about 20% of total water intake [24]. Therefore, we set the AI of water only from fluids, preferably drinking water, to be at 2L/day for men and 1.6L/day for women.

5.3. The PREDIMED study

Study design

The PREDIMED study is a large, multicentre, randomized, parallel group and controlled field trial conducted for the primary prevention of CVD. The main aim of the present study was to evaluate the effect of two traditional MedDiets, one supplemented with nuts and the other supplemented with extra virgin olive oil (EVOO), in comparison with a low-fat control diet, on primary cardiovascular prevention (a composite of AMI, stroke and cardiovascular death) in a middle-age and elderly population at high cardiovascular risk. The secondary endpoints in the context of the PREDIMED Study, such as death by any cause, heart failure with pulmonary edema, new-onset diabetes mellitus, MetS, dementia and/ or other neurodegenerative disorders, and cancer incidence other than non-melanoma skin cancer (colorectal, breast, lung, stomach and prostate) have been also assessed. Finally, intermediate outcomes including changes in blood pressure, weight change, fasting blood glucose, blood lipids and biomarkers of inflammation were also evaluated.

Study population

The individuals were recruited between October 2003 and July 2011 in several centers from Spain (Málaga, Sevilla, Islas Baleares, Barcelona, Reus-Tarragona, Pamplona, País Vasco, Valencia, Gran Canaria). The present study included community-dwelling men aged between 55 and 80 and women aged 60 to 80 years, who were free of CVD at baseline but at high risk of cardiovascular events.

The inclusion criteria for the participants in the study were presenting either:

- T2DM. Diagnosis of T2DM is based on current treatment with insulin or oral hypoglycemic drugs.
- Or at least three of the following risk factors:
  - Family history of premature CVD.
  - Overweight or obesity (BMI ≥ 25 kg/m2).
  - Current smoking (> 1 cig/day during the last month).

- Systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, or antihypertensive medication.
- LDL-cholesterol ≥ 160 mg/dL or lipid- lowering therapy.
- HDL cholesterol ≤ 40 mg/dL in men or ≤ 50 mg/dL in women.

On the other hand, individuals were excluded if they met any of the following criteria:

- Documented history of previous CVD, including CHD (angina, AMI, coronary revascularization procedures or existence of abnormal Q waves in the ECG), stroke (either ischemic or hemorrhagic, including transient ischemic attacks), or clinical peripheral artery disease with symptoms of intermittent claudication.
- Severe medical condition that may impair the ability of the person to participate in a nutrition intervention study (e.g. digestive disease with fat intolerance, advanced malignancy, or major neurological, psychiatric or endocrine disease).
- Any other medical condition thought to limit survival to less than 1 year.
- Immunodeficiency or HIV-positive status.
- Illegal drug use, chronic alcoholism or problematic use of alcohol or total daily alcohol intake >80 g/d.
- BMI > 40 kg/m2.
- Difficulties or major inconvenience to change dietary habits.
- Impossibility to follow a Mediterranean-type diet, for religious reasons or due to the presence of disorders of chewing or swallowing (e.g. difficulties to consume nuts).
- A low predicted likelihood to change dietary habits according to the Prochaska and DiClemente stages of change model [295].
- History of food allergy with hypersensitivity to any of the components of olive oil or nuts.
- Participation in any drug trial or use of any investigational drug within the last year.
- Institutionalized patients for chronic care, those who lacked autonomy, were unable to walk, lacked a stable address, or were unable to attend visits in the Primary Care Health Centers every 3 months.
- Illiteracy.

- Patients with an acute infection or inflammation (e.g. pneumonia) were allowed to participate in the study 3 months after the resolution of their condition.

The selection process started extracting names of potential participants from the clinical records. Medical doctors and the study investigators reviewed the records to assess the eligibility criteria of the candidates and excluded those participants meeting any of the exclusion criteria.

Potential participants were contacted trough a telephone call or during the routine clinical visits in order to know if they were interested in participate. A face-to face interview was scheduled. In the first interview, the characteristics and objectives of the study were explained and the informed consent was obtained. After the two informed consents signed, for the study participation and biochemical analysis and for the DNA recollection, participants were randomized to three equally sized intervention groups (1:1:1 ratio). The random allocation was centralized. The duration of the first visit was about 30 minutes, which allowed us verifying if the candidates met all the inclusion criteria. In this screening visit, the inclusion questionnaire and general questionnaire were completed by the PREDIMED trained personnel.

Intervention

The participants of the PREDIMED Study were randomly and equally assigned (1:1:1) to one of three intervention groups (**Figure 3**):

- A Mediterranean type diet supplemented with EVOO (MedDiet + EVOO).
- A Mediterranean type diet supplemented with nuts (MedDiet + nuts).
- Advice to follow a low-fat diet (control group).

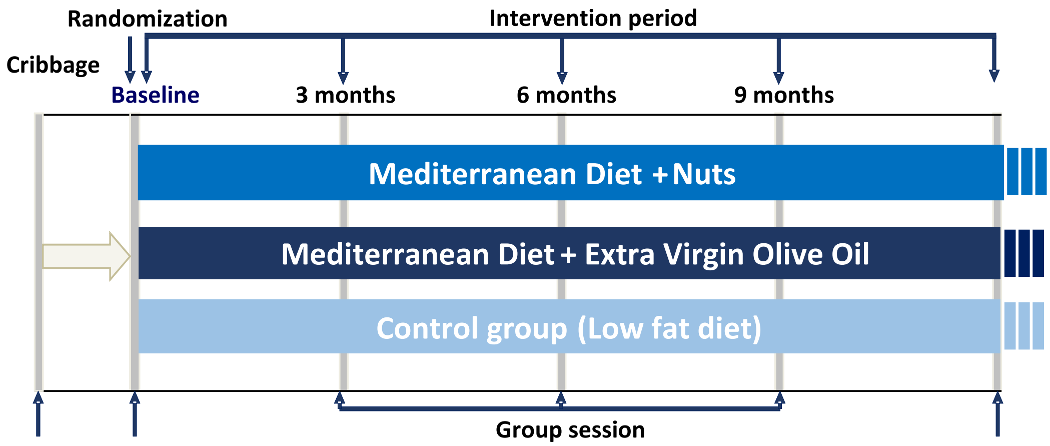

Figure 3. Design of the PREDIMED trial

The *PREDIMED* dietary intervention followed a behavioral strategy focused on promoting a MedDiet in the two intervention groups, but with any specific recommendations on energy restriction or physical activity practice in the two intervention groups. The participants in the two intervention groups with MedDiet received for free, approximately 1 liter per week of EVOO or 30g of mixed nuts (15g of walnuts, 7.5g of hazelnuts, and 7.5g of almonds), depending on the intervention arm. The free provision of EVOO or nuts in the intervention arm increased the compliance and the adherence to the intervention. Participants in the control group received free small non-food gifts (kitchenware, tableware, aprons or shopping bags). Registered dieticians were responsible for the dietary intervention and they received several training sessions before and during the trial with experts in nutrition and dietetics education. At baseline and at follow-up visits, dieticians gave personalized recommendations on dietary changes to the participants in order to achieve the specific aims of each intervention.

MedDiet intervention groups

Registered dieticians ran individual and group dietary-training sessions at baseline visit and quarterly thereafter encouraging the adherence to the MedDiet. Trained dieticians provided some of the following recommendations to increase the adherence to the intervention, in the two MedDiet groups:

- Use olive oil as the main fat for cooking and dressing.
- The consumption of ≥ 2 daily servings of vegetables (at least one of them as uncooked).
- ≥ 2-3 daily servings of fresh fruits (including natural juices).
- ≥ 3 weekly servings of legumes.
- ≥ 3 weekly servings of fish or seafood (at least one serving of fatty fish).
- ≥ 1 weekly serving of nuts or seeds.
- Select white meats (poultry without skin or rabbit) instead of red meats or processed meats (burgers, sausages).
- Cook regularly and dress vegetables, pasta, rice and other dishes (at least twice a week) with tomato, garlic and onion adding or not other aromatic herbs (*sofrito*).

On the contrary, dieticians discourage the consumption of cream, butter, margarine, cold cuts, entrails, carbonated and/or sweetened beverages, pastries, industrial bakery products (such as cakes, donuts, or cookies), industrial desserts (puddings, custard), French fries or potato chips, and out-of-home pre-cooked meals. Total fat intake was *ad libitum* and a high fat intake, as long as majority derived from fatty fish, olive oil or nuts, was allowed.

Control intervention group

The intervention in the control group was based on giving the participants dietary recommendations on a low-fat diet according to Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) [312]. The goal was to reduce the intake of all types of fat, both animal fat and vegetable fat. The dieticians encourage the consumption of low-fat dairy products, lean meats, cereals, potatoes, pasta, rice, fruits and vegetables and discourage the intake of red meat and processed meats, fatty fish, sweets and pastry, and also olive oil and nuts, for being foods which high amounts of fat. The recommendations that the dieticians gave to the control group were as follows:

- Use the least possible amount of oil (no more than 2 tablespoons per day) for cooking and dressing food.
- Remove all visible fat from meat before cooking and cool soups and broth to remove fat layer on top before heating.
- If you choose to eat red meat, eat meat cuts low in fat instead of high fat ones such as beacon, beef and lamb.
- Do not eat butter, margarine, lard or other fat spreads.
- Do not consume fat-enriched dairy products, heavy cream, custard, ice cream and use instead low-fat dairy products.
- Cook legumes, pasta, rice and potatoes with the least amount of oil and other fats, such as fatty-meats, cold cuts, beacon, sausages, cracklings, and do not use tomato sauce simmered with olive oil, garlic and herbs (sofrito).
- Eat only lean fish and avoid fatty-fish.
- Avoid eating liver, kidney and entrails in general, fried foods, commercial sauces, mayonnaise and cooked foods.
- Do not eat sweets and pastry, such as cookies, cakes, pies and muffins.
- Do not eat vegetal fatty foods such as tree nuts (walnuts, hazelnuts, almonds…), peanuts, sunflower seeds, French fries and other salty snacks.

The dieticians used other strategies in order to increase the compliance of the intervention in the three arms of the study. Specific personalized objectives taking into account the medical conditions and preferences of each participants, using the accomplishments in the previous months as support to provide further empowerment and self-reward, and try to avoid contradictory dietary advices from other health professionals external to the *PREDIMED* Study, are some examples of it.

Group sessions

Every three months group sessions, of 20 participants as maximum, were scheduled separately for every intervention diet (MedDiet + EVOO, MedDiet + nuts or control group). The sessions included:

- A briefly recall of the key points that should be followed according to 14-item questionnaire (MedDiet groups) or 9-items questionnaire (Control group).
- Informative talk and description of the delivered written material (descriptions of 4 to 5 foods typically from each arm of intervention and year season, 1-week shopping list, weekly plan of meals and recipes).
- Clarification of questions regarding the instructions provided.
- Free provision of EVOO and nuts to the MedDiet intervention groups and non-food gifts to the control group.

Data assessment

In the PREDIMED study, a general questionnaire about CV risk factors, history of illnesses, medication use, family history of disease, smoking and alcohol use, educational achievement, occupation and socio-economic status were administered to the participants at baseline and yearly during the follow-up. Anthropometric and biochemical evaluations were also performed and registered in the same questionnaires. Dieticians also completed a validated 14-item questionnaire of adherence to the MedDiet (**Appendix 2**) and a quantitative score of compliance with the control (low-fat diet group), as was detailed before. Yearly, the 14-item questionnaire was the primary measure used in this study to appraise adherence of participants to the MedDiet. MedDiet questionnaire was adapted from a previous questionnaire from a Spanish case-control study for myocardial infraction [313]. In addition to the 9 initial items from the original questionnaire [314], 5 extra items were added to assess adherence to the traditional MedDiet foods and cooking habits, and this new version of the questionnaire was validated. Dieticians used a validated 14-item questionnaire in order to give personalized advice on MedDiet during the individualized visits. The maximum score in the questionnaire was 14 points, and the results obtained were used to assess the adherence to the MedDiet of the participants and also to focus the intervention on the points that participants were not following. By the other side, dieticians used a 9- item quantitative score of compliance with the low-fat control diet to assess and give personalized advice in order to enhance the adherence to the intervention. Trained dieticians completed a 137-item semi-quantitative FFQ in a face-to-face interview with the participant, at baseline and annually thereafter. The objective of the present questionnaire was to estimate average daily nutrient intake over the previous 12-month period. It was design to be semi-quantitative and to evaluate the consumption frequency of the food items on an incremental scale with nine levels (never or almost never; 1–3 times per month; once per week; 2–4 times per week; 5–6 times per week; once per day; 2–3 times per day; 4–6 times per day; more than six times per day). This questionnaire has been validated before in elderly population at high cardiovascular risk from Spain [298]. Energy and nutrient intake were estimated using Spanish food composition tables [299,300]. Physical activity was assessed using the validated Spanish version of the Minnesota Leisure-Time Physical Activity questionnaire (**Appendix 1**) [301]. A tolerance and side effect questionnaire was completed in the follow-up visits. Weight (kg) and height (m) were measured with light clothing and no shoes, using calibrated scales and a wall-mounted stadiometer, respectively. BMI (kg/m2) was calculated after, using weight and height values. Waist circumference (cm) was measured midway between the lowest rib and the iliac crest using an anthropometric tape. Blood pressure was measured using a validated oscillometer [Omron HEM705CP, Hoofddorp, Netherlands] in triplicate with a 5 minutes interval between each measurement, and the mean of these three values was considered as the final record.

Blood and urine samples were collected at baseline and years 1, 3, 5 and 7 (or final visit) by trained personnel. Blood samples were obtained in fasting conditions and plasma glucose, serum cholesterol, HLD cholesterol, and triglycerides concentrations were determined using standard enzymatic automated methods. In patients whose triglycerides were less than 400 mg/dl, LDL-cholesterol concentrations were estimated using Friedewald formula [315]. Tubes for EDTA plasma, citrate plasma, buffy coat and serum were collected and aliquots are kept frozen at -80ºC. Participants were considered to be diabetic, hypercholesterolemic or hypertensive if they had previously been diagnosed as such, and/or they were being treated with antidiabetic, cholesterol-lowering, or antihypertensive agents, respectively.

MetS definition

MetS and its features were defined in accordance with the updated harmonized International Diabetes Federation and the American Heart Association/National Heart, Lung, and Blood Institute criteria [199].

Participants were considered to have MetS if they present three or more of the following components:

- Abdominal obesity for European individuals (≥88cm and ≥102cm in women and men, respectively).
- Hypertriglyceridemia (≥150g/dL) or drug treatment for elevated TG.
- Low concentrations of HDL-cholesterol (<40mg/dL in men; <50mg/dL in women) or drug treatment for low HDL-cholesterol.
- High blood pressure (systolic ≥130 and/or diastolic ≥85mmHg) or antihypertensive drug treatment.
- High fasting glucose (≥100mg/dL) or drug treatment for diabetes.

5.4. Statistical analysis

The studies presented in this work are cross-sectional or observational prospective cohort analyses within the Liq.In[7] study, PREDIMED and PREDIMED-PLUS trials. All the analyses were performed using SPSS statistical software, versions 19.0 and 22.0 (SPSS Inc, Chicago, Illinois) and JMP version 12.1.0 (SAS Institute Inc., Cary NC, USA). The level of significance for all statistical tests was set at $P < 0.05$ for bilateral contrast.

In general for all the analyses in order:

- To compare the differences between continuous variables of the study participants, ANOVA (parametric test) or the Pearson chi-squared (parametric test) tests for categorical variables was used.
- To correct for multiple comparisons, the Bonferroni post-hoc test was used.

- To assess the risk of the main outcomes according to categories of exposures, in the cross-sectionals analysis, logistical regression models, adjusted for different confounders, were used.
- Follow-up time was calculated as the interval between the random assignment and date of the event or the end of follow-up (the date of the last visit or the last recorded clinical event of participants still alive).
- To assess the risk (Hazard Ratio [HR]) of the main outcomes (MetS and its components) according to categories of the exposures, multivariate time-dependent Cox proportional regression models were used. The models were adjusted for potential confounding variables.
- To determine linear trend, assigning the median value to each category and using it as a continuous variable in the various models were assessed.
- To represent the long-term intake, a mean between all the yearly repeated measurements of the exposure was performed, and it was used as the mean consumption during the follow-up.
- The relative validity of the fluid-specific questionnaire was assessed using the correlational analysis Bland Altman agreement method, and it was compared with Uosm and 24-hour volume. The analysis was adjusted for potential confounders.
- The repeatability of the fluid-specific questionnaire was examined by paired t-test.
- The degree of gross misclassification in the fluid-specific questionnaire was evaluated using contingency tables, comparing quintiles of total water intake and osmolality or 24-hours urine volume.

6. RESULTS

6. RESULTS

Six published original articles are part of the results of the present doctoral thesis. The specific objectives and corresponding publications are summarized in **Table 1**.

Table 1. Objectives and corresponding publications of this doctoral thesis

Objectives	Publications
To assess the repeatability and the relative validity of a new fluid-specific questionnaire designed to measure habitual consumption of drinking water and different types of beverage in Spanish population.	**Ferreira-Pêgo C,** Nissensohn M, Kavouras SA, et al. **Beverages intake assessment questionnaire: relative validity and repeatability.** Nutrients. 2016 Jul 30; 8(8):E475. PMID: 27483318. **Impact factor 2015:** 3.759 **Category and position:** Nutrition and Dietetics Q1
To evaluate the total fluid and sugar intake provided by different types of beverages in Spain. To assess the percentage of individuals complying with the EFSA recommendations for total fluid intake and the WHO recommendations for free-sugars.	**Ferreira-Pêgo C**, Babio N, Fenández-Alvira JM, et al. **Fluid intake from beverages in Spanish adults; cross-sectional study.** Nutr Hosp. 2014 May 1; 29(5):1171-8. PMID: 24952000. **Impact factor 2014:** 1,040 **Category and position:** Nutrition and Dietetics Q4
To evaluate the associations between physical exercise practice or adherence to the MedDiet and the total fluid intake.	**Ferreira-Pêgo C**, Babio N, Salas-Salvadó J. **A higher Mediterranean diet adherence and exercise practice are associated with a healthier drinking profile in a healthy Spanish adult population**. Eur J Nutr. 2015 Dec 8; [Epub ahead of print]. PMID: 26646673. **Impact factor 2015:** 3.239 **Category and position:** Nutrition and Dietetics Q2
To evaluate the total fluid intake from beverages in adult populations from 13 countries in three continents.	**Ferreira-Pêgo C**, Guelinckx I, Moreno LA, et al. **Total fluid intake and its determinants: cross-sectional surveys among adults in 13 countries worldwide.** Eur J Nutr. 2015 Jun; 54 Suppl 2:35-43. PMID: 26066354.

To assess the percentage of individuals complying with the EFSA AI recommendations.	**Impact factor 2015:** 3.239 **Category and position:** Nutrition and Dietetics Q2
To describe the intake of drinking water and other type of beverages in adults from 13 countries in three continents. To report energy intake from beverages and to assess the percentage of adults exceeding the WHO recommendations on free sugars intake.	Guelinckx I, **Ferreira-Pêgo C**, Moreno LA, et al. **Intake of water and different beverages in adults across 13 countries.** Eur J Nutr. 2015 Jun; 54 Suppl 2:45-55. PMID: 26072214. **Impact factor 2015:** 3.239 **Category and position:** Nutrition and Dietetics Q2
To examine the associations between the average consumption of sugar- and artificially sweetened beverages, and natural and bottled fruit juices and the risk of MetS.	**Ferreira-Pêgo C**, Babio N, Bes-Rastrollo M, et al. **Frequent consumption of sugar- and artificially sweetened beverages, and natural and bottled fruit juices is associated with an increased risk of metabolic syndrome in a mediterranean population at high CVD risk.** J Nutr. 2016 Jun 29; 146(8):1528-36. PMID: 27358413. **Impact factor 2015:** 3.740 **Category and position:** Nutrition and Dietetics Q1

6.1. Beverage intake assessment questionnaire: relative validity and repeatability in a Spanish population with metabolic syndrome from the PREDIMED-PLUS study.

Ferreira-Pêgo C, Nissensohn M, Kavouras SA, Babio N, Serra-Majem L, Martín-Águila A, Mauromoustakos A, Álvarez J, Salas-Salvadó J. Nutrients. 2016;8(8). PMID: 27483318 doi: 10.3390/nu8080475.

Study 1 overview. Novelty and significance.
What is already known?
- Estimating the total fluid intake and the real beverage pattern of a population can be considered as a big challenge in nutritional epidemiology. - Several authors assessed the associations between hydration, water or beverages intake and health or disease, however results in some cases are controversial. - These controversial results could be due to the differences in the methodology used. - It is common the use a FFQ or a 24-hour recall, however these questionnaires were designed mainly to evaluate food and not fluid intake as a whole, underestimating its consumption.
What this study adds?
- The Bland-Altman analysis display a relatively good agreement between total daily fluid intake assessed using the fluid-specific questionnaire, and Uosm and 24-hours volume (-0.65 and 0.22, respectively [P<0.001]). - For the osmolality analysis, both of the two methods classified the 66% of the individuals into the same or adjacent quintile (± 1 quintile). - In the 24-hours urine volume analysis, the 58.2% of the individuals were categorized in the same or adjacent quintile (± 1 quintile) in both of the two methods. - In the repeatability analysis, no significant differences in fluid consumption from beverages were found between baseline and 6 months or 1-year assessments.
Summary
- For the first time, we report that the proposed fluid-specific assessment questionnaire designed to assess water and other beverages consumption in Spanish adult individuals, was found to be relatively valid and highly repeatable. - This easily administered tool may be useful for clinicians and researchers interested in assessing beverages, patterns and changes in consumption and its influence in health or disease.

nutrients

MDPI

Article

Beverage Intake Assessment Questionnaire: Relative Validity and Repeatability in a Spanish Population with Metabolic Syndrome from the PREDIMED-PLUS Study

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Abstract: We assess the repeatability and relative validity of a Spanish beverage intake questionnaire for assessing water intake from beverages. The present analysis was performed within the framework of the PREDIMED-PLUS trial. The study participants were adults (aged 55–75) with a BMI $\geqslant$27 and <40 kg/m^2, and at least three components of Metabolic Syndrome (MetS). A trained dietitian completed the questionnaire. Participants provided 24-h urine samples, and the volume and urine osmolality were recorded. The repeatability of the baseline measurement at 6 and 1 year was examined by paired Student's *t*-test comparisons. A total of 160 participants were included in the analysis. The Bland–Altman analysis showed relatively good agreement between total daily fluid intake assessed using the fluid-specific questionnaire, and urine osmolality and 24-h volume with parameter estimates of −0.65 and 0.22, respectively (R^2 = 0.20; p < 0.001). In the repeatability test, no significant differences were found between neither type of beverage nor total daily fluid intake at 6 months and 1-year assessment, compared to baseline. The proposed fluid-specific assessment questionnaire designed to assess the consumption of water and other beverages in Spanish adult individuals was found to be relatively valid with good repeatability.

Keywords: relative validity; repeatability; fluid questionnaire; beverage; PREDIMED-PLUS study; Spain

1. Introduction

Nowadays, estimating the total fluid intake and real beverage pattern of a population may be considered as a real challenge in nutritional epidemiology. The associations between hydration, water, or beverage intake with health or disease has recently become an important area of research [1,2]. Several authors have assessed the relationship between the consumption of beverages and specific outcomes: for example, the intake of sugar-sweetened beverages (SSBs) and metabolic syndrome (MetS) or type 2 diabetes (T2DM) [3], hypertension [4–6] and other cardiometabolic variables [7]; or the intake of drinking water and its relationship to cardiovascular diseases (CVD) [8]. However, the results in some cases are controversial [9–11] and it is probably partially attributable to the difficulties in assessing the real fluid pattern [12]. Water is an essential nutrient for life [13] and the research on its contribution to human health is very important, so it is essential that the technique used to assess the consumption of different types of beverage is sufficiently sensitive.

To evaluate total fluid intake (all drinking water and beverages), it is common to use food frequency questionnaires (FFQ) or 24-h recall [14,15]. However, these questionnaires were mainly designed to evaluate food intake, and not fluid consumption as a whole. In addition, most food records or dietary recalls do not evaluate the consumption of drinking water because they do not provide calories. The assessment of beverage intake in recent years has mostly focused on SSBs and alcoholic drinks [16,17]. For this reason, and also because fluids are often consumed between meals and are not perceived as a food, fluid intake tends to be underestimated by the individual and the interviewer [3,18–20].

In 2010, Hedrick and coworkers published a questionnaire designed to assess the consumption of different types of beverage in the American population [21]. However, to the best of our knowledge, there is no standardized and validated questionnaire in Spanish that has been developed as a research tool for the specific assessment of beverage intake.

For this reason, the main aim of the present study was to assess the repeatability and the relative validity of a new fluid-specific questionnaire designed to measure the habitual consumption of drinking water and different types of beverages in a Spanish population.

2. Material and Methods

2.1. Subjects and Design

The present analysis was performed within the framework of the PREDIMED-PLUS trial, the design of which has been described elsewhere [22]. Briefly, the PREDIMED-PLUS is a large, multicenter, parallel group, randomized and controlled clinical trial designed for evaluating the safety and effectiveness of a multifaceted intervention program for alleviating excessive cardiovascular morbidity and mortality in overweight and obese individuals.

The primary endpoint of the PREDIMED-PLUS trial is to determine the effect on CVD morbidity and mortality of an intensive weight loss intervention program based on an energy-restricted traditional Mediterranean diet (MedDiet), increased physical activity and behavioral therapy in comparison with an intervention based on traditional Mediterranean diet advice (energy-unrestricted MedDiet) and traditional health care for CVD prevention.

All participants provided written informed consent, and the PREDIMED-PLUS protocol and procedures were approved by the Institutional Review Board Comité de Ética de Investigación Clínica del Hospital Universitario de Gran Canaria Dr. Negrín (code 130093, 30 January 2014) and Comité Ètic d'Investigació Clínica del Hospital S. Joan de Reus (code 13-07-25/7proj2, 25 July 2013). The trial is registered at clinicaltrials.gov; identifier: ISRCTN89898870.

The study participants were adult men aged 55–75 and women aged 60–75 with a body mass index (BMI) ⩾27 and <40 kg/m^2 and who met at least three of the following criteria for the MetS: abdominal obesity for European individuals (waist circumferences ⩾88 cm in women and ⩾102 cm in men), hypertriglyceridemia (⩾150 g/dL) or drug treatment for high plasma triglyceride (TG) concentration, low high-density lipoprotein (HDL)-cholesterol (<50 mg/dL in women and <40 mg/dL in men), high blood pressure (systolic blood pressure ⩾130 mmHg or diastolic blood pressure ⩾85 mmHg) or antihypertensive drug treatment, or high fasting glucose (⩾100 mg/dL) or drug treatment for T2DM. MetS was defined in accordance with the updated harmonized criteria of the International Diabetes Federation and the American Heart Association and National Heart, Lung and Blood Institute [23].

The analysis included a total random sample of 160 individuals randomized to the PREDIMED-PLUS trial from the Reus and Las Palmas de Gran Canaria centers.

2.2. Assessment of Fluid Intake

A trained dietician, on behalf of participants at an interview, filled in the fluid-specific questionnaire, recording the daily and weekly consumption of different types of beverage over the previous month (Figure 1 in English and Supplementary materials Figure S1 in Spanish). The average daily fluid intake from beverages was estimated on the basis of 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, sugar-sweetened beverages (SSBs) (200 and 330 cc), artificially-sweetened beverages (ASBs) (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, sprits, mixed alcoholic drinks, energy drinks, sports drinks (200 and 330 cc), meal replacement shakes and other beverages. Total fluid intake was considered to be the sum of all types of beverage.

The amount of water in each beverage was estimated using the percentage of water values from the United States Department of Agriculture (USDA) online database [24]. All of the analyses were performed taking into account the mL of water content in each beverage.

2.3. Urine Collection

Participants provided a 24-h urine sample, and trained personnel recorded the volume, the day it was provided and the mean environmental temperature of the collection day. Participants were advised that, in the morning, the first urine of the collection day should be discarded, and the first urine sample of the following day included, thus concluding the 24-h cycle. After receiving the urine sample, the trained personnel aliquoted the samples and kept them at −80 °C. Urine osmolality (Uosm) was measured (mOsm/kg) before 31 weeks of freezing using the refractive index method and the osmometer ARKRAY OM6050 (Arkay Global Business, Kyoto, Japan) Osmo Station. Urine osmolality is a measure of the number of dissolved particles per unit of water in urine. Some of these particles can include chloride, glucose, potassium, sodium or urea. In the context of nutrition, the osmolality of a 24-h urine sample reflects the self-regulating activity of renal concentration or dilution mechanisms during a 24-h period. It measures the functional surplus of water and characterizes 24-h hydration status [25].

2.4. Assessment of Other Covariates

At baseline and in each visit during the follow-up, questionnaires were administered about lifestyle variables, educational achievement, history of illness, and medication use. Physical activity was assessed using a validated Spanish version of the Minnesota Leisure-Time Physical Activity questionnaire [26]. Trained personnel took the anthropometric measurements. Weight and height were measured with light clothing, and no shoes with calibrated scales and a wall-mounted stadiometer (Certified scale BARYS with stadiometer T2), respectively. Trained dietitians completed a 137-item semi-quantitative and validated [27] FFQ in a face-to-face interview with the participant. Energy and protein intake were estimated using a Spanish food composition table [28,29]. In addition, dietitians administered a 17-item MedDiet screener, adapted from the 14-item questionnaire validated for the PREDIMED study [30], to assess the degree of adherence to the traditional MedDiet.

predimed plus

SPANISH BEVERAGE INTAKE ASSESSMENT QUESTIONNAIRE

Centre | Participant | Visit | Date

Instructions:
Please indicate your answer for your consumption last month.
For each type of beverage consumed, indicate the number of times per day or per week, and with an "X" the moment of the day that you consumed it.
For example, if you drank 2 glasses of wine per week with lunch, mark "lunch" in the "moment of the day" column and put a 2 in "per week" column. If a drink is consumed every day, for example water, indicate how many times "per day" you consumed it. For example: 6 times a day.
Do not take into account the liquids used in the kitchen or in other culinary preparations, such as sauce or homemade dessert.
If you drink coffee with milk, mark it in the category "coffee with milk" and not in the dairy categories.

		FREQUENCY OF CONSUMPTION											
		TIMES			MOMENT OF THE DAY								
TYPE OF BEVERAGE		RARELY OR NEVER	PER WEEK	PER DAY	BEFORE BREAKFAST	BREAKFAST	BETWEEN BREAKFAST AND LUNCH	LUNCH	BTEWEEN LUNCH AND DINNER	DINNER	AFTER DINNER	DURING NIGHT
Tap water	200 cc											
Bottled water (sparkling/ still)	200 cc											
Natural fruit juices	200 cc											
Bottled fruit juices	200 cc											
Natural vegetable juices (*gazpacho*, tomato, etc.)	200 cc											
Bottled vegetable juices (*gazpacho*, tomato, etc.)	200 cc											
Whole milk	200 cc											
Semi-skimmed milk	200 cc											
Skimmed milk	200 cc											
Drinking yogurt	100 cc											
	200 cc											
Milkshakes	200 cc											
Vegetable drinks (soy, oat, almond, etc.)	200 cc											
Soups	200 cc											
Jellies and sorbets	120 cc											
Sugar sweetened beverages	200 cc											
	330 cc											
Artificially sweetened beverages	330 cc											
	200 cc											
Espresso (sweetened)	30-50 cc											
Espresso (unsweetened or sugar-free)	30-50 cc											
White coffee (sweetened)	125 cc											
White coffee (unsweetened or sugar-free)	125 cc											
Tea (sweetened)	200 cc											
Tea (unsweetened or sugar-free)	200 cc											
Other infusions (sweetened)	200 cc											
Other infusions (unsweetened or sugar-free)	200 cc											
Beer	200 cc											
	330 cc											
Non-alcoholic beer	330 cc											
	200 cc											
Wine, champagne	120 cc											
High alcoholic content beverages (whisky, rum, vodka, gin)	50 cc											
Mixed alcoholic drinks (cocktails, gin tonic, *piña colada*, etc.)	200 cc											
Energy drinks (Red Bull, Burn, etc.)	200 cc											
Sport/ Isotonic drinks	200 cc											
	330 cc											
Meal replacement shakes	200 cc											
Other drinks:												

Figure 1. The beverage intake assessment questionnaire in English (translated version and not validated tool).

2.5. Statistical Analysis

Beverages and total fluid intake (mL/day) and demographic characteristics are presented as a means (SD) for continuous variables or percentages (numbers) for dichotomous variables. Student's *t*-test or Pearson's χ^2 tests were used to compare the quantitative or categorical general characteristics of the participants.

To assess relative validity, the total daily fluid intake assessed by the fluid-specific questionnaire was compared to the urine osmolality and the 24-h urine volume values. Associations among these variables were assessed using the correlational analysis Bland–Altman agreement method. A total of 160 participants were included in the validity analysis. A stepwise method was used to select only the significant predictors for urine osmolality. The list of covariates that were not kept in the final model (i.e., did not contribute significantly) to the model urine osmolality were: sex, height, weight, center of recruitment, intervention group, total protein intake, MedDiet adherence, leisure-time physical activity, mean environmental temperature, urine albumin and urine creatinine. The covariates that were kept in the model included age, BMI and total energy consumption. The model for the 24-h urine volume analysis included age and total energy intake. No predictor interactions were found with any of the aforementioned variables. Quintiles of total water intake, osmolality and 24-h urine volume were calculated. The osmolality and 24-h urine volume values were adjusted by the same covariates as were used in the validity analysis. The degree of gross misclassification in the fluid-specific questionnaire with respect to the adjusted osmolality and adjusted 24-h urine volume values was evaluated using contingency tables. The proportions of correctly categorized subjects in the same or adjacent quintiles, and also the individuals classified in extreme quintiles were calculated.

The repeatability of the fluid-specific questionnaire was examined by comparing baseline, and six-month and 12-month values (in 45 and 34 individuals, respectively) with paired Student's *t*-tests. For a comparison between repeatedly measured variables of consumption of each type of beverage and total fluid intake during time (baseline, six month and one year), a linear mixed-effect model for repeated measures was used. In order to avoid the effect of the intervention on beverage and total-water intake, only individuals from the control group were included in the repeatability analysis.

The level of significance for all the statistical tests was set at $p < 0.05$ for bilateral contrast. Analyses were performed using JMP version 12.1.0 (SAS Institute Inc., Cary, NC, USA) and with SPSS software, version 22.0 (SPSS Inc., Chicago, IL, USA).

3. Results

A total of 160 participants (68 men and 92 women) with a mean age of 65.3 years (range 55 to 75 years) were included in the present analysis. Height and weight, but not BMI, were significantly different between men and women. Such lifestyle variables as leisure-time physical activity, MedDiet adherence and total energy consumed were different between genders. Levels of urine osmolality, urine creatinine and urine albumin were higher in men. Women took significantly more pain relief pills and tranquilizers than men. The general characteristics of the study participants are summarized in Table 1.

Table 1. General characteristics of the study population.

Variables	All Population (n = 160)	Men (n = 68)	Women (n = 92)	p-Value [a]
Age, years	65.3 (4.9)	64.5 (5.9)	65.9 (3.9)	0.097
Height, m	1.62 (0.09)	1.69 (0.06)	1.56 (0.06)	<0.001
Weight, kg	86.7 (14.3)	94.3 (12.5)	81.9 (12.9)	<0.001
BMI, kg/m^2	33.0 (4.3)	32.9 (3.6)	33.1 (4.7)	0.328
Leisure-time physical activity, METs/week	3123 (2804)	4006 (2945)	2471 (2518)	<0.001
Mediterranean diet score, (0–17 points)	9.2 (2.5)	8.5 (2.6)	9.8 (2.3)	<0.005
Total energy intake, kcal/day	2229 (551)	2330 (606)	2155 (497)	<0.005
Total protein intake, g/day	134 (357)	189 (545)	93 (22)	0.276
Urine volume, mL/day	1722 (651)	1762 (698)	1693 (616)	0.506
Urine osmolality, mOsm/kg	551 (211)	631 (204)	492 (196)	<0.001
Urine albumin, mg/dL	13.8 (31.8)	20.0 (39.5)	9.0 (23.4)	0.047
Urine creatinine, μmol/dL	7718 (3760)	9440 (4204)	6431 (2783)	<0.001
Urine albumin to creatinine ratio, mg/g	17.1 (43.4)	22.2 (53.2)	13.2 (33.9)	0.228
Use of medications, % (n)				
Aspirin	24.4 (39)	26.5 (18)	22.8 (21)	0.596
Pain relief	33.7 (54)	17.6 (12)	45.6 (42)	<0.005
Tranquilizers	27.5 (44)	17.6 (12)	34.8 (32)	0.016
Vitamin/minerals	6.9 (11)	2.9 (2)	9.8 (9)	0.091
Heart problems	4.4 (7)	5.9 (4)	3.3 (3)	0.423
Antihypertensive agents	79.4 (127)	82.3 (56)	77.2 (71)	0.423
Statins	56.9 (91)	50.0 (34)	62.0 (57)	0.131
Insulin	6.2 (10)	5.9 (4)	6.5 (6)	0.869
Oral anti-diabetic drugs	30.0 (48)	30.9 (21)	29.3 (27)	0.834
Others	68.1 (109)	63.2 (43)	71.7 (66)	0.254

Data expressed as means (SD) or percentages (n). Abbreviations: BMI, body mass index. [a] p-Values for comparisons between groups were tested by Student's t-test or χ^2 as appropriate.

3.1. Relative Validity of the Questionnaire

Total daily fluid intake from beverages assessed by the specific questionnaire was negatively associated with age and urine osmolality, and positively associated with BMI and total energy intake (R^2: 0.20; $p < 0.001$). The Bland–Altman analysis showed relatively good agreement between total daily fluid intake assessed using the fluid-specific questionnaire, and urine osmolality and 24-h volume with parameter estimates of −0.65 and 0.22, respectively. The validity results for the total daily fluid intake assessed with the specific questionnaire are presented in Table 2. The Bland–Altman plot showing the relationship between total daily fluid intake and 24-h urine volume is shown in a supplementary file (Figure S2).

Table 2. Parameter estimates for two candidate models (osmolality and urine volume) with similar predictive ability of total daily beverage intake.

Term	Parameter Estimate	Standardized β *	Standard Error	*p*-Value	R^2
Intercept	2278				
Osmolality	−0.65	−0.26	0.18	0.0005	0.20
Age	−25.13	−0.23	7.94	0.0019	
BMI	23.86	0.15	11.38	0.0376	
Total energy	0.27	0.25	0.08	0.0007	
Intercept	2455				
Urine volume	0.22	0.27	0.06	0.0003	0.20
Age	−26.03	−0.24	7.93	0.0013	
Total energy	0.24	0.23	0.07	0.0019	

* Standardized beta weights are indicative of effect size.

The percentage of gross misclassification (both over-and underestimation by the fluid-specific questionnaire) as indices of validity of the fluid-specific questionnaire in categorizing individuals was performed (Supplementary Materials Table S1). Osmolality analysis classified 66% of the individuals into the same or the adjacent quintile (±1 quintile) with both methods. A total of 4.4% of the individuals were classified into quintiles at opposite ends of the scale (highest quintile of total water from beverage intake and lowest quintile of osmolality). A total of 6.9% of the population was classified into the lowest quintile of total water intake and the highest quintile of osmolality, suggesting that the total water intake from fluids may have been underestimated. In the 24-h urine volume analysis, 65.7% of the individuals were categorized in the same or the adjacent quintile (± 1 quintile) by both methods. A total of 4.4% and 1.3% of the population studied were misclassified in extreme quintiles (the highest quintile of total water intake and the lowest 24-h urine volume quintile, and the lowest of the total water intake and the highest 24-h urine volume quintiles, respectively).

3.2. Repeatability of the Questionnaire

Table 3 shows the repeatability of the fluid-specific questionnaire measurements for each type of beverage analyzed (baseline vs. six months and baseline vs. one year). The consumption in mL/day of each type of beverage and total daily fluid intake at baseline, six months and one year is described. The differences in the consumption (mL/day) between baseline and six months and baseline and one year, and differences in the consumption during all the visits are also shown in the table. No significant differences were found in the fluid consumption from beverages between the baseline and six months or one-year assessments.

Table 3. Repeatability of the beverage intake assessment questionnaire.

Beverage Category	Baseline (mL/day) (n = 67)	Baseline vs. 6 Months			Baseline vs. 1 Year			
		Mean (SD)			Mean (SD)			
		6 Months (mL/day) (n = 45)	Differences from Baseline	p-Value [a]	1 Year (mL/day) (n = 34)	Differences from Baseline	p-Value [a]	p-Value [b]
Tap water	289 (571)	449 (657)	62 (413)	0.32	360 (577)	−23 (502)	0.79	0.389
Bottled water	755 (539)	773 (714)	80 (505)	0.29	813 (612)	125 (577)	0.22	0.905
Natural fruit juices	39 (69)	27 (54)	1 (79)	0.92	28 (61)	16 (75)	0.21	0.537
Bottled fruit juices	26 (93)	22 (52)	7 (46)	0.33	19 (44)	7 (29)	0.16	0.880
Natural vegetable juices	6 (28)	16 (36)	9 (29)	0.05	1 (9)	−1 (16)	0.79	0.073
Bottled vegetable juices	14 (69)	4 (14)	−5 (32)	0.25	4 (18)	−7 (41)	0.35	0.451
Whole milk	24 (92)	3 (17)	−16 (89)	0.22	25 (74)	4 (125)	0.86	0.284
Semi-skimmed milk	43 (81)	67 (126)	8 (125)	0.67	63 (123)	9 (131)	0.69	0.467
Skimmed milk	95 (146)	59 (107)	−19 (145)	0.38	54 (102)	−36 (151)	0.17	0.192
Drinking yogurt (100 cc)	13 (32)	10 (32)	−6 (32)	0.23	8 (23)	−6 (25)	0.18	0.765
Drinking yogurt (200 cc)	6 (31)	13 (46)	5 (61)	0.58	10 (42)	4 (54)	0.56	0.562
Milkshakes	0 (2)	0 (0)	0 (3)	0.32	2 (10)	1 (11)	0.53	0.289
Vegetable drinks	21 (80)	9 (39)	5 (49)	0.47	38 (128)	33 (133)	0.16	0.330
Soups	36 (30)	34 (35)	0 (45)	0.93	50 (56)	17 (52)	0.07	0.144
Jellies and sorbets	2 (11)	1 (5)	−1 (9)	0.61	1 (4)	−1 (7)	0.64	0.594
SSBs (200 cc)	11 (34)	11 (38)	3 (31)	0.53	7 (32)	−3 (18)	0.32	0.862
SSBs (330 cc)	8 (39)	18 (90)	6 (92)	0.68	10 (51)	5 (54)	0.59	0.707
ASBs (200 cc)	7 (48)	21 (118)	11 (134)	0.57	39 (158)	37 (157)	0.18	0.363
ASBs (330 cc)	42 (164)	8 (32)	−54 (200)	0.08	18 (45)	−61 (215)	0.11	0.292
Espresso sweetened	16 (31)	9 (20)	−4 (31)	0.33	9 (18)	−4 (20)	0.25	0.287
Espresso unsweetened	24 (35)	36 (38)	7 (36)	0.22	31 (37)	2 (23)	0.62	0.223
White coffee sweetened	23 (63)	5 (25)	−3 (40)	0.66	4 (21)	−2 (36)	0.69	0.063
White coffee unsweetened	9 (31)	3 (18)	−5 (35)	0.32	7 (28)	3 (36)	0.57	0.492

Table 3. *Cont.*

Beverage Category	Baseline (mL/day) (n = 67)	Baseline vs. 6 Months Mean (SD)			Baseline vs. 1 Year Mean (SD)			
		6 Months (mL/day) (n = 45)	Differences from Baseline	p-Value [a]	1 Year (mL/day) (n = 34)	Differences from Baseline	p-Value [a]	p-Value [b]
Tea sweetened	7 (29)	2 (13)	−7 (26)	0.09	14 (48)	2 (65)	0.82	0.246
Tea unsweetened	25 (87)	34 (105)	17 (79)	0.15	19 (51)	−2 (54)	0.82	0.718
Other infusions sweetened	27 (96)	13 (66)	12 (67)	0.23	17 (55)	15 (56)	0.13	0.646
Other infusions unsweetened	34 (91)	51 (107)	14 (90)	0.30	54 (139)	12 (106)	0.51	0.613
Beer (200 cc)	18 (67)	10 (32)	−12 (68)	0.24	1 (4)	−18 (71)	0.13	0.266
Beer (330 cc)	32 (91)	47 (119)	2 (131)	0.92	26 (66)	6 (69)	0.63	0.580
Non-alcoholic beer (200 cc)	5 (25)	11 (39)	−8 (45)	0.21	5 (24)	−4 (20)	0.28	0.581
Non-alcoholic beer (330 cc)	13 (54)	3 (14)	4 (22)	0.25	2 (15)	−11 (58)	0.25	0.283
Wine	35 (63)	41 (68)	−7 (60)	0.46	60 (85)	9 (55)	0.35	0.257
High alcoholic content beverages	1 (3)	1 (4)	0 (3)	0.66	1 (2)	0 (3)	0.26	0.988
Mixed alcoholic beverages	1 (6)	0 (3)	0 (0)	-	0 (0)	0 (3)	0.32	0.388
Energy drinks	0 (0)	0 (0)	0 (0)	-	0 (0)	0 (0)	-	-
Sports drinks (200 cc)	0 (3)	0 (0)	0 (4)	0.32	0 (0)	0 (0)	-	0.558
Sports drinks (330 cc)	0 (0)	2 (13)	2 (13)	0.32	0 (0)	0 (0)	-	0.328
Meal replacement shakes	0 (0)	0 (0)	0 (0)	-	0 (0)	0 (0)	-	-
Other drinks	0 (0)	0 (0)	0 (0)	-	0 (0)	0 (0)	-	-
Total water intake	1711 (64)	1816 (498)	106 (475)	0.14	1804 (435)	128 (559)	0.19	0.477

Data expressed as means (SD). [a] p-values for comparisons between groups were tested by Student's t-test; [b] p-Values for comparisons between repeated measures were tested by linear mixed models test.

4. Discussion

The main objective of the present analysis was to assess the relative validity and repeatability of a fluid-specific questionnaire designed to measure the habitual consumption of drinking water and different types of beverage. We report for the first time that the use of a fluid-specific questionnaire in Spanish and designed for the Spanish population seems to be highly repeatable, and relatively valid for estimating the daily intake of water from beverages. This tool may be useful for clinicians and researchers interested in assessing habitual water-drinking and beverage-consumption patterns, particularly in large-scale investigations, in which other resource-intensive dietary intake assessment techniques are not so accurate [31].

Although the present fluid-specific questionnaire is the only one to have been validated in Spanish, other questionnaires designed to evaluate beverage intake have been published and validated by a variety of different methods [17,21,31,32]. In 2009, Neuhouser and coworkers developed a questionnaire for assessing the consumption of snacks and beverages, mainly sweetened beverages, by young adolescents [31]. The participants filled in the self-reported beverage questionnaire and also a four-day dietary record. This second method was compared with the beverage questionnaire to assess its validity. The same method was used by Hedrick in 2010 to validate a questionnaire designed to assess the intake of water and caloric beverages [21]. This study used the energy intake from the four-day food record as a method for validating the fluid questionnaire. Although urine samples were collected, they were used to objectively determine total fluid intake and to encourage accurate self-reporting, not for purposes of validation. To date, and to the best of our knowledge, only one questionnaire has been validated using hydration indices with 24-h urine samples [32]. In 2012, Malisova and colleagues developed a "water balance questionnaire", designed to evaluate water drinking and also water intake from solids and other beverages [32]. For validation purposes, urine was collected from 40 healthy adults and osmolality, 24-h volume, specific gravity, pH and color were evaluated. Although all of these indices have been demonstrated to be biomarkers of hydration, nowadays there is still no biomarker universally accepted as the "gold standard" [33,34]. Nevertheless, in the Malisova study, urine osmolality was proposed as the most promising urine biomarker of all the ones used [32,35]. In the present analysis, the 24-h urine samples were frozen for a few weeks, and the freezing-point depression method could not be used for assessing osmolality. Even though the method used in our study was not the same as the one used in the previously mentioned paper, the validation results were very similar in both studies. The results were also similar for the 24-h urine volume as a biomarker of hydration status. Urine volume in both of our studies and Malisova's was found to be significantly related to hydration, but not as strongly as to urine osmolality.

In our study, only 1% to 7% of the subjects were misclassified into extreme quintiles. We found that total water intake was considerably underestimated with the fluid-specific questionnaire in comparison with adjusted-osmolality values. This may be because beverages, mainly drinking water, are consumed during the day and often between meals, so they are not perceived as an important food by the participants and tend to be underestimated [18,19].

The second important outcome of the present study is that the repeatability of the Spanish fluid-specific questionnaire was tested. No differences were found for any of the beverages or in the total daily fluid intake at the different times of evaluation (baseline versus six months or one year), either during all the visits as repeated measures. Therefore, beverage intake and patterns can be compared over time.

The test–retest interval between the three evaluation times of the questionnaire is a factor that has an important influence on repeatability [27]. If the interval is too short, the following evaluations can be influenced by the memory of the first answers, and repeatability will be overestimated. On the other hand, if the interval is too long, the drinking patterns may have changed, which could lead to an underestimation of repeatability [36]. According to a comprehensive review, the time intervals in reports using FFQs range between 2 h and 15 years [37]. In the present analysis, we chose time intervals of six months and one year to prevent the types of bias mentioned above.

This study has several strengths. The ability to accurately assess the validity and repeatability of a questionnaire relies on having a large sample [38] and using multiple statistical methods, which has been achieved in this present study. The second strength is the use of hydration biomarkers instead of dietary intake methods to determine the validity of the analysis. Biomarkers make it possible to improve validation, as they avoid bias caused by measurement errors (memory of the interviewers, errors in estimating food intake), which impact on the statistical power of the study. Another important strength of the present analysis is that the questionnaire was completed by trained dietitians. By avoiding the use of self-reported data we significantly reduced the risk of underreporting errors. However, the study also has several limitations. The present questionnaire may underestimate certain beverage categories because of the serving sizes established (for example, water intake (tap and bottled)). However, estimated mean daily water intake and also total daily fluid intake are very similar to those reported in 2014 in a Spanish population [39], and the present findings did not indicate a ceiling effect. Due to the fact that our population was middle-aged and elderly rather than healthy individuals, future studies should focus on healthy adults and children and other minorities to determine if the fluid-specific questionnaire is a valid tool across other population groups. Another limitation was the lack of a measure to assure the completeness of the 24 h urine samples. However, at the moment the urine was brought in, we asked the participants whether they had followed the instructions and whether they had had any problem with the collection. A final limitation was the use of frozen samples. It has been suggested that freezing urine samples generates urinary sediments that consist predominantly of endogenous calcium oxalate dehydrate and amorphous calcium crystals [40] and that this may account for the changes in osmolality observed after freezing. However, several studies have shown that the changes in frozen urine osmolality are trivial and physiologically irrelevant, especially because daily variations in urine osmolality are considerably larger than these changes [41,42]. The long-term stability and measurement validity for frozen urine were found to be good without the addition of a preservative. The prospective storage of frozen urine aliquots, even exceeding 10 years, appears to be an acceptable and valid tool in epidemiological settings for subsequent urine analysis [43]. Nevertheless, in the present study, we measured osmolality levels in a subsample of urine just after the collection (n = 59), without freezing, and no significant differences were found (data not shown).

5. Conclusions

The present fluid-specific questionnaire appears to be a relatively valid and a highly reliable tool for assessing intake of water and other types of beverages in Spanish adults. The Spanish beverage intake assessment questionnaire may help nutrition researchers and clinicians to evaluate beverages, patterns and changes in consumption and their influence on health or disease.

Supplementary Materials: The following are available online at http://www.mdpi.com/2072-6643/8/8/475/s1, Figure S1: The beverage intake assessment questionnaire in Spanish (validated tool); Figure S2: Bland–Altman plots showing the relationship between total daily water intake (mL/day) and 24-h urine volume (mL/day); Table S1: Contingency tables for the gross misclassification between quintiles of total daily water intake and (A) osmolality adjusted or (B) 24-h urine volume adjusted.

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Author Contributions: L.S.-M. and J.S.-S. designed the PREDIMED-PLUS study and were the coordinators of subject recruitment and follow-up at the outpatient clinics; C.F.-P., M.N., N.B., L.S.-M., J.Á.-P. and J.S.-S. conducted the research; C.F.-P., S.A.K., A.M. and J.S.-S. analysed the data; C.F.-P., N.B. and J.S.-S. wrote the manuscript; A.M.Á. performed the urine laboratory analysis; N.B. and J.S.-S. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors have read and approved the final manuscript.

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Abbreviations

SSBs, sugar-sweetened beverages; ASBs, artificially-sweetened beverages; FFQ, food frequency questionnaire; CVD, cardiovascular diseases; MetS, metabolic syndrome; MedDiet, Mediterranean diet; USDA, United States Department of Agriculture; SD, Standard Deviation; ANOVA, analysis of variance; BMI, body mass index.

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Supplementary Materials: Beverage Intake Assessment Questionnaire: Relative Validity and Repeatability in a Spanish Population with Metabolic Syndrome from the PREDIMED-PLUS Study

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predimed plus

CUESTIONARIO DE VALORACIÓN DE INGESTA DE BEBIDAS

Nodo | **Participante** | **Visita** | **Fecha**

Instrucciones:
Por favor indique su respuesta haciendo referencia al mes pasado.
Por cada tipo de bebida consumida, marque con un número la cantidad de veces al día o a la semana, y con una "X" el momento en que la consumió.
Por ejemplo, si usted bebió 2 vasos de vino por semana, marque el número 2 en "a la semana" situado en la columna "veces". Si se trata de una bebida que consume todos los días, por ejemplo agua, indique cuantas veces la consume en la columna "al día" (por ejemplo: 6 veces al día).
No cuente los líquidos utilizados en la cocina o en otras preparaciones culinarias, como por ejemplo al preparar una salsa o un postre casero.
Si consume el café con leche, márquelo en la categoría de bebidas "café con leche" y no en las categorías de leche.

		FRECUENCIA DE CONSUMO										
		VECES			MOMENTO							
TIPO DE BEBIDA		NUNCA O CASI NUNCA	A LA SEMANA	AL DÍA	ANTES DEL DESAYUNO	CON EL DESAYUNO	ENTRE DESAYUNO Y COMIDA	CON LA COMIDA	ENTRE COMIDA Y CENA	CON LA CENA	DESPUES DE LA CENA	DURANTE LA NOCHE
Agua de grifo	200 cc											
Agua embotellada (con/ sin gas)	200 cc											
Zumos naturales de frutas	200 cc											
Zumos envasados de frutas	200 cc											
Zumos vegetales naturales (gazpacho, de tomate, etc.)	200 cc											
Zumos vegetales envasados (gazpacho, de tomate, etc.)	200 cc											
Leche entera	200 cc											
Leche semidesnatada	200 cc											
Leche desnatada	200 cc											
Lácteos bebibles	100 cc											
	200 cc											
Batidos lácteos	200 cc											
Bebidas vegetales (bebida de soja, almendras, avena, etc.)	200 cc											
Sopas y caldos	200 cc											
Sorbetes, gelatinas	120 cc											
Refrescos	200 cc											
	330 cc											
Refrescos Light /Zero	330 cc											
	200 cc											
Café sólo o cortado (con azúcar)	30-50 cc											
Café sólo o cortado (sin azúcar, con/sin edulcorante)	30-50 cc											
Café con leche o americano (con azúcar)	125 cc											
Café con leche o americano (sin azúcar, con/sin edulcorante)	125 cc											
Té (con azúcar)	200 cc											
Té sin azúcar (sin azúcar, con/sin edulcorante)	200 cc											
Otras infusiones (con azúcar)	200 cc											
Otras infusiones (sin azúcar, con/sin edulcorante)	200 cc											
Cerveza, Sidra	200 cc											
	330 cc											
Cerveza sin alcohol o Light	330 cc											
	200 cc											
Vino (tinto, rosado o blanco), cava	120 cc											
Bebidas alcohólicas de alta graduación (whisky, ron, vodka, ginebra)	50 cc											
Bebidas alcohólicas combinadas (cubata, gin-tonic, piña colada, cócteles, etc.)	200 cc											
Bebidas energéticas (*Red Bull*, *Burn*, etc.)	200 cc											
Bebidas para deportistas/ isotónicas	200 cc											
	330 cc											
Batidos sustitutivos de comidas/ híper proteicos	200 cc											
Otros (especifique):												

Figure S1. The beverage intake assessment questionnaire in Spanish (validated tool).

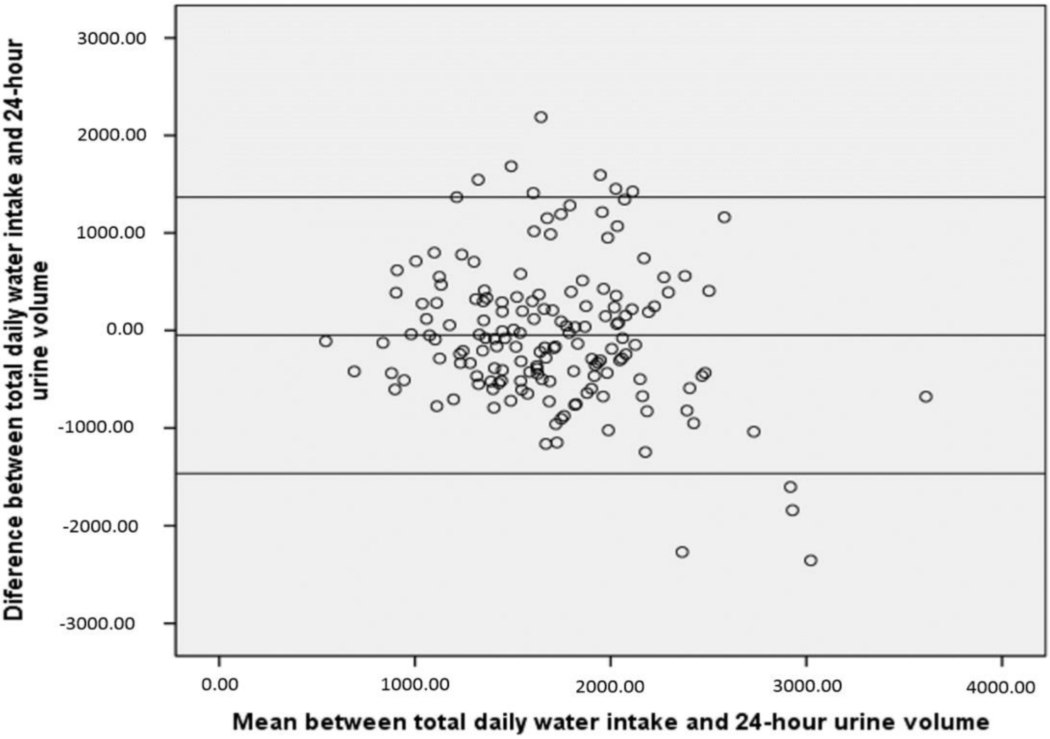

Figure S2. Bland-Altman plots showing the relationship between total daily water intake (mL/day) and 24-h urine volume (mL/day).

Table S1. Contingency tables for the gross misclassification between quintiles of total daily water intake and (**A**) osmolality adjusted or (**B**) 24-h urine volume adjusted.

		(A) Quintiles of Osmolality Adjusted (%)				
		Q1	**Q2**	**Q3**	**Q4**	**Q5**
Quintiles of total daily water intake (%)	**Q1**	6.4	1.9	2.4	2.4	6.9
	Q2	3.1	7.7	4.4	2.4	2.4
	Q3	2.4	6.3	5.8	3.8	1.8
	Q4	3.6	1.8	6.3	6.9	1.3
	Q5	2.4	2.4	3.1	4.4	7.7
		(B) Quintiles of 24-h Volume Adjusted (%)				
		Q1	**Q2**	**Q3**	**Q4**	**Q5**
	Q1	8.1	4.4	5.0	1.3	1.3
	Q2	3.1	5.0	5.0	3.1	3.8
	Q3	2.5	5.0	3.8	5.0	3.8
	Q4	1.9	1.3	4.4	5.0	7.5
	Q5	4.4	4.4	1.9	5.6	3.8

6.2. Fluid intake from beverages in Spanish adults: cross-sectional study.

Ferreira-Pêgo C, Babio N, Fenández-Alvira JM, Iglesia I, Moreno LA, Salas-Salvadó J. Nutr Hosp. 2014;29(5):1171-8. PMID: 24952000. doi: 10.3305/nh.2014.29.5.7421.

Study 2 overview. Novelty and significance.
What is already known?
- Water is a natural resource that is essential for life and for human daily nutrition. - The excess or deficiency of water or other types of beverages intake and its micronutrients can determine the state of health or disease. - It is very important to evaluate the fluid intake of a population and to compare it with the available public health recommendations.
What this study adds?
- We described for the first time the consumption of different types of beverages in a healthy Spanish population. - We analyzed the fluid intake by gender, age range and moment of consumption during the day. - We report that approximately 50% of the adult population do not cover the total water intake recommended by the EFSA. - Approximately 27% of our study population consumed more free sugar than recommended by the WHO only from beverages (intrinsic or added).
Summary
- Half of the adults studied did not meet the EFSA fluid intake AI values. - Water was the main fluid consumed. - Differences in the pattern of fluid consumption were observed between ages and genders. - A quarter of the population studied consumes from beverages alone, already more sugar than recommended for the total diet.

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Original / *Otros*

Fluid intake from beverages in Spanish adults; cross-sectional study

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Abstract

Introduction: **Dietary questionnaires usually only assess the intake of drinks that provide calories, but do not accurately evaluate total fluid or water intake. The evaluation of the fluid consumption pattern of a population has been the main objective of only a very few studies.**

Objective: **To evaluate the total fluid intake from different types of beverages in Spanish adults.**

Methods: **A total of 1,262 adults aged 18-70 years were randomly recruited from all Spanish regions. The information about the quantity and quality of daily fluid intake from different types of beverages was collected using a 24h fluid-specific diary over 7 consecutive days.**

Results: **50.4% of the study population had a fluid intake < 80% of the EFSA recommendations for total water intake. The odds of meeting the recommendations of total fluid intake were higher in women [OR: 2.48; 95%CI: 1.81-3.40], and in those with higher leisure-time physical activity (3-4 times/week [OR: 1.57; 95%CI: 1.01-2.46]; 5 times/week or more [OR: 1.97; 95%CI: 1.37-2.83]). Women consumed significantly more hot and sweet light beverages. However, men consumed significantly more sweet regular and alcoholic drinks. A significant higher percentage of young and normal/underweight subjects exceed the WHO recommendations for free sugars (> 10% total energy intake) from beverages alone.**

Conclusion: **Half of the adults studied do not meet the EFSA fluid intake recommendations. Water is the main fluid consumed. Differences in the pattern of fluid consumption were observed between ages and genders. A quarter of the population studied consumes from beverages alone already more sugar than recommended from the total diet.**

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DOI:10.3305/nh.2014.29.5.7421

Key words: *Fluid intake. Spain. Beverages. Water. Adult.*

INGESTA DE LÍQUIDOS A PARTIR DE BEBIDAS EN ADULTOS ESPAÑOLES; ESTUDIO TRANSVERSAL

Resumen

Introducción: **Los cuestionarios dietéticos, solamente evalúan la ingesta de bebidas calóricas. Sin embargo, no evalúan adecuadamente la ingesta total de líquidos o de agua.**

Objetivo: **Evaluar la ingesta total de líquidos procedente de diferentes tipos de bebidas, en adultos españoles.**

Métodos: **1.262 adultos (18-70 años) fueron seleccionados al azar en regiones españolas. La información sobre la cantidad y calidad de la ingesta diaria de líquidos se recogió mediante un registro de 24 horas específico para la evaluación de fluidos durante 7 días consecutivos.**

Resultados: **La ingesta de agua a partir de diferentes bebidas estaba por debajo de las recomendaciones de la EFSA en el 50,4% de la población. La probabilidad de cumplir las recomendaciones de la EFSA para la ingesta de agua fue mayor en mujeres [OR: 2.48, IC95%: 1.81-3.40], y participantes con mayor practica de actividad física (3-4 veces/semana [OR: 1,5, IC95%: 1.01-2.46]; 5 o más veces/semana [OR: 1.97, IC95%: 1.37-2.83]). Las mujeres consumían más bebidas calientes y refrescos light. El consumo de refrescos regulares y de bebidas alcohólicas fue mayor en los hombres. Un mayor porcentaje de hombres, jóvenes y participantes con IMC < 30 kg/m² consumían azúcar procedente de bebidas, por encima de las recomendaciones de la OMS.**

Discusión: **La mitad de la población estudiada no cumple las recomendaciones de la EFSA para la ingesta de fluidos. El agua embotellada o del grifo es la principal bebida consumida. Existen diferencias en el consumo de bebidas en relación a la edad y género. Una cuarta parte de la población estudiada consume un exceso de azúcar procedente de las bebidas.**

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Palabras clave: *Ingesta de líquidos. España. Bebidas. Agua. Adultos.*

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Introduction

Water is a natural resource that is essential for life and for human daily nutrition[1]. Total body water represents between 50% and 70% of total body weight[2,3], and is therefore the greatest component of the human body[4]. Body water is essential for the physiological processes of digestion, absorption, metabolism and elimination of non-digestible metabolic wastes, and also for the structure and function of the circulatory system. It also transports nutrients and other body substances, and directly helps to maintain body temperature[5].

It is assumed that the contribution of food to total water intake is approximately 20%, whereas fluids, including tap and bottled water and other types of beverages, provide 80%[6]. Fluids provide not only water but also minerals and other nutrients. For example, water, especially natural mineral water, may provide calcium, magnesium and sodium; tea provides flavonoids, antioxidants and a few micronutrients, and milk provides proteins, calcium and vitamins. In fact, some fluids can provide micronutrient levels comparable with those of some natural foods[7]. The excess or deficiency of these compounds provided by different types of beverages can determine the state of health or disease. For example, a meta-analysis in 2010 demonstrated that a high consumption of sugar-sweetened beverages is associated with the presence of type II diabetes and metabolic syndrome, in part because of their contribution to weight gain[8].

Estimating the total fluid intake and real beverage pattern of a population is a real challenge to nutritional epidemiology. Dietary questionnaires are given to assess food intake but not to assess fluid consumption as a whole, because they usually focus only on the intake of solid foods and drinks providing calories. For this reason and because fluids are often consumed outside mealtimes, and are not perceived as a food, fluid intake tends to be underestimated[9-12]. This may explain the important intra and inter-individual differences observed in the amount and pattern of fluid intake in different populations[4,13-16]. For example, data collected by the same method showed that the main sources of fluid intake are water, sugar-sweetened beverages and hot drinks in Canadian[16], Mexican[17,18] and United Kingdom populations[19], respectively. The main aim of the present study is to evaluate the total fluid and sugar intake provided by different types of beverages in Spain, to assess the percentage of individuals complying with the EFSA recommendations for total fluid intake and the WHO recommendations for sugars coming from total diet, and to assess the associated determinants of the total fluid intake in adult individuals.

Methods

Design and study population

The present study is a cross-sectional analysis of Spanish data, designed to assess the sources of fluid consumption, from water to different types of beverages, and the association of this consumption with lifestyle and health. The study took place between march and may 2012, and 1,502 participants were randomly recruited from a database of voluntary individuals for population surveys after they had been stratified by age, gender, region (except Ceuta, Melilla and Canary Islands), habitat (rural or urban), educational and socioeconomic level.

Participants working in advertising, marketing, market research, media or manufacture, distribution and sale of different types of beverages, participants reporting a mean fluid intake below 0.4 L or higher than 6 L daily, and those participants that did not complete the fluid intake record were excluded (n = 240). So, the effective sample size for these analyses was 1,262 participants, all of whom provided informed consent.

Assessment of fluid intake

A fluid-specific record was provided to all participants so that they could collect information on their usual intake of fluids over 7 consecutive days. The data were collected at two different times: a first interview at home, when the record was delivered and explained, and a second visit after 7 days, when the completed questionnaire was collected after the interviewer had checked it with the participants. The record asked participants when they consumed fluids during the day, what beverages they consumed and in what volumes using standard portion sizes (one standard serving, cup, glass, can, bottle, etc). Sugar from beverages was calculated using updated Spanish food composition tables[20]. The addition (by hand) of sugar to each beverage was also evaluated and participants were asked to state the number of teaspoons used. The total sugar provided by beverages was calculated as the sum of the amount contained in the beverage and added by the participant.

There were eleven possible responses to the question "moment of fluid consumption": Just after you wake up, at breakfast, during the morning, just before the lunch, at lunch, during the afternoon, just before dinner, at dinner, after dinner, just before going to bed, during the night. The intake of fluid *outside the main meals* at whatever time was regarded as being different from breakfast, lunch and dinner.

The questionnaire items on beverages included: water (tap water, filtered tap water, natural mineral water, sparkling natural mineral water, flavoured water, water from a fountain); hot beverages (coffee, white coffee, espresso with a drop of milk, cappuccino, tea, beverages made from cereals, other infusions and hot beverages); milk and milk derivates (milk, milkshakes, milkshakes with juice, liquid yogurt, other milk drinks); juices (home-made juice, bottled juice, nectars, nectar without added sugar, other fruit drinks); sweet regular beverages: carbonated soft drinks (cola, orange, lemon, bitter, tonic water, other flavours) non-carbonated soft-drinks (orange, lemon, sports drinks, energy drinks, regular iced tea, other flavours), other sugared soft drinks; sweet light beverages: diet carbonated soft drinks (cola, orange, lemon, other flavours), diet non-carbonated soft drinks (orange, lemon, diet iced tea), other diet soft drinks; and alcoholic drinks (beer, alcohol-free beer, lemon beer, wine, wine with soda, alcoholic mixed drinks, other alcoholic drinks).

The percentage of individuals who did not follow the recommendations of the European Food Safety Agency (EFSA) for total water intake was calculated. The EFSA recommends that men should have a total water intake of 2.5 L every day and women 2 L. This water can come from food but also from different types of beverage. As foods usually contribute about 20% of water intake, the EFSA recommendations for total fluid intake in men is 2 L/day and women 1.6 L/day of beverages, of which preferably water[21], since water is the preferred beverage to fulfil daily water needs according to a guidance system in the United States[7].

Assessment of other variables and lifestyle factors

Leisure-time physical activity of more than thirty minutes a day was evaluated with a self-reported questionnaire. There were four possible responses: five times a week or more, between three and four times a week, between once and twice a week, and once every two weeks or less. In addition, variables such as marital status, socioeconomic characteristics, region, habitat (urban or rural) and education level were also assessed. The Institute of Medicine (IOM) equations were used to estimate the total energy expenditure of each individual[22], so that the percentage of individuals consuming more than 10% of energy requirements as free sugar, as recommended by WHO, could also be calculated[23].

Assessment of body composition

Height in metres (m) and weight in kilograms (kg) were evaluated with a self-reported questionnaire. With these values, body mass index (BMI) was calculated in kg/m^2.

Statistical analysis

All the data are presented either as means and 95% confidence intervals (CI) for continuous variables or numbers and percentages for dichotomous variables. We compared the distribution of the selected characteristics between groups using 2 tests for categorical variables or Student's t-tests or analysis of variance (ANOVA), as appropriate, for continuous variables. The Bonferroni post-hoc test was used to correct for multiple comparisons. The odds ratio for meeting the EFSA recommendations or not for water intake (dependent variable) was assessed for several variables by logistic regression models adjusted for gender, age (years), body mass index (kg/m^2), socioeconomic characteristics (lower and middle-low, middle, upper-middle and high), habitat (5,000-30,000 inhabitants, 30,000-200,000 inhabitants, more than 200,000 inhabitants), educational level (primary education, secondary education, high education) and leisure-time physical activity (once every 2 weeks or less, once or twice per week, 3-4 times/week and ≥ 5 times/week). All statistical tests were two-tailed and the significance level was set at $P < 0.05$. All analyses were performed using the SPSS software version 19.0 (SPSS Inc, Chicago, IL).

Results

A total of 1,262 participants (630 men and 632 women) took part with a mean age of 43 years and recruited from all over Spain (except Ceuta, Melilla and the Canary Islands). There were no significant differences in the proportion of individuals in different age categories, region, type of habitat and educational level between the study sample and the Spanish population as a whole. No gender differences were observed in the prevalence of age categories, type of habitat or education level. The baseline characteristics of participants are summarized in table I. The body-mass-index and the proportion of individuals with overweight or obesity was higher in men than in women. Most of the study population were of middle socioeconomic status and secondary educational level, and reported low leisure-time physical activity. Women were more sedentary than men.

The mean volume consumed of water (tap water, filtered tap water, natural mineral water, sparkling mineral water, flavoured water and fountain water) was 1,011 ml/day for the whole population (1,050 ml for women and 973 ml for men). Water intake from different types of beverages was below the EFSA recommendations (1,600 ml/d for women and 2,000 ml/d for men) in 50.4% of the whole population (41.6% of women and 59.2% of men). In total, 40.3% of the study population (31% of the women and 49.5% of the men) consumed < 90% of EFSA recommended for total fluid intake. 20.1% of the whole population (20.9% of the women and 19.4% of the men) consumed between 90 and 110% of the total EFSA recommendations, and 39.6% of whole population (48.1% of the women and 31.1% of the men) consumed > 110% of the EFSA recommendations ($P < 0.001$) (data not shown).

The odds of meeting the EFSA recommendations for water intake (table II) was higher in women [OR: 2.48; 95% CI: 1.81-3.40], and in participants with higher leisure-time physical activity (3-4 times a week [OR: 1.57; 95% CI: 1.01-2.46]; 5 times a week or more [OR: 1.97; 95% CI: 1.37-2.83].

Table III shows the total daily fluid intake and the amount of each type of beverage consumed according

Table I
General characteristics of the study population

Baseline variables	*All population (n = 1,262)*	*Women (n = 632)*	*Men (n = 630)*	*P value*[a]
Age, years	43 (41.9, 43.5)	43 (41.5, 43.7)	43 (41.8, 43.7)	0.74
Age categories,% (n)				0.76
18 to 35 years	34 (431)	33 (212)	35 (219)	
36 to 50 years	35 (447)	37 (233)	34 (214)	
51 to 65 years	24 (305)	24 (149)	25 (156)	
66 to 70 years	6 (79)	6 (38)	6 (41)	
BMI, kg/m²	25.6 (25.4, 25.8)	25.1 (24.7, 25.4)	26.1 (25.8, 26.4)	< 0.001
BMI classification, % (n)[b]				< 0.001
Under and normal weight	51 (638)	58 (367)	43 (271)	
Overweight	36 (453)	28 (177)	44 (276)	
Obesity	13 (171)	14 (88)	13 (83)	
Region, % (n)				0.99
Region 1 (Catalonia/Aragon)	12 (156)	12 (76)	13 (80)	
Region 2 (east)	18 (226)	18 (116)	17 (110)	
Region 3 (south)	20 (251)	19 (122)	20 (129)	
Region 4 (centre)	7 (87)	7 (45)	7 (42)	
Region 5 (north-centre)	8 (98)	8 (48)	8 (50)	
Region 6 (northwest)	9 (115)	10 (60)	9 (55)	
Barcelona and Madrid	26 (329)	26 (165)	26 (164)	
Habitat, % (n)				0.27
5,000 to 30,000 inhabitants	31 (389)	31 (197)	30 (192)	
30,000 a 200,000 inhabitants	36 (450)	37 (236)	34 (214)	
More than 200,000 inhabitants	33 (423)	32 (199)	36 (224)	
Socioeconomic level, % (n)				0.004
Lower and middle-low	31 (391)	34 (215)	28 (176)	
Middle	44 (552)	45 (281)	43 (271)	
Upper-middle and high	25 (319)	22 (136)	29 (183)	
Educational level, % (n)				0.06
Primary education	17 (217)	17 (104)	18 (113)	
Secondary education	64 (803)	67 (421)	61 (382)	
Higher education	19 (242)	17 (107)	21 (135)	
Leisure-time physical activity, % (n)				< 0.001
1 time every 2 weeks or less	41 (521)	48 (301)	35 (220)	
1-2 times a week	20 (246)	16 (100)	23 (146)	
3-4 times a week	15 (191)	12 (78)	18 (113)	
5 times a week or more	24 (304)	24 (153)	24 (151)	

Data expressed as means (95% CI) or percentages (n). Abbreviations: BMI, body mass index. [a]P values for comparisons between groups were tested by Student's t-test or χ^2 as appropriate.
[b]BMI (kg/m²) was divided into the following categories: underweight and normal weight (BMI < 24.9 kg/m²), overweight (BMI between 25-30 kg/m²), and obesity (BMI > 30.0 kg/m²).

to gender. Women consumed significantly more hot and sweet light beverages than men. Consumption of sweet regular beverages and alcoholic drinks was significantly higher in men than in women. No significant differences were observed for total fluid intake or water intake between genders.

Total fluid intake and beverage consumption according to age ranges are shown in table IV. Younger participants (18-35 years) consumed fewer hot beverages, more fruit juices and more sweet regular beverages than others age categories (P < 0.05). Participants aged between 51-65 years consumed significantly more alcoholic drinks than younger participants. There were no significant differences in total fluid intake or water intake between age categories.

The total daily intake of different types of beverage and when they were consumed (during the main meals/outside the main meals) are described in table V. No significant differences were observed in the times at which water and juices were consumed throughout the study population for either women or men.

The consumption of hot beverages, sweet regular beverages, and alcoholic drinks was significantly higher during the main meals than at other times of the day. During the main meals –for the whole population and women, but not for men–, the intake of sweet light beverages, and milk and derivates was significantly greater than at other times. In both genders, total fluid intake was significantly higher during the main meals.

Table II
Association (Odds ratio) between compliance with EFSA recommendations for total daily fluid intake and several socio-demographic variables

Variables	*All population (n = 1,262)*	*Women (n = 632)*	*Men (n = 630)*
Gender [a]	2.48 (1.81-3.40)	-	-
Age	0.99 (0.98-1.00)	0.99 (0.98, 1.01)	0.99 (0.97-1.01)
BMI	0.99 (0.96-1.03)	1.00 (0.96-1.05)	1.05 (0.98-1.12)
Habitat			
5,000 to 30,000 inhabitants	1 (ref)	1 (ref)	1 (ref)
30,000 to 200,000 inhabitants	1.30 (0.91-1.85)	1.31 (0.84-2.04)	1.35 (0.73-2.49)
More than 200,000 inhabitants	0.71 (0.48-1.05)	0.63 (0.38-1.05)	0.83 (0.43-1.60)
Socioeconomic level			
Lower and middle-low	1 (ref)	1 (ref)	1 (ref)
Middle	1.12 (0.76-1.64)	1.04 (0.65-1.67)	1.16 (0.59-2.29)
Upper-middle and high	1.22 (0.75-1.99)	1.33 (0.73-2.44)	1.01 (0.43-2.40)
Educational level			
Primary education	1 (ref)	1 (ref)	1 (ref)
Secondary education	0.92 (0.57-1.15)	0.97 (0.53-1.78)	0.90 (0.41-1.98)
Higher education	1.06 (0.56-1.99)	1.38 (0.62-3.09)	0.81 (0.28-2.34)
Leisure-time physical activity			
1 time every 2 weeks or less	1 (ref)	1 (ref)	1 (ref)
1-2 times a week	0.91 (0.57-1.43)	0.98 (0.55-1.74)	0.85 (0.39-1.86)
3-4 times a week	1.58 (1.01-2.46)	1.24 (0.68-2.25)	2.13 (1.05-4.32)
5 times a week	1.97 (1.37-2.86)	1.85 (1.18-2.89)	2.28 (1.19-4.36)

Data expressed as ORs (95% CI). [a]Gender was coded as 0 for men and 1 for women.

Table III
Total daily consumption of different types of beverage (ml/day) in all population and stratified by gender

Variables	*All population (n = 1,262)*	*Women (n = 632)*	*Men (n = 630)*	*P value*[a]
Water	1011 (973, 1049)	1050 (997, 1103)	973 (918, 1027)	0.05
Hot beverages	305 (290, 320)	349 (327, 371)	261 (242, 279)	<0.001
Milk and derivates	103 (92, 114)	94 (83, 106)	111 (93, 129)	0.14
Juices	94 (84, 104)	88 (77, 99)	101 (85, 117)	0.20
Sweet regular beverages	152 (136, 167)	128 (111, 145)	176 (150, 201)	0.003
Sweet light beverages	38 (28, 48)	50 (35, 64)	26 (12, 40)	0.02
Alcoholic drinks	195 (176, 215)	103 (86, 121)	288 (255, 320)	<0.001
Beer and wine	179 (161, 197)	93 (76, 109)	265 (234,297)	<0.001
Spirit drinks	16 (13, 19)	10 (6, 14)	22 (17, 27)	<0.001
Total daily fluid volume	1901 (1856, 1946)	1865 (1804, 1927)	1937 (1872, 2003)	0.12

Data expressed as means (95% CI). [a]P values for comparisons between gender were tested by Student's t-test.

When stratified by BMI, obese participants consumed more hot beverages and less milk and milk derivates than participants from the other BMI categories (P < 0.05). Overweight individuals consumed more alcoholic drinks than those with obesity or normal weight (P < 0.05) (data not shown).

The whole population consumed a total of 46.7 g/d (187 kcal/d) of sugar added by hand and contained in beverages, men consumed 52 g/d (208 kcal) and women 41.2 g/d (165 kcal) (P < 0.001).

The consumption of calories from sweet regular beverages (48.5 kcal in women; 67.4 kcal in men) and alcoholic drinks (13.4 kcal in women; 32.9 kcal in men) was significantly higher in males than females. No significant differences between genders were found for the other beverages (data not shown).

Table VI shows the percentage of participants who consumed more sugar than is recommended by WHO[24] only from beverages (less than 10% of the estimated energy requirements). Younger participants and people with normal or underweight more frequently consume sugar over the recommendations (P < 0.001) than old individuals or people with overweight. Compared to men, a higher percentage of women consumed sugar above the recommendations (P = 0.08).

Discussion

The main objective of the present pioneering study is to estimate the total fluid intake and the real fluid pattern of a large sample of Spanish individuals. We re-

Table IV
Total daily consumption of different types of beverages (ml/day) stratified by age range

Variables	*18-35 years (n = 431)*	*36-50 years (n = 447)*	*51-65 years (n = 305)*	*66-70 years (n = 79)*	*P value*[a]
Water	1037 (972, 1102)	1019 (953, 1084)	958 (884, 1032)	1036 (867, 1204)	0.46
Hot beverages	224 (202, 247)[b]	330 (305, 356)[c]	370 (340, 399)[c]	352 (297, 407)[c]	< 0.001
Milk and derivates	141 (117, 165)[b]	89 (73, 104)[c]	76 (60, 93)[c]	76 (42, 110)[c]	< 0.001
Juices	117 (101, 134)[b]	96 (76, 115)	64 (50, 79)[c]	76 (45, 107)	0.001
Sweet regular beverages	233 (199, 266)[b]	144 (121, 168)[c, d]	71 (49, 92)[c, e]	79 (30, 104)[c]	< 0.001
Sweet light beverages	53 (35, 71)	38 (25, 52)	23 (0, 49)	8 (0, 17)	0.07
Alcoholic drinks	140 (116, 164)[b]	200 (168, 231)	271 (220, 322)[c]	181 (120, 242)	< 0.001
Beer and wine	113 (92, 135)[b]	189 (159, 220)[c]	257 (207, 306)[c]	179 (118, 197)	< 0.001
Spirit drinks	26 (19, 33)[b]	10 (6, 14)[c]	14 (8, 20)[c]	2 (0, 5)[c]	< 0.001
Total daily fluid volume	1948 (1867, 2028)	1919 (1843, 1994)	1836 (1749, 1923)	1798 (1626, 1970)	0.18

Data expressed as means (95% CI). [a]P values for comparisons between groups were tested by bivariate analysis of variance (ANOVA) followed by post hoc tests with the Bonferroni correction.
$P < 0.05$ for differences between letters ([b] versus [c] and [d] versus [e]).

Table V
Total daily intake of different types of beverages (ml/day) by moment of consumption

	All population (n = 1,262)			*Women (n = 632)*			*Men (n = 630)*		
Variables	*During the main meal*	*Outside the main meal*	*P value*[a]	*During the main meal*	*Outside the main meal*	*P value*[a]	*During the main meal*	*Outside the main meal*	*P value*[a]
Water	503 (481, 525)	508 (479, 536)	0.78	513 (484, 543)	536 (495, 577)	0.37	492 (460, 525)	480 (440, 520)	0.60
Hot beverages	173 (164, 182)	131 (121, 141)	< 0.001	186 (174, 198)	163 (147, 179)	0.01	160 (147, 173)	100 (88, 111)	< 0.001
Milk and derivates	59 (52, 65)	44 (36, 52)	0.003	55 (46, 63)	39 (32, 47)	0.005	62 (52, 72)	48 (34, 62)	0.09
Juices	48 (42, 55)	45 (39, 51)	0.44	43 (35, 51)	45 (37, 52)	0.71	54 (43, 66)	46 (37, 55)	0.18
Sweet regular beverages	103 (91, 114)	49 (42, 56)	< 0.001	90 (75 105)	38 (31, 45)	< 0.001	116 (97, 134)	60 (47, 72)	< 0.001
Sweet light beverages	25 (18, 31)	12 (7, 18)	< 0.001	34 (23, 45)	15 (9, 20)	< 0.001	15 (9, 21)	10 (1, 20)	0.24
Alcoholic drinks	108 (96, 120)	87 (76, 98)	0.001	60 (49, 72)	43 (34, 52)	0.002	156 (136, 177)	131 (112, 150)	0.03
Beer and wine	106 (95, 118)	72 (62, 82)	< 0.001	59 (47, 70)	33 (25, 41)	< 0.001	154 (134, 175)	111 (93, 128)	< 0.001
Spirit drinks	1 (1, 2)	14 (11, 17)	< 0.001	1 (0, 2)	9 (5, 12)	< 0.001	2 (0, 3)	20 (15, 24)	< 0.001
Total daily fluid volume	1022 (1000, 1044)	879 (844, 914)	< 0.001	984 (955, 1013)	881 (832, 929)	< 0.001	1059 (1027, 1092)	877 (826, 928)	< 0.001

Data expressed as mean (95% CI). [a]P values for comparisons between during and outside meals were tested by Student's t-test.

Tabla VI
Participants exceeding the WHO recommendation of < 10% energy from free sugar, from beverages consumption

	n	*%*	*P value*[a]
Gender			
Women (n = 632)	185	29.3	0.08
Men (n = 630)	156	24.9	
Age, categories			
18-35 years old (n = 431)	164	38.1	<0.001
36-50 years old (n = 447)	122	27.3	
51-65 years old (n = 305)	47	15.4	
66-70 years old (n = 79)	9	11.4	
BMI, categories			
Under and normal weight (n = 638)	204	32	<0.001
Overweight (n = 453)	101	22.3	
Obesity (n = 171)	37	21.6	

[a]P values for comparisons between groups were tested by Student's t-test or χ^2 as appropriate. * Sugar recommendations: < 10% of the daily energy intake[23].

port for the first time that approximately half of the adult population do not cover the total water intake recommended by the EFSA[21].

Our results are in agreement with the data collected by the EFSA[9] evaluating fluid consumption in 13 European countries and which show that only Denmark and Germany consumed a mean of at least two liters of water per individual from all types of beverages. Our findings also add new knowledge to the current scientific literature made by other research[9,13,24], showing that a considerable proportion of Spanish adults do not have a healthy fluid consumption pattern.

Interestingly, in our study compliance with recommendations for total fluid intake was mainly associated with physical activity and with being a woman, but not with education, socioeconomic status or type of habitat (rural or urban). The higher compliance with recommendations for total fluid intake by people who practice physical activity is partly due to the fact that they tend to drink more as they have increased fluid demands[25,26]. The social determinants of the consumption of water and other types of beverage may explain why women tend to comply more with recommendations for total fluid intake. In fact, women tend to have a better lifestyle pattern[27] and, in general, adults with a healthier dietary pattern usually have a healthier fluid pattern,[28] which leads to greater water consumption[28].

In the present study, fluid consumption was assessed with a 24 h fluid-specific diary over 7 consecutive days. Not only did it assess the type and amount of fluid ingested, but also the times at which beverages were consumed and the amount of sugar added by hand to drinks. The same methodology was used in a French study, and both studies found that water consumption represented more than 50% of the total daily fluid intake in all age groups and in both genders[29]. This is important because plain water is regarded as the healthiest option for hydration, and increasing water consumption is a recommended strategy for reducing energy intake[30].

Total fluid intake in our study was non-significantly higher in men than in women. This is in agreement with other studies evaluating fluid intake in other populations[4,14,16]. However, in our study, the percentage of women who met the EFSA recommendations was higher than the percentage of men (58.4% of women, but only 40.8% of men).

Several of our findings about the pattern of fluid consumption in our population deserve comment. Men generally consumed more of all type of beverages with some exceptions: for example, total water (tap water or mineral water), hot beverages and sweet light beverages, all without or few calories. These finding have also been observed in other populations[28], which suggests that women are more aware of the need to consume fewer calories in the form of drinks to avoid overweight or obesity[31,32]. Age is also an important determinant of the general fluid pattern. As in other studies[13,29,33], the mean total fluid intake in our study progressively decreased as age increased. This can probably be explained by a decrease in the perception of thirst with age[26,34], but social determinants cannot be discounted. The type of fluid consumed also changed with age. The intake of milk, juices, and sweet beverages (regular or light) decreased with age, whereas the intake of hot beverages increased. The decrease in the mean milk intake observed in our population may be partly due to the fact that the percentage of individuals with lactase deficiency is higher in elderly people[35,36].

As reported in other studies in adults and seniors[29,37], more beverages were consumed during the main meals than at other times of the day. For example, Bellisle[29] reported that fluids were consumed more at breakfast, dinner and lunch than at other secondary meals. In our study only spirits were consumed more outside the main meals, and water was consumed in similar amounts.

Beverages can account for a substantial share of daily calories. Most of these calories come from sweet regular beverages, alcohol drinks, milk and milk derivates, and juices[16]. Approximately 27% of our study population consumed more sugar than recommended by the WHO (> 10% of the total daily calories) only from the sugar in beverages (intrinsic or added)[23]. These results are alarming if it is taken into account that other studies show that an excessive consumption of calories from sugar has unhealthy effects[8,38,39].

Several potential limitations of our study deserve comment. The main limitation is that our population is probably not representative of the general Spanish population because individuals were randomly recruited from a database of volunteers for population surveys. Despite this, the final distribution of the individuals studied among age groups, gender, region of Spain and educational categories is very similar to the real distribution of the population in Spain. The second limitation has to do with the cross-sectional design of the study, which means that no conclusions about cause/effect relationships can be drawn. Third, the fact that anthropometric measures were self-reported and not measured may produce some systematic bias. Finally, the 24 h fluid-specific diary over 7 consecutive days must be validated in the future with gold standard methods, so that total fluid intake can be reliably assessed.

One of the strengths of this study is that it uses a 24 h fluid-specific diary over 7 consecutive days that allows to assess the total fluid intake and real fluid pattern. Also, the population was randomly recruited using the quota-based sample method from a database of volunteers for population surveys, which led to a large representative sample of Spanish adults in relation to the stratum considered[40]. Moreover, this report is the first specific description of total fluid intake in Spanish adults.

Total beverage consumption and types of beverage consumed showed some differences between genders and age groups. Approximately half of the Spanish population does not meet the EFSA recommendations for total fluid intake. Water is the main beverage consumed, but a significant amount of dietary calories are provided by other beverages. A quarter of the studied population consume more sugar from beverages than is recommended by the WHO (> 10% of total daily calories)[23]. There is enough evidence to prove that replacing sweet drinks by water has beneficial effects on health[30,41] so it is imperative to promote the consumption of water, especially in children, parents and educators, and also elderly people, and limit the intake of sugar from beverages in Spain. Longitudinal studies should be carried out in various populations to determine the chronic contribution of fluid consumption to health.

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Conflict of interests

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6.3. A higher Mediterranean diet adherence and exercise practice are associated with a healthier drinking profile in a healthy Spanish adult population.

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Study 3 overview. Novelty and significance.
What is already known?
- Lifestyle is one of the most important factors conditioning health. - Physical activity and adherence to a healthy diet, including a healthy beverage pattern, are considered essential components of a healthy lifestyle that can reduce the risk of several non-communicable chronic diseases. - An inadequate water intake has several consequences on health and human performance, so the influence of determinant factors (e.g. lifestyle) other than classical individual factors (sex, age, body surface, etc.) and/ or environmental conditions for covering the fluid intake recommendations needs to be clarified.
What this study adds?
- Individuals with the highest scores in the 14-item MedDiet adherence questionnaire consumed significantly more water and wine and less SSBs compared with those with the lowest scores. - Individuals who engaged in most physical exercise presented a higher total daily fluid intake and also consumed greater quantities of drinking water, wine, milk and dairy products and fewer SSBs. - Participants with a higher MedDiet adherence and physical exercise practice had a greater probability of complying with EFSA total daily fluid intake and WHO free-sugar intake recommendations.
Summary
- We report for the first time that healthy individuals with the highest scores for MedDiet adherence and physical exercise practice presented the healthiest beverage patterns. - The higher consumption of drinking water in those individuals in the highest category of MedDiet adherence suggested that it should be borne in mind as another key element of MedDiet definition.

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ORIGINAL CONTRIBUTION

A higher Mediterranean diet adherence and exercise practice are associated with a healthier drinking profile in a healthy Spanish adult population

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Abstract
Purpose Very few studies have examined the association between beverage intake patterns and healthy lifestyle characteristics. Most of the research that has been carried out focuses on the consumption of soft drinks or alcohol and ignores the overall beverage pattern. The aim of this study is to evaluate the association between consumption of different types of beverage and physical exercise practice and MedDiet adherence.
Methods Cross-sectional information about fluid intake from different types of beverages was collected in 1262 men and women between 18 and 70 years old, using a 24-h fluid-specific diary over seven consecutive days. Physical exercise was evaluated with a self-reported questionnaire, and MedDiet adherence was assessed using a validated 14-item questionnaire. Both variables were classified into three categories.
Results Individuals with greater adherence to the MedDiet showed a higher intake of water and wine and a lower consumption of sweet regular beverages. Participants who engaged in more physical exercise consumed more water, milk and derivatives, juices and wine and less sweet regular beverages. Compared to the lowest category, the possibility of meeting the EFSA recommendations of total fluid intake was greater in individuals with eight or more points on the MedDiet adherence questionnaire [OR 1.94; 95 % CI 1.25–3.01] and in those who practice physical exercise three times a week or more [OR 1.71; 95 % CI 1.22–2.39]. Participants with a healthier lifestyle had a lower risk of exceeding the WHO's free-sugar recommendations only from beverages.
Conclusions Participants with greater adherence to the MedDiet and who engaged in more physical exercise exhibit a healthier pattern of fluid intake.

Keywords Fluid intake · Mediterranean diet · Physical exercise · Adult · Beverage

Abbreviations

EFSA	European Food Safety Agency
ORs	Odds ratios
IOM	Institute of Medicine
BMI	Body mass index
WHO	World Health Organization
CI	Confidence intervals
MedDiet	Mediterranean diet

Introduction

Lifestyle is one of the most important factors conditioning health [1]. Physical activity and adherence to a healthy diet, including a healthy beverage pattern, are considered essential components of a healthy lifestyle that reduces the risk of several non-communicable chronic diseases.

The benefits of physical exercise on health and the adverse effects of sedentary behavior are both well

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recognized [2–4]. An increase in physical exercise has been shown to be associated with an increase in longevity [5, 6] and a decrease in the risk of cardiovascular and all-cause mortality [7], coronary heart disease and stroke [8], diabetes, and some types of cancer [4]. While more physically active men and women tend to have a higher daily fluid intake [9], the beverage pattern as a whole of individuals with different levels of physical exercise has not been well ascertained in the past.

Similarly, one of the recognized healthy dietary patterns is the so-called Mediterranean diet (MedDiet), which has been associated with several health benefits that reduce the risk of type 2 diabetes [10–12], metabolic syndrome [13, 14] and major cardiovascular events [15]. This dietary pattern is characterized by a high consumption of vegetables, legumes, grains, fruits, nuts and virgin olive oil, a moderate consumption of fish, and a low consumption of red and processed meat, pastries, butter and creams. While the traditional MedDiet is characterized by a "healthier beverage pattern" with a moderate consumption of milk and dairy products, and red wine, mainly with meals, and a low intake of sugar-sweetened beverages [16], little is known about the association between MedDiet adherence and beverage pattern at a population level. In addition, as an inadequate water intake has several consequences on health and human performance, especially in dehydration states [17, 18], it is important to evaluate determinant factors for covering the fluid intake recommendations other than classical individual factors (sex, age, body surface) and environmental conditions. In this sense, it is important to assess whether lifestyle determines the percentage of individuals meeting fluid intake recommendations established at a population level. Therefore, the main aim of the present study was to evaluate the associations between physical exercise practice or adherence to the MedDiet and the total fluid intake, the consumption of different types of beverages and the percentage of population covering fluid and free-sugar recommendations in a sample of healthy Spanish adults.

Methods

Design and study population

The present study is a cross-sectional analysis designed to assess the sources of fluid consumption in Spain—both water and other beverages—and the associations between lifestyle and the fluid consumption pattern [19], compliance with European Food Safety Agency's (EFSA) total fluid intake and the World Health Organization (WHO)'s free-sugar recommendations [20, 21].

The presented survey is part of an international study conducted in adults and elderly individuals (≥18 years) from 13 different surveys conducted in Latin America, Europe and Asia by public and private organizations [22]. The present study took place between March and May 2012 in all regions of Spain (except Ceuta, Melilla and the Canary Islands) and was referred to as Liq.In^7 [23]. The participants were recruited via a systematic, non-random sampling until the quotas for age, gender, region, habitat and/or socioeconomic characteristics in relation to the total country population were met. Participants were apparently healthy and were excluded if they were not able to read and write in the language of the questionnaire. Participants who did not complete the full fluid intake record and those who reported a mean total daily fluid intake below 0.4 L/day or higher than 6 L/day were also not eligible to participate in the present survey ($n = 240$). The effective sample size for the present study was 1262 participants, all of whom provided informed consent. The present study was submitted to the Ethics Committee of the University Hospital of Sant Joan de Reus (ref. C.E.I.C-012), was reviewed, was found to be of less than minimal risk and noninvasive and was approved without requiring signed informed consent. Socioeconomic level was assessed using a self-administered questionnaire and was categorized using the Market Research Society classification [24, 25]. Full details of the study protocol have been published elsewhere [19].

Assessment of fluid intake

The usual intake of fluids by participants over seven consecutive days was evaluated using a self-reported and non-validated 24-h fluid-specific diary over seven consecutive days.

This record assessed the moment of the day when the participants consumed fluids, and the type and the volumes of beverages using standard portion sizes. Sugar naturally present in beverages was calculated using a Spanish food composition table [26], and the addition (by hand) of free sugar to each beverage was also estimated by the number of teaspoons used. Hereinafter, we used the 2002 Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases definition of free sugar [21, 27].

The record items on beverages included the following EFSA-used categories [28]: water (tap water, filtered tap water, natural mineral water, sparkling natural mineral water, flavored water, drinking fountain water); hot beverages (coffee, white coffee, espresso with a drop of milk, cappuccino, tea, beverages made from cereals, other infusions and hot beverages); milk and milk derivatives (milk, milkshakes, milkshakes with juice, liquid yogurt, other milk drinks); juices (home-made juice, bottled juice, nectars, nectar without added sugar, other fruit drinks); sweet regular beverages: carbonated soft drinks (cola, orange, lemon, bitter, tonic water, other flavors), non-carbonated soft drinks (orange, lemon, sports drinks, energy drinks, regular iced tea, other flavors), other sugared soft drinks; sweet light beverages: diet carbonated soft drinks (cola, orange, lemon, other flavors), diet non-carbonated soft drinks (orange, lemon, diet iced tea), other diet soft drinks; and alcoholic drinks (beer, alcohol-free beer, lemon beer, wine, wine with soda, alcoholic mixed drinks, other alcoholic drinks). Total fluid intake is defined as the sum of all these beverages.

The percentage of individuals who did not meet the EFSA recommendations was calculated based on the EFSA recommendations for total water intake (water from food and beverages) set at 2.5 and 2 L/day for men and women, respectively. EFSA takes the assumption that foods contribute about 20 % to total water intake; therefore, the EFSA recommendations for total fluid intake were set at 2 and 1.6 L/day for men and women, respectively, most of which must preferably be consumed as water [29].

Assessment of other variables and lifestyle factors

Physical exercise practice of more than 30 min a day (active walking, swimming, cycling, aerobics and team or individual sports) was evaluated with a non-validated self-reported questionnaire and categorized as: three times a week or more, between one and two times a week and once every 2 weeks or less. In order to assess the adherence to the MedDiet, the participants were given a Spanish validated 14-item questionnaire [30, 31]. This 14-item validated screener consists of 12 questions on food consumption frequency and two questions on food intake habits considered characteristic of the Spanish MedDiet. Each question was scored 0 or 1. One point was given for using olive oil as the principal source of fat for cooking, preferring white meat over red meat or for consuming: (1) four or more tablespoons (1 tablespoon = 13.5 g) of olive oil/day (including that used in frying, salads, meals eaten away from home, etc.); (2) two or more servings of vegetables/day; (3) three or more pieces of fruit/day; (4) <1 serving of red meat or sausages/day; (5) <1 serving of animal fat/day; (6) <1 cup (1 cup = 100 mL) of sugar-sweetened beverages/day; (7) seven or more servings of red wine/week; (8) three or more servings of pulses/week; (9) three or more servings of fish/week; (10) fewer than two commercial pastries/week; (11) three or more servings of nuts/week; or (12) two or more servings/week of a dish with a traditional sauce of tomatoes, garlic, onion or leeks sautéed in olive oil. If the condition was not met, 0 points were recorded for the category. The final score ranged from 0 to 14 points. Using this score, we have categorized MedDiet adherence into three categories: poor (<5 points), average (between 6 and 7 points) and good adherence (>8 points).

In addition, variables such as marital status, socioeconomic characteristics, region, habitat (urban or rural) and education level were also recorded.

The Institute of Medicine (IOM) equations were used to estimate the total energy expenditure of each individual [32], using the gender, age, weight, height and physical exercise of each individual. Therefore, the percentage of individuals consuming more than 10 % of energy requirements as free sugar, as recommended by WHO, was calculated [21]. In 2015, the WHO suggested a further reduction in the free-sugar intake recommendations to 5 % of total energy intake [27]. The percentage of individuals consuming more free sugar than this suggested value was also calculated.

Weight (kg) and height (m) were evaluated with a self-reported questionnaire, and body mass index (BMI) (kg/m^2) was calculated.

Statistical analysis

Data are presented either as means and 95 % confidence intervals (CI) for continuous variables or as numbers and percentages for dichotomous variables. We compared the distribution of the selected characteristics between groups using χ^2 tests for categorical variables or Student's t tests or analysis of variance (ANOVA), as appropriate, for continuous variables. The Bonferroni post hoc test for multiple comparisons was used. Logistical regression models were fitted to assess the associations between meeting the EFSA recommendations for total fluid intake (dependent variable) and MedDiet adherence score (three categories) or physical exercise practice (three categories) as exposure. The models were adjusted for gender, age (years), habitat (5000–30,000 inhabitants, 30,000–200,000 inhabitants, more than 200,000 inhabitants), socioeconomic characteristics (lower and middle-low, middle, upper-middle and high), educational level (primary education, secondary education, higher education), physical exercise (once every 2 weeks or less, once or twice per week and ≥3 times per week) (except when physical exercise was the independent variable), MedDiet score (except when MedDiet adherence was the independent variable) and BMI (kg/m^2). Linear trend tests were calculated using the median adherence to the MedDiet score of each category and introducing this new value as a continuous variable in the models. All statistical tests were two-tailed, and the significance level was set at $P < 0.05$. All analyses were performed using the SPSS software version 22.0 (SPSS Inc., Chicago, IL).

Results

A total of 1262 participants (630 men and 632 women) were recruited from all regions of Spain (except from

Ceuta, Melilla and the Canary Islands). The baseline characteristics of participants across MedDiet adherence and physical exercise categories are summarized in Table 1. Men presented significantly lower adherence to the MedDiet and physical exercise than women. Age was higher as adherence to the MedDiet increased, and BMI was lower as physical exercise increased. Participants in the highest category of MedDiet adherence and/or physical exercise have a higher socioeconomic and educational level, respectively.

Table 2 shows the total daily fluid intake and the amount of each type of beverage consumed across the various categories of MedDiet adherence score and physical exercise practice. Individuals with the highest scores in the 14-item MedDiet adherence questionnaire consumed significantly more water and wine and less sweet regular beverages than individuals with the lowest scores. Consumption of milk and derivatives was significantly higher in participants with a lower MedDiet adherence score than in those with a MedDiet adherence between 6 and 7 points. No significant differences were observed in total daily fluid volume between the categories of MedDiet adherence.

Individuals who engaged most in physical exercise presented a higher intake of water, milk and derivates and wine and a lower consumption of sweet regular beverages than those who did little physical exercise. Significant differences were observed in the total daily fluid volume intake when participants who engaged in physical exercise three times a week or more were compared with individuals in the lower categories.

The odds of meeting the EFSA recommendations for total fluid intake (Table 3) were significantly higher in those participants with greater adherence to the MedDiet (≥8 points) in the crude model. This association remained even after adjusting for potential confounders [OR 1.94; 95 % CI 1.25–3.01 (*P* for trend <0.05)]. Women [OR 1.83; 95 % CI 1.05–3.20] and participants with a BMI ≥ 25 kg/m^2 [OR 2.83; 95 % CI 1.37–5.82] who were in the highest MedDiet adherence category showed a greater probability of meeting EFSA recommendations for total fluid intake than those who were in the lower adherence category (*P* for trend <0.05). Subjects who did most physical exercise (≥3 times a week) had greater odds of meeting the EFSA recommendations for total daily fluid intake [OR 1.71; 95 % CI 1.22–2.39], even in the adjusted model, using the frequency of physical exercise ≤1 time every 2 weeks as reference. These results were consistent among subgroups of gender and BMI.

Participants in the highest category of MedDiet adherence or physical exercise practice were less likely to exceed the WHO recommendations for free-sugar consumption (≥10 % of energy from free sugar) only from beverages consumption and the EFSA recommendations for total fluid intake, compared with ones in the lowest categories (Fig. 1 Panels a and b, respectively). Regarding the MedDiet adherence, 73.6 % of the participants with an adherence lower than 5 points, 55.9 % of the individuals presenting between 6 and 7 points and 48.4 % of the participants in the higher category (≥8 points) exceeded the 5 % of energy from free sugar only from beverages consumption (data not shown). Regarding physical exercise, 63.5 % of individuals in the lower category, 62.2 % of the individuals practicing exercise between 1 and 2 times/week and 49.1 % of the individuals more physically active (≥3 times/week) exceeded the 5 % of the total energy intake from free sugar (data not shown). Participants in the highest category of MedDiet adherence or physical exercise were significantly less likely to exceed the WHO suggestions for free-sugar consumption (5 % of total energy from free sugar) only from beverages consumption (data not shown). No significant differences were observed in the proportion of participants meeting the EFSA recommendations for total daily fluid intake across categories of MedDiet adherence or physical exercise practice.

Participants with a higher adherence to the MedDiet (>8 points) and physical exercise practice (≥3 times/week) showed a greater probability of meeting EFSA recommendations in the crude model, taking into account participants in the lowest MedDiet adherence category and lower physical exercise practice as a reference. This association remained even after adjusting for potential confounders [OR 2.84; 95 % CI 1.20–6.71] (Table 4). We have also analyzed the combined association of MedDiet adherence and physical exercise practice in relation to the WHO's free-sugar recommendations (≥10 % of energy from free sugar). Subjects with a higher adherence to the MedDiet (>8 points) and physical exercise practice (≥3 times/week) showed a lower probability of exceeding the WHO's free-sugar recommendations after adjusting for potential confounders [OR 0.53; 95 % CI 0.25–0.97], taking into account participants in the lowest MedDiet adherence category and lower physical exercise practice as a reference (Table 4).

Discussion

The main objective of the present study was to evaluate the associations between MedDiet adherence or physical exercise and the fluid consumption pattern in a sample of healthy Spanish adults. We report for the first time that healthy individuals with the highest scores for MedDiet adherence and most physical exercise practice presented the healthiest beverage patterns.

Although our results are in agreement with those reported by other investigators [33–35], to the best of our knowledge the present study is the first to have assessed not

Table 1 General characteristics of the study population, categorized by MedDiet adherence and physical exercise

	MedDiet adherence (score: 0–14 points)				Physical exercise			
	<5 ($n = 307$)	6–7 ($n = 517$)	>8 ($n = 438$)	*P* value[a]	≤1 time/2 weeks ($n = 521$)	1–2 times/week ($n = 246$)	≥3 times/week ($n = 495$)	*P* value[a]
Men [% (*n*)]	57.3 (176)	48 (248)	47 (206)	0.01	42.2 (219)	59.3 (145)	53.3 (262)	<0.001
Age (years)	36. 9 (35.6, 38.2)	42.5 (41.3, 43.7)	47.1 (45.8, 48.4)	<0.001	43.2 (42.1, 44.4)	41.7 (39.9, 43.4)	42.8 (41.5, 44.0)	0.34
Age categories [% (*n*)]				<0.001				0.50
18–35	51.5 (158)	35 (181)	21 (92)		32 (167)	39 (96)	34 (168)	
36–50	33.6 (103)	36 (186)	36.1 (158)		37 (193)	33 (81)	35 (173)	
51–65	13.4 (41)	23.6 (122)	32.4 (142)		25 (130)	23 (57)	24 (119)	
66–70	1.60 (5)	5.40 (28)	10.5 (46)		6 (31)	5 (12)	7 (35)	
BMI (kg/m^2)	25.4 (24.9, 25.9)	25.6 (25.2, 25.9)	25.7 (25.3, 26.1)	0.68	25.9 (25.6, 26.4)	25.4 (24.9, 25.9)	25.3 (24.9, 25.6)	0.02
BMI classification [% (*n*)][b]				0.34				0.17
Under- and normal weight	54.7 (168)	50.5 (261)	47.7 (209)		48 (250)	52 (127)	53 (262)	
Overweight	32.9 (101)	35 (181)	39 (171)		36 (188)	37 (91)	36 (178)	
Obesity	12.4 (38)	14.5 (75)	13.2 (58)		16 (83)	12 (28)	11 (55)	
Habitat [% (*n*)]				0.17				0.16
5000–30,000 Inhabitants	30.3 (93)	31.1 (161)	30.8 (135)		32 (167)	36 (88)	27 (134)	
30,000–200,000 Inhabitants	31.9 (98)	34.8 (180)	39.3 (172)		34 (177)	32 (79)	39 (193)	
≥200,000 Inhabitants	37.8 (116)	34 (176)	29.9 (131)		34 (177)	32 (79)	34 (168)	
Socioeconomic level [% (*n*)]				<0.01				0.08
Lower and middle-low	27.7 (85)	35.8 (185)	27.6 (121)		33 (172)	27 (67)	31 (153)	
Middle	50.2 (154)	38.3 (198)	45.7 (200)		46 (240)	44 (108)	42 (208)	
Upper-middle and high	22.1 (68)	25.9 (134)	26.7 (117)		21 (109)	29 (71)	27 (134)	
Educational level [% (*n*)]				0.10				<0.001
Primary education	13.7 (42)	17.8 (92)	18.9 (83)		20 (104)	16 (40)	15 (74)	
Secondary education	70 (215)	62.5 (323)	60.5 (265)		67 (349)	59 (146)	62 (307)	
Higher education	16.3 (50)	19.7 (102)	20.5 (90)		13 (68)	24 (60)	23 (114)	

Data expressed as means (95 % CI) or percentages (*n*)

BMI body mass index

[a] *P* values for comparisons between groups were tested by Student's *t* test or χ^2 as appropriate

[b] BMI (kg/m^2) was divided into the following categories: underweight and normal weight (BMI < 24.9 kg/m^2), overweight (BMI between 25 and 30 kg/m^2) and obesity (BMI > 30.0 kg/m^2)

Table 2 Consumption of different types of beverages (mL/day) categorized by MedDiet adherence and physical exercise

	MedDiet adherence (score: 0–14 points)				Physical exercise			
	≤5 (n = 307)	6–7 (n = 517)	≥8 (n = 438)	P value[a]	≤1 time/2 weeks (n = 521)	1–2 times/week (n = 246)	≥3 times/week (n = 495)	P value[a]
Water	913 (842, 983)[b]	990 (932, 1048)[b]	1106 (1037, 1176)[c]	<0.01	946 (891, 1001)[b]	949 (871, 1027)[b]	1112 (1044, 1179)[c]	<0.001
Hot beverages	286 (258, 314)	307 (285, 329)	317 (291, 344)	0.27	323 (299, 347)	274 (245, 303)	302 (279, 326)	0.05
Milk and derivates	128 (98, 159)[b]	93 (79, 107)[c]	97 (81, 113)	0.03	87 (74, 100)[b]	110 (88, 131)	117 (96, 138)[c]	0.04
Juices	101 (83, 119)	85 (72, 98)	101 (81, 121)	0.30	83 (70, 95)	89 (69, 110)	110 (91, 128)	0.05
Sweet regular beverages	248 (209, 287)[b]	159 (133, 184)[c]	78 (61, 95)[c]	<0.001	169 (144, 195)[b]	195 (150, 239)[b]	113 (94, 132)[c]	<0.001
Sweet light beverages	46 (17, 75)	41 (27, 55)	29 (17, 41)	0.39	37 (19, 56)	25 (11, 38)	45 (30, 60)	0.33
Alcoholic drinks	188 (145, 230)	182 (155, 208)	219 (185, 252)	0.23	175 (147, 202)	204 (163, 245)	214 (180, 248)	0.17
Beer and wine	168 (128, 209)	164 (139, 190)	204 (172, 237)	0.14	159 (133, 185)	190 (150, 229)	195 (163, 227)	0.20
Beer	122 (89, 155)	106 (89, 123)	113 (91, 136)	0.64	109 (89, 130)	112 (89, 136)	116 (93, 139)	0.91
Wine	46 (30, 63)	58 (43, 74)	91 (72, 111)	0.002	50 (37, 63)	77 (49, 105)	79 (62, 96)	0.02
Spirit drinks	19 (13, 25)	17 (13, 21)	14 (7, 20)	0.41	15 (11, 19)	14 (9, 19)	19 (13, 25)	0.42
Total daily fluid volume	1911 (1821, 2000)	1857 (1789, 1925)	1948 (1868, 2028)	0.22	1821 (1756, 1885)[c]	1846 (1748, 1944)[c]	2014 (1937, 2092)[b]	<0.001

Data expressed as means (95 % CI)

[a] P values for comparisons between groups were tested by bivariate analysis of variance (ANOVA) followed by post hoc tests with the Bonferroni correction. $P < 0.05$ for differences between letters ([b] versus [c])

Table 3 Association between compliance with total daily fluid intake recommendations and MedDiet and physical exercise

	MedDiet adherence (score: 0–14 points)				Physical exercise			
	≤5 ($n = 307$)	6–7 ($n = 517$)	≥8 ($n = 438$)	*P* for trend	≤1 time/2 weeks ($n = 521$)	1–2 times/week ($n = 246$)	≥3 times/week ($n = 495$)	*P* for trend
Crude model	1 (ref)	1.56 (1.03, 2.35)	2.08 (1.38, 3.13)	<0.01	1 (ref)	0.79 (0.51, 1.24)	1.65 (1.20, 2.26)	<0.01
Adjusted model[a]	1 (ref)	1.43 (0.93, 2.20)	1.94 (1.25, 3.01)	<0.01	1 (ref)	0.88 (0.56, 1.40)	1.71 (1.22, 2.39)	<0.01
Gender								
Men	1 (ref)	1.59 (0.79, 3.17)	2.10 (1.03, 4.31)	0.06	1 (ref)	0.84 (0.38, 1.84)	1.99 (1.10, 3.60)	0.02
Women	1 (ref)	1.34 (0.78, 2.32)	1.83 (1.05, 3.20)	0.03	1 (ref)	0.95 (0.53, 1.70)	1.56 (1.03, 2.34)	0.03
BMI								
<25 kg/m^2	1 (ref)	1.11 (0.64, 1.92)	1.52 (0.86, 2.67)	0.10	1 (ref)	0.88 (0.47, 1.62)	1.73 (1.09, 2.73)	0.02
≥25 kg/m^2	1 (ref)	2.29 (1.13, 4.66)	2.83 (1.37, 5.82)	0.02	1 (ref)	0.84 (0.42, 1.70)	1.70 (1.04, 2.77)	0.03

Data expressed as ORs (95 % CI)

[a] Mediterranean diet adherence model adjusted for age, BMI, gender (men, women), habitat (5000–30,000 inhabitants, 30,000–200,000 inhabitants, ≥200,000 inhabitants), socioeconomic level (lower and middle-low, middle, upper-middle and high), educational level (primary, secondary, higher) and physical exercise (≤1 time/2 weeks, 1–2 times/week, ≥3 times/week); physical exercise model adjusted for age, BMI, gender (men, women), habitat (5000–30,000 inhabitants, 30,000–200,000 inhabitants, ≥200,000 inhabitants), socioeconomic level (lower and middle-low, middle, upper-middle and high), educational level (primary, secondary, higher) and adherence to the Mediterranean diet

only the different types of beverages consumption but also the total daily fluid intake using a specific questionnaire designed to prospectively record beverage consumption and sugar added by hand to beverages.

Interestingly, in our study higher MedDiet adherence was mainly associated with being a woman and age. The fact that women tend to have a healthier lifestyle, which includes a healthier dietary pattern, may explain why females tend to adhere more closely to the MedDiet [36, 37]. Studies assessing dietary patterns in different populations have also found a direct association between age categories and higher adherence to the MedDiet [37–39]. As expected, we observed that men and participants with a lower BMI were more physically active in their leisure time. The regular consumption of wine, mainly with meals, and a lower intake of sweet regular beverages were considered key elements in defining the traditional MedDiet [15]. Although the present cross-sectional study is in agreement with this definition, the increased consumption of drinking water in those individuals in the highest category of MedDiet adherence suggests that it must be regarded as another key element when defining the MedDiet in the future. This is important because the consumption of sugar-sweetened beverages has mostly been associated with an increased risk of obesity and other metabolic conditions [40–42].

It should be pointed out that the greater consumption of wine in those individuals in the highest MedDiet category is only to be expected, because the 14-item MedDiet adherence questionnaire used in our study awarded one point for the intake of seven glasses of wine or more per week [43].

In our study, those individuals who least followed the MedDiet consumed more milk and milk products. This may be because they are younger, and several studies have demonstrated that young people tend to move away from Mediterranean pattern [37, 44, 45]. In addition, milk and other daily beverages are not regarded as typical Mediterranean foods [16, 39, 46].

To the best of our knowledge, the possible associations between physical exercise and total fluid intake or different types of beverages consumption have not been subject to a great deal of research among the general populations to date. In our study, individuals who engaged in most physical exercise presented a higher total daily fluid and water consumption, probably because they had an increased fluid loss and consequently a higher demand of fluid intake [47, 48]. However, this study is not able to conclude whether these higher intakes cover the higher intake demand. Hydration biomarkers would be required to investigate this; however, this was outside the scope of this survey. Besides the increased water intake, individuals who engaged in most physical exercise also consume greater quantities of wine, milk and dairy products and fewer sweet regular beverages. Although there is no physiological explanation,

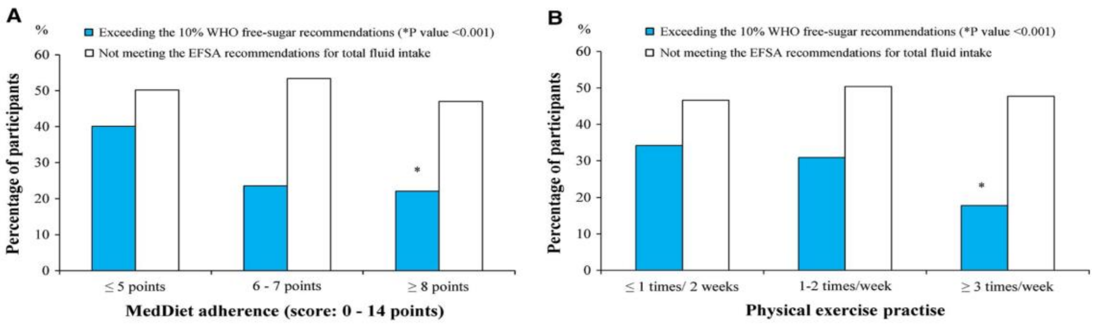

Fig. 1 Percentage of participants not meeting the fluid intake and exceeding the free-sugar recommendations, according to MedDiet adherence (**a**) and physical exercise (**b**). EFSA recommendations for total fluid intake (2000 mL for men and 1600 mL for women) and WHO's free-sugar recommendations were used (≥10 % of total daily energy from free sugar) only from beverages. **P* values for comparisons between groups were tested by χ^2

Table 4 Association between compliance with EFSA's total daily fluid intake or WHO's free-sugar recommendations and a combined effect of MedDiet adherence and physical exercise practice

	Crude model	Adjusted model[a]
EFSA's total daily fluid intake recommendations		
Low adherence to MedDiet and physical exercise practice ($n = 58$)	1 (ref)	1 (ref)
High adherence to MedDiet and physical exercise practice ($n = 135$)	2.54 (1.10, 5.85)	2.84 (1.20, 6.71)
WHO's free-sugar recommendations		
Low adherence to MedDiet and physical exercise practice ($n = 58$)	1 (ref)	1 (ref)
High adherence to MedDiet and physical exercise practice ($n = 135$)	0.46 (0.22, 0.93)	0.53 (0.25, 0.97)

Data expressed as ORs (95 % CI)

MedDiet Mediterranean diet

[a] Adjusted model for: age, BMI, gender (men, women), habitat (5000–30,000 inhabitants, 30,000–200,000 inhabitants, ≥200,000 inhabitants), socioeconomic level (lower and middle-low, middle, upper-middle and high) and educational level (primary, secondary, higher). Low Mediterranean diet was considered as a score of ≤5 points, and low physical exercise was considered as a practice of ≤1 time/2 weeks; high Mediterranean diet was considered as a score of ≥8 points, and high physical exercise was considered as a practice of ≥3 times/weeks

a higher consumption of milk and dairy products in more active individuals has also been previously described in some populations [49, 50].

In our study, compliance with the EFSA recommendations for total fluid intake was mainly associated with greater adherence to the MedDiet, mainly in women and overweight or obese individuals. Also, individuals who engaged most in physical exercise, independently of gender and BMI, tended to comply better with the EFSA's total fluid intake recommendations as reported previously by our group [19].

Finally, in our study, a higher percentage of individuals in the lowest category of MedDiet adherence or physical exercise show an intake of free sugar, only from beverage, above the WHO recommendations.

Several potential limitations and strengths of our study deserve comment and have, in fact, been discussed elsewhere [19]. The main limitation of this pilot study is that our population is probably not representative of the general Spanish population. However, the final distribution of the individuals studied among age groups, gender, region and educational categories is very similar to the real distribution of the population in Spain. The second limitation is inherent to its cross-sectional design, which limits the potential to discern causative relationships. The third limitation is related to the assessment of the fluid intake without assessing water moisture from food; however, in our study, we only assessed the percentage of individuals not covering the EFSA's drinking water recommendations that do not take into account water from solid foods. In addition, although fluid intake was assessed in moderate climate temperature conditions (between March and May), we cannot assume that total fluid and type of beverage consumed are representative of the entire year. Finally, the fact that anthropometric measures and physical exercise practice were self-reported and not measured may produce some systematic bias. One of the strengths of our study is that it uses a 24-h fluid-specific diary over seven consecutive days that makes it possible to assess the total fluid intake and real fluid pattern, reducing the differences between week and weekend days.

This study is the first to specifically describe associations between dietary and physical activity patterns and total fluid and beverage intake in healthy Spanish adults. Participants who adhere more closely to the MedDiet and who engage in more physical exercise have a healthier fluid intake pattern, characterized by a high intake of water and wine and a low intake of sugar-sweetened beverages. Participants with a healthier lifestyle had a greater probability of complying with EFSA's total daily fluid intake and WHO's free-sugar intake recommendations. These results suggest that changing the fluid intake can have beneficial effects on other lifestyle parameters. However, future studies are warranted to confirm our results and to establish cause–effect associations in order to design future public health recommendations.

Acknowledgments The authors are indebted to the participants in the study for their collaboration. The presented data was collected by TNS.

Compliance with ethical standard

Conflict of interest C.F.-P. reports no conflicts of interest. J.S.-S is member of the scientific advisory board on fluid intake of Danone Research. J.S.-S. and N.B. have received consultancies from Danone S.A.

Informed consent All the participants give their consent prior to the inclusion in the study. University Hospital of Sant Joan de Reus Ethics Committee gives their approval to the study protocol (ref. C.E.I.C-012).

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6.4. Total fluid intake and its determinants: cross-sectional surveys among adults in 13 countries worldwide.

Ferreira-Pêgo C, Guelinckx I, Moreno LA, Kavouras SA, Gandy J, Martinez H, Bardosono S, Abdollahi M, Nasseri E, Jarosz A, Babio N, Salas-Salvadó J. Eur J Nutr. 2015;54 Suppl 2:35-43. PMID: 26066354. doi: 10.1007/s00394-015-0943-9.

Study 4 overview. Novelty and significance.
What is already known?
- Nowadays, there is still a lack of studies assessing the amount of fluid and the type of beverages consumed regionally or worldwide, at population level. - To keep the balance between water input and water loss, individuals are recommended to comply with the reference values of total water intake that have been established by some international societies or institutions.
What this study adds?
- The median total fluid intake for the total population was 1.98 L/day. - Differences were found between countries, as for example Germany had the highest total fluid intake (2.47 L/day), and Japan the lowest (1.50 L/day). - A total of 59.2% of women complied with the reference value of 1.6 L, whereas only 40.6% of men complied with the reference value of 2 L, set by EFSA. - The 9.0% of the population did not consume even half of the reference value and 40.5% consume between 50 and 100%.
Summary
- This study was the first one that enables total fluid intake to be compared between countries because the same methodology of data recording was used in all the surveys. - We reported for the first time that less than 50% of the women and approximately 60% of the men from 13 different countries did not comply with the AI values of water from fluids. - The information that the present study provides, suggests that the reference values for the intake of water from fluids should be improved in the future.

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ORIGINAL CONTRIBUTION

Total fluid intake and its determinants: cross-sectional surveys among adults in 13 countries worldwide

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Abstract

Purpose To evaluate the total fluid intake from drinking water and beverages in adult populations from different countries and assess the percentage of individuals complying with the European Food Safety Agency (EFSA) adequate intake (AI) of water from fluids.

Methods A total of 16,276 adults (7580 men and 8696 women) aged between 18 and 70 years (mean age 39.8 years) were randomly recruited from 13 different countries from three continents. Information about the total daily fluid intake (sum of drinking water and beverages) was collected using a 24-h fluid-specific record over seven consecutive days.

Results Important differences in total fluid intake between countries were found; however, few differences between men and women were reported in most of the countries. Less than 50 % of the women and approximately 60 % of the men do not comply with the EFSA AI of water from fluids. Women were more than twice as likely as men to meet these AI (OR 2.15; 95 % CI 2.02–2.29). The odds of meeting the AI of water from fluids were lower in individuals over 50 years (OR 0.88; 95 % CI 0.80–0.96). Nine percent of the total population consumed less than half of the AI, 40.5 % between 50 and 100 %, and 50.5 % more than the AI.

Conclusions There were considerable differences in total fluid intake between countries but not between genders. Only 40 % of men and 60 % of women comply with the EFSA AI of water from fluids. Men and elderly individuals had an increased risk of not complying with this reference value.

Keywords Fluid intake · Beverages · Adult population · EFSA adequate intake · Water · Liq.In[7]

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Introduction

Water is involved in practically all functions of the human body and plays a crucial role in life and health. Body water is essential not only for the digestion, absorption, metabolism and elimination of metabolites, but also for the structure and function of tissues and the maintenance of body temperature [1]. Dehydration can affect human health to such an extent that it can cause death. Even dehydration of only 1 or 2 % of body water has been shown to impair cognitive functions, alertness and capacity for exercise [2].

To keep the balance between water input and water losses, individuals are recommended to comply with the reference values of total water intake that have been established by some international societies or institutions [3, 4]. Total water intake includes water from drinking water, beverages of all kinds and food moisture. These reference values are largely based on observational studies of total water intake conducted in healthy individuals and the estimation of total water balance, which takes into account losses. However, the established reference values vary considerably, which can be partly explained by differences in the methodology used to estimate fluid intake and/or losses [5].

In most of the studies, food frequency questionnaires or 24-h recall was used to evaluate total fluid intake (sum of drinking water and beverages of all kinds). However, these questionnaires are designed to evaluate food intake and not fluid consumption as a whole. They usually focused only on the intake of solid foods and drinks, predominantly on those that provide calories. For this reason, and because fluids are often consumed outside mealtimes and not perceived as a food, fluid intake tends to be underestimated by as much as 500 mL/day [6–9].

Also, most food records or dietary recalls do not capture the consumption of water; the consumption of other beverages is often underestimated by the individual or the interviewer [10]. This means that little is known about total fluid intake, so it is difficult to establish fluid recommendations on the basis of scientific evidence.

For this reason, the main aim of the present study is: (a) to evaluate the total fluid intake from beverages in adult populations from 13 countries in three continents, (b) to assess the percentage of individuals complying with the European Food Safety Agency (EFSA) adequate intake (AI) of water from fluids and (c) to assess the possible determinants of total fluid intake.

Methods

Design and study population

The present study is a cross-sectional analysis of original or published data collected in adults and elderly (≥18 years) by 13 different surveys conducted in Latin America (Mexico [11], Brazil and Argentina), Europe (Spain [12], France, UK [13], Germany, Poland and Turkey) and Asia (Iran [14], China [15], Indonesia and Japan) by public (Iranian National Nutrition and Food Technology Research Institute, NNFTRI, and Chinese Centre for Disease Control, CDC) and private organizations. The primary objective of these surveys was to assess the sources of fluid consumption, including drinking water and different types of beverages. The individual surveys took place between 2008 and 2014 and were referred to as Liq.In[7]. The participants in each country were randomly recruited either from a database of volunteers for population surveys or via systematic door-to-door recruitment until the quotas for age, gender, region, habitat and/or socioeconomic characteristics in relation to the total country population were met.

The following individuals were excluded from participating: those working in company advertising; marketing; market research; the media; the manufacture, distribution and sale of water; and all kinds of beverages. Likewise, people not able to read and write in the language of the questionnaire were not eligible to participate in the survey. Having a specific diagnosed disease and/or following a medically prescribed diet was additional exclusion criteria in UK, Iran and China. The surveys in Argentina, Poland and Japan also excluded participants who had taken part in a survey about non-alcoholic drinks in the previous 6 months. Participants who did not complete the full fluid intake record, participants reporting a mean total daily fluid intake below 0.4 L/day or higher than 6 L/day or those who had participated in a market research study in the previous 6 months were excluded from the analysis. Pregnancy or lactation was not a specific exclusion in the most countries, except in Iran and China. The effective sample size for the present study was 16,276 participants. Individuals who agreed to be part of the survey received detailed information about the survey's objectives, what was expected of them, and information about the study's provisions to preserve confidentiality, risks and benefits, and a clear explanation about their option to participate voluntarily or not in the study. After being given a fully informed description of the study, following the principles of informed consent, participants were asked for their oral approval to participate. No monetary incentive was offered for taking part in the study. All data were recorded anonymously. Therefore, subjects included in the dataset cannot be identified, either directly or through identifiers. The survey protocol of the unpublished surveys was reviewed and approved by the University of Arkansas Review Board (ref. 14-12-376).

Assessment of total fluid intake

All participants were provided with a 24-h fluid-specific record so that they could collect information on their fluid intake over seven consecutive days. The 7-day fluid-specific record was always presented in the official language of the country. In all countries except France, Germany and Japan, a paper version of this 7-day fluid-specific record was delivered and explained to the participants during an initial interview at home. After a period of 7 days, the fluid record was collected from the participant's home by the researcher and checked with the participant. In France, Germany and Japan, participants completed 7-day fluid-specific record online. On the morning of the first day, these participants received an electronic reminder with written instructions on how to fill in the fluid record. Paper memory cards were made available to the participants so that they could make notes during the day and subsequently complete the fluid record online. Both the paper and online records had the same structure: The participants were asked the type and temperature of the beverage, the volume of the intake, the reason for the intake, and where and when it was consumed. The questionnaire also asked whether the fluid was consumed by itself or with some food, but did not record the food consumed. To assist the participants in estimating how much fluid was consumed, the records were supported by a photographic booklet of standard fluid containers. The questionnaire items on different types of fluids included: water (tap water, still bottled water and sparkling bottled water); hot beverages (coffee, tea and other hot beverages); milk and milk derivatives; regular sweet beverages (carbonated soft drinks, non-carbonated soft drinks, juices, energy drinks, sports drinks, other sugared soft drinks); diet sweetened beverages (diet carbonated soft drinks, diet non-carbonated soft drinks, other diet soft drinks); and alcoholic drinks. Total fluid intake was defined as the sum of all these categories.

The percentage of individuals following the EFSA adequate intake of water from fluids was calculated. The EFSA sets an AI of total water intake for men and women at 2.5 and 2 L, respectively. The sources of this water can be food moisture, drinking water and different types of beverage. The EFSA assumes that foods usually contribute about 20 % of total water intake [3]. Therefore, we set the AI of water from fluids, preferably water, to be at 2 L/day for men and 1.6 L/day for women. Within this manuscript, we will as of now on refer to these values as AI of fluids.

Assessment of socioeconomic and anthropometric variables

Socioeconomic level was assessed using a self-administered questionnaire in most of the countries and was categorized using the Market Research Society classification [16, 17].

Height in meters (m) and weight in kilograms (kg) were self-reported by participants, except in Poland, Iran and China where these variables were measured. The body mass index (BMI) was calculated (kg/m^2). In Mexico, Brazil, Argentina, Indonesia and Japan, no anthropometric data were available.

Statistical analysis

Data are presented either as means and 95 % confidence intervals (95 % CI), medians and 25th and 75th percentiles for continuous variables, or numbers and percentages for dichotomous variables. We compared the distribution of the selected characteristics between groups using χ^2 tests for categorical variables or Student's t tests or analysis of variance (ANOVA), as appropriate, for continuous variables. Logistic regression models were fitted to assess the associations between compliance with the AI of fluids for total fluid intake (dependent variable) and gender (two categories) or age categories (four categories) as exposure. The models were adjusted for gender (except when gender was the independent variable), age in years (except when age categories were the independent variable), BMI in kg/m^2 and socioeconomic characteristics (lower and middle-low, middle, upper-middle and high). All statistical tests were two-tailed, and the significance level was set at $p < 0.05$. All analyses were performed using the SPSS software version 22.0 (SPSS Inc, Chicago, IL).

Results

The present analysis was conducted in a total of 16,276 participants (7580 men and 8696 women) from 13 countries. The baseline characteristics of participants are summarized in Table 1. The mean age of the population was 39.8 years old, with a range between 18 and 87 years. A total of 25.9 % of the population were more than 50 years of age, 22.7 % were between 40 and 49 years of age, and 23.9 and 27.5 % were between 30 and 39, and 18 and 29, respectively. The participants had a mean BMI of 25.1 kg/m^2, and more than half had a low or middle-low socioeconomic level.

Table 2 shows the median and distribution in percentiles of the total fluid intake by country. The median total fluid intake for the total population was 1.98 L/day. Few differences were observed in the median consumption of total fluid intake between men and women in most of the countries. Germany had the highest total fluid intake (2.47 L/day), and Japan the lowest (1.50 L/day).

As shown in Fig. 1, the percentage of individuals meeting with the AI of fluids varied considerably between

Table 1 General characteristics of the study population, categorized by country

	Gender (%)		Age (years)	Age categories (years) (%)				BMI (kg/m²)	Socioeconomic level (%)		
	Men	Women		18–29	30–39	40–49	≥50		AB	C	D
Mexico ($n = 1498$)	38.3	61.7	38.4 (37.7, 39.2)	34.0	20.8	19.6	25.7	ND	6.7	45.6	47.7
Brazil ($n = 1924$)	48.9	51.1	34.6 (34.1, 35.1)	38.1	26.5	25.5	9.9	ND	20.1	45.5	34.4
Argentina ($n = 507$)	47.5	52.5	37.4 (36.3, 38.6)	37.5	21.1	17.8	23.7	ND	8.5	55.4	36.1
Spain ($n = 1240$)	50.8	49.2	42.9 (42.1, 43.7)	19.0	23.5	24.8	32.7	25.6 (25.4, 25.8)	25.4	70.8	3.8
France ($n = 1534$)	52.4	47.6	44.7 (43.9, 45.4)	18.8	19.8	21.3	40.1	25.2 (25, 25.5)	ND	ND	ND
UK ($n = 897$)	41.4	58.6	43.9 (42.9, 44.9)	18.4	24.1	23.2	34.3	27.2 (26.7, 27.6)	17.3	53.4	29.3
Germany ($n = 1868$)	45.8	54.2	42.9 (42.3, 43.5)	17.0	21.3	28.7	33.0	26.2 (26, 26.5)	ND	ND	ND
Poland ($n = 1062$)	48.7	51.3	46.1 (45.1, 47.1)	19.5	19.9	17.8	42.8	26 (25.8, 26.3)	10.0	73.0	17.0
Turkey ($n = 961$)	50.8	49.2	34.4 (33.7, 35)	38.1	27.6	23.4	10.9	25 (24.7, 25.3)	ND	ND	ND
Iran ($n = 572$)	49.5	50.5	36.9 (35.9, 37.9)	36.0	26.0	19.8	18.2	25.3 (24.9, 25.7)	22.6	34.4	43.0
China ($n = 1466$)	50	50	39.4 (38.8, 40)	24.7	25.4	25.8	24.1	22.7 (22.5, 22.8)	ND	ND	ND
Indonesia ($n = 1366$)	32.5	67.5	35.2 (34.6, 35.9)	39.3	27.6	17.3	15.7	ND	25.8	55.4	18.7
Japan ($n = 1381$)	50.5	49.5	ND	26.4	27.2	21.3	25.1	ND	ND	ND	ND
Total population[a] ($n = 16{,}276$)	46.6	53.4	39.8 (39.6, 40.1)	27.5	23.9	22.7	25.9	25.1 (25, 25.2)	17.5	54.3	28.1

Data expressed as mean (95 % CI) or percentage

BMI body mass index, *ND* no data

[a] Include only those countries with data available on the presented characteristics

countries. Women were more likely to comply with AI of fluids. A total of 59.2 % of women complied with the reference value of 1.6 L, whereas only 40.6 % of men complied with the reference value of 2 L. In all the countries included in this analysis, a higher percentage of women complied with the AI of fluids. Only in five of the 13 countries, more than 50 % of the men comply with the AI of fluids.

Figures 2 and 3 show the adjusted odds ratio (OR) (95 % CI) of complying with the AI of fluids, for gender and age range, respectively. When the analysis of total population was stratified by gender (Fig. 2), women were more than twice as likely as men to meet the AI of fluids (OR 2.149; 95 % CI 2.02–2.29). In all the countries, men were at greater risk than women of not complying with the AI of fluids. When the total population was stratified by age (Fig. 3), we observed that participants between 30 and 39 years old had a nonsignificant 3 % lower probability of complying with the AI of fluids, whereas individuals of over 50 years of age presented a significant 12.4 % lower probability of compliance in comparison with the age range 18–29 years old. In terms of compliance with the AI of fluids, no differences were found between individuals of 40–49 years of age and those younger than 29 years.

Table 3 shows the percentage of the population that complied with the AI of fluids according to adequacy percentage categories. Of the total population from the different countries, 9.0 % did not consume even half of the reference value, 40.5 % consume between 50 and 100 %, and 50.5 % consume the adequate intake set by EFSA. Japan had the highest percentage of population (17.1 %) that consumed less than half of the AI of fluids, and the UK was the country with the lowest (1.2 %). Germany had the highest percentage of individuals complying with AI of fluids (73.8 %), whereas Japan had the lowest (28.8 %).

Discussion

The main objective of the present innovative study is to estimate total fluid intake (water and other beverages) and assess the percentage of individuals who comply with the EFSA adequate intake of water from fluids (drinking water and beverages of all kinds). We report that less than 50 % of the women and approximately 60 % of the men from 13 different countries did not comply with the adequate intake values of water from fluids.

To the best of our knowledge, to date, only a few national population-based studies conducted on healthy individuals [18–27] have reported total fluid intake as a primary outcome. Of these, only four used a 7-day record to evaluate the total fluid intake [15, 19–21], while the others used dietary records of 4 days or less. Only one used a 7-day fluid-specific record [15].

Our study reported a higher total fluid intake than other investigators have reported for the same countries [19–21]. This may be because a prospective fluid-specific

Table 2 Total fluid intake in L/day, categorized by country

	Mean (SD)	Percentiles						
		5	10	25	50	75	90	95
Total population (*n* = *16,276*)	1.98 (0.95)	0.77	0.93	1.27	1.80	2.49	3.28	3.81
Mexico (*n* = 1498)	1.81 (0.97)	0.66	0.79	1.12	1.59	2.31	3.13	3.73
Brazil (*n* = 1924)	2.22 (1.11)	0.82	1.00	1.40	2.00	2.80	3.75	4.50
Argentina (*n* = 507)	2.30 (0.99)	1.02	1.17	1.59	2.15	2.88	3.63	4.28
Spain (*n* = 1240)	1.90 (0.81)	0.82	0.99	1.33	1.77	2.35	2.98	3.43
France (*n* = 1534)	1.56 (0.67)	0.68	0.80	1.08	1.45	1.94	2.46	2.82
UK (*n* = 897)	2.32 (0.86)	1.12	1.32	1.68	2.19	2.83	3.46	3.95
Germany (*n* = 1868)	2.47 (0.89)	1.00	1.27	0.83	2.46	3.08	3.71	3.98
Poland (*n* = 1062)	1.64 (0.54)	0.86	1.00	1.24	1.57	1.96	2.40	2.62
Turkey (*n* = 961)	2.21 (1.06)	0.89	1.06	1.44	2.02	2.76	3.58	4.22
Iran (*n* = 572)	1.92 (0.80)	0.87	1.03	1.33	1.81	2.33	3.03	3.34
China (*n* = 1466)	1.76 (0.92)	0.66	0.81	1.13	1.56	2.16	2.96	3.62
Indonesia (*n* = 1366)	2.28 (1.02)	0.91	1.05	1.48	2.13	2.96	3.78	4.22
Japan (*n* = 1381)	1.50 (0.64)	0.61	0.76	1.02	1.40	1.88	2.36	2.72
Men (*n* = *7580*)	1.97 (0.96)	0.77	0.92	1.26	1.78	2.48	3.27	3.84
Mexico (*n* = 574)	1.77 (0.92)	0.63	0.76	1.10	1.58	2.24	3.09	3.66
Brazil (*n* = 941)	2.34 (1.16)	0.85	1.05	1.45	2.10	3.00	4.00	4.70
Argentina (*n* = 241)	2.32 (0.94)	1.06	1.19	1.67	2.13	2.87	3.60	4.22
Spain (*n* = 630)	1.94 (0.84)	0.80	0.99	1.34	1.80	2.37	3.01	3.52
France (*n* = 804)	1.55 (0.66)	0.69	0.80	1.08	1.43	1.93	2.41	2.82
UK (*n* = 371)	2.24 (0.82)	1.08	1.30	1.62	2.15	2.80	3.25	3.78
Germany (*n* = 856)	2.51 (0.94)	0.92	1.21	1.81	2.43	3.06	3.73	4.03
Poland (*n* = 517)	1.70 (0.53)	0.94	1.10	1.31	1.63	2.04	2.47	2.67
Turkey (*n* = 488)	2.15 (1.01)	0.90	1.05	1.42	1.93	2.70	3.49	4.03
Iran (*n* = 283)	1.92 (0.78)	0.89	1.04	1.33	1.80	2.37	3.03	3.33
China (*n* = 733)	1.78 (0.95)	0.68	0.82	1.12	1.57	2.16	3.02	3.82
Indonesia (*n* = 444)	2.33 (1.08)	0.94	1.07	1.47	2.18	2.99	3.93	4.41
Japan (*n* = 698)	1.47 (0.63)	0.59	0.72	1.01	1.39	1.84	2.28	2.66
Women (*n* = *8696*)	1.98 (0.95)	0.78	0.93	1.28	1.81	2.50	3.29	3.80
Mexico (*n* = 924)	1.84 (1.00)	0.69	0.80	1.12	1.60	2.34	3.20	3.82
Brazil (*n* = 983)	2.10 (1.05)	0.80	0.97	1.30	1.90	2.57	3.51	4.20
Argentina (*n* = 266)	2.29 (1.04)	0.99	1.13	1.50	2.15	2.93	3.74	4.41
Spain (*n* = 610)	1.87 (0.79)	0.83	0.97	1.32	1.73	2.29	2.89	3.37
France (*n* = 730)	1.57(0.61)	0.67	0.78	1.08	1.44	1.97	2.50	2.81
UK (*n* = 526)	2.37 (0.88)	1.17	1.34	1.75	2.23	2.89	3.58	4.07
Germany (*n* = 1012)	2.45 (0.90)	0.96	1.23	1.78	2.44	3.07	3.62	3.94
Poland (*n* = 545)	1.57 (0.55)	0.77	0.94	1.19	1.51	1.88	2.32	2.573.53
Turkey (*n* = 473)	2.27 (1.11)	1.08	1.20	1.55	2.00	3.05	3.88	4.59
Iran (*n* = 289)	1.92 (0.82)	0.86	1.02	1.33	1.83	2.27	3.04	3.40
China (*n* = 733)	1.75 (0.89)	0.66	0.80	1.14	1.56	2.17	2.92	3.54
Indonesia (*n* = 922)	2.26 (0.99)	0.88	1.04	1.48	2.10	2.95	3.68	4.11
Japan (*n* = 683)	1.52 (0.65)	0.66	0.79	1.04	1.42	1.93	2.41	2.75

questionnaire was used, which enabled participants to better register all the sources of fluid consumption. For example, a previous study that evaluated total fluid intake in an adult population of 20–54 years old from France revealed that the median fluid consumption was 1300 mL/day and that intake was lower in older individuals [21]. In contrast, our study found that the total median fluid intake for France was 1560 mL/day. Although the authors did not evaluate the percentage of participants who did not comply with the EFSA reference values of total water intake, their results suggest

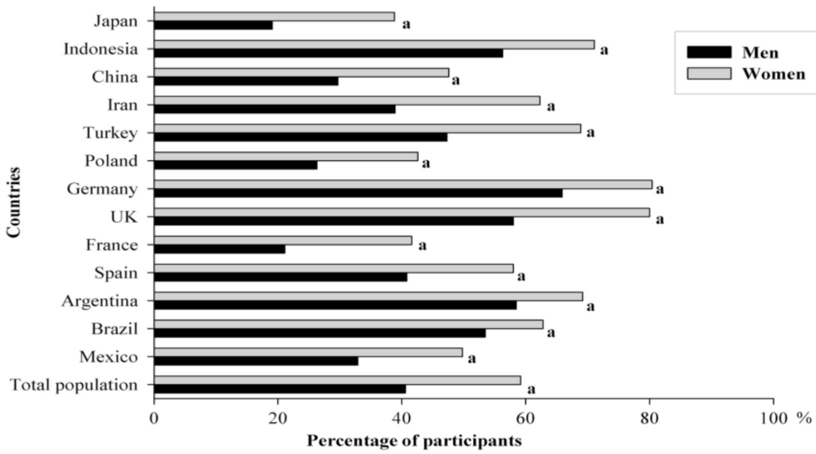

Fig. 1 Percentage of participants complying with EFSA adequate intake of water from fluids, by country and gender. [a]p value <0.001

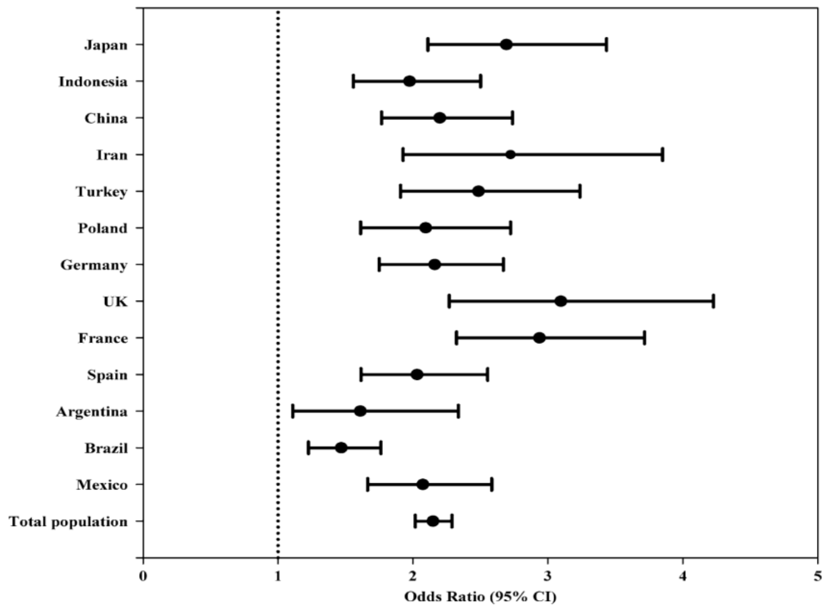

Fig. 2 Association between compliance with EFSA adequate intake of water from fluids (outcome) and gender (exposure) according to countries. Men were considered as reference. Logistic regression model adjusted for age, body mass index and socioeconomic level. *95 % CI* 95 % confidence interval

that a high percentage of the French population are at risk of an inadequate intake. In Germany, in 2011, total fluid intake recorded by adults with a 7-day food record was found to be only 1526 mL/day for men and 1214 mL/day for women [20]. Our study found the median total fluid intake in Germany to be remarkably higher (approximately 2510 and 2450 mL/day for men and women, respectively), which means that a higher percentage of German males and females comply with the AI of fluids. In the UK [19], previous reports of median total fluid intake (1900 mL for men and 1520 mL for women) are also lower than the findings of the present study (2240 and 2370 mL for men and women, respectively).

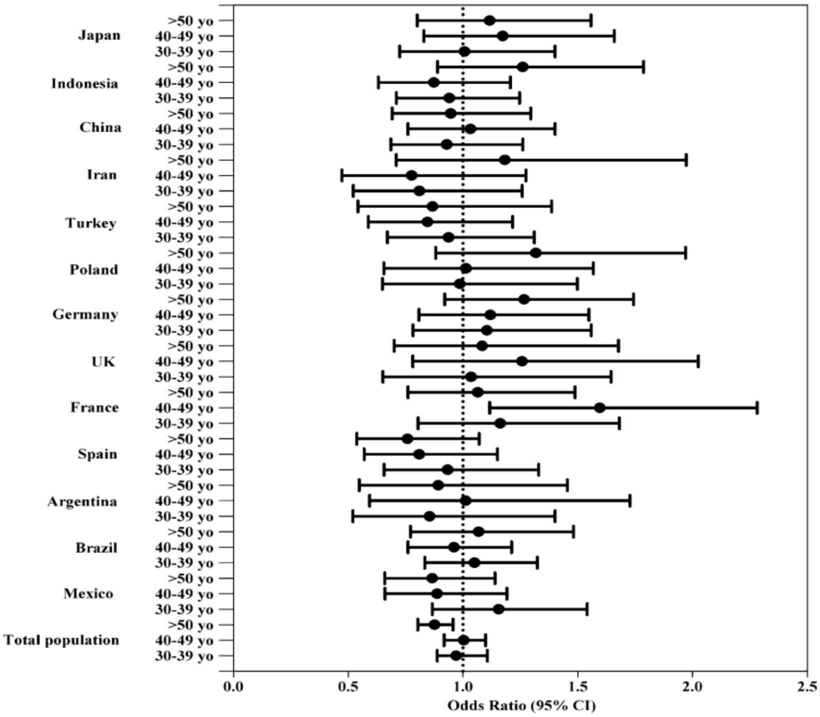

Fig. 3 Association between compliance with EFSA adequate intake of water from fluids (outcome) and age categories (exposure), according to countries. The 18–29 age range was considered as reference. Logistic regression model adjusted for gender, body mass index and socioeconomic level. *95 % CI* 95 % confidence interval, *yo* years old

Table 3 Percentage of the population by adequacy percentage categories, achieving EFSA adequate intake of water from fluids

	≤50 %	50–75 %	75–100 %	>100 %
Mexico ($n = 1498$)	13.5	22.4	20.8	43.3
Brazil ($n = 1924$)	7.5	16.6	17.7	58.2
Argentina ($n = 507$)	2.8	13.2	19.9	64.1
Spain ($n = 1240$)	7.4	17.1	26.2	49.3
France ($n = 1534$)	15.9	28.2	25.0	30.9
UK ($n = 897$)	1.2	10	17.8	70.9
Germany ($n = 1868$)	4.1	7.9	14.2	73.8
Poland ($n = 1062$)	6.1	26.5	32.8	34.7
Turkey ($n = 961$)	5.8	16.8	19.5	58.4
Iran ($n = 572$)	5.3	21.2	23.1	50.5
China ($n = 1466$)	14.1	23.6	23.7	38.7
Indonesia ($n = 1366$)	2.7	15.5	15.6	66.2
Japan ($n = 1381$)	17.1	29.8	24.2	28.8
Total population ($n = 16,276$)	9.0	19.3	21.2	50.5

Our study is the first that enables total fluid intake to be compared between countries because the same methodology of data recording was used in all the surveys. Germany and the UK were the countries where the highest percentages of the population complied with the AI of fluids, whereas Japan was the country with the lowest. It is difficult to find a physiological reason for these between-country differences. The well-known and described differences in climate conditions (temperature and humidity) between countries cannot explain the differences found in our study because some warm countries (where fluid demands should be higher) had lower total fluid intakes than cold ones. However, these differences may be partly explained by the fact that not all surveys were carried out in the same season, even though all surveys aimed to perform data collection during the period of mild climate (spring or autumn). It is accepted that temperatures are more extreme during the summer, so fluid intake and loss are also expected to be higher. Water needs in summer increase because water loss through sweat higher than in winter [18]. Another issue that must be noted is that, in summer, habits of adapting environmental conditions (air-conditioned or heating rooms) are less similar than those in winter. However, we cannot discount that other social determinants of fluid intake may explain some of the differences observed between countries in the present study [28, 29].

Although total fluid intake may well be expected to be different between men and women because of well-recognized differences in body surface and composition, our study found no significant differences in total fluid intake between genders in most of the countries. This adds further weight to the argument that social or educational aspects may play an important role in determining total fluid consumption. In this regard, it has been frequently reported that women in developed countries tend to have a healthier lifestyle pattern than men [28] and it is generally accepted that adults with a healthier dietary pattern usually have a healthier fluid pattern (that is to say, an increased consumption of water and total fluids) [29]. This also may explain the positive association between complying with the AI of fluids and being women in all the countries evaluated.

Several potential limitations of our study need to be considered. Although all samples were randomly selected from a database of volunteers for population-based surveys or through a door-to-door recruitment process using the same quota sample method, which led to a large representative sample of adults in each country for the stratum considered [30], the populations in our study are not fully representative of the general population of each country. Nevertheless, the final distribution of the individuals studied among age groups, gender, regions and educational categories was very similar to the real distribution of the population of each country studied. The second limitation is inherent to the survey itself: The method used to collect anthropometric (reported or measured) and socioeconomic data was not the same in each country, and in some surveys, this information was not assessed. However, this information was only used to characterize the samples and would not influence the main outcome. Third, because we have only assessed the total fluid intake and no biomarkers of hydration status were used, no conclusions about the risk of dehydration and health can be drawn. Finally, the 24-h fluid-specific record over 7 days used in the present study must be validated in the future with gold-standard methods, in order to have the certainty that total fluid intake is reliably assessed.

The most relevant strength of this analysis is that it reports for the first time the description of total fluid intake of 16,276 participants in 13 countries from three continents. Moreover, a unique 24-h fluid-specific record over seven consecutive days was used that focused on self-reported total fluid intake, encompassing different types of fluids and was supported by visual aids, to facilitate recall and recording. This is the first time that the actual fluid pattern of a large sample of adults is recorded for all of these countries and valuable information is provided about the real differences in fluid intake between and within countries. This information suggests that if the reference values of water from fluids would be improved in the future, there should be a particular emphasis on those population groups found to be more at risk of not drinking enough, specifically the male gender and the elderly.

In conclusion, there were considerable differences in total fluid intake between countries but not between genders. For all the countries, only 40 % of men and 60 % of women comply with the EFSA adequate intake of water from fluids. Men had an increased risk of not complying with the EFSA adequate intakes of water from fluids. In most countries, elderly individuals had an increased risk of not complying with these adequate intakes. These results signify that a considerable portion of the study populations is potentially a risk of hydration-related health consequences such as chronic kidney disease [31]. Therefore, there is a clear need for additional longitudinal studies confirming the possible effects on health of an inadequate intake of water from fluids. Moreover, since there is merging evidence that a low fluid intake is a potential risk factor for health, the reference values of total water intake should be translated into practical recommendations for the general population and are ideally supported with community interventions.

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Conflict of interest C.F.-P. and J.A. reports no conflicts of interest. J.S.-S, L.A.M., S.A.K., J.G., H.M. are members of the scientific advisory board on fluid intake of Danone Research. S.A.K. has received research grants form Danone Research. B.S. has received research grant from R&D AQUA Group, Indonesia. A.M and N.E. have received research grant/consultancies from Damavand Mineral Water Company, Iran. J.S.-S. J.G. and N.B. have received consultancies from Danone S.A. IG is an employee of Danone Research.

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6.5. Intake of water and different beverages in adults across 13 countries.

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Study 5 overview. Novelty and significance.
What is already known?
- Different health institutions and nutrition societies have shown concern regarding an excessive intake of energy coming from free sugars, especially present in sweetened beverages, and its effect on health and disease. - However, the scientific evidence regarding this area of nutritional epidemiology is still scarce.
What this study adds?
- In all of the 13 countries and among the different fluid types, drinking water was the most consumed beverage. - SSBs was the third fluid mostly consumed with a daily intake ranging from 0.10 L/day in China to 0.57 L/day in Mexico. - In México, Brazil and Argentina the contribution of sweetened beverages, including SSBs and fruit juices, to the total fluid intake was as large as or even larger than water's contribution. - Total mean energy intake through total fluid ranged from a minimum of 182 kcal/day in Indonesia to a maximum of 817 kcal/day in Germany. - The highest proportion of adults exceeding the WHO recommendation was observed in Germany (70.9%), followed by Brazil (65.7%), Mexico (65.1%), UK (61.5%) and Argentina (60.4%); whereas the lowest proportion was observed in Indonesia (10.9%).
Summary
- The mean energy intake from fluids was higher than expected due to the high consumption of SSBs and fruit juices, reaching up to 694 kcal/day of energy intake on average. - Considering all countries together, 44.5% of the population exceeded the WHO recommendations on energy intake provided by free sugar, solely by fluids. - The results obtained in the present international survey highlight the need to educate adults about the nutritional composition of the different fluids.

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ORIGINAL CONTRIBUTION

Intake of water and different beverages in adults across 13 countries

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Abstract

Purpose To describe the intake of water and all other fluids and to evaluate the proportion of adults exceeding the World Health Organisation (WHO) recommendations on energy intake from free sugar, solely from fluids.

Methods A total of 16,276 adults (46 % men, mean age 39.8 years) were recruited in 13 countries from 3 continents. A 24-h fluid-specific record over 7 days was used for fluid assessment.

Results In Spain, France, Turkey, Iran, Indonesia and China, fluid intake was characterised by a high contribution of water (47–78 %) to total fluid intake (TFI), with a mean water intake between 0.76 and 1.78 L/day, and a mean energy intake from fluids from 182 to 428 kcal/day. Between 11 and 49 % of adults exceeded the free sugar WHO recommendations, considering solely fluids. In Germany, UK, Poland and Japan, the largest contributors to TFI were hot beverages (28–50 %) and water (18–32 %). Mean energy intake from fluids ranged from 415 to 817 kcal/day, and 48–62 % of adults exceeded free sugar WHO recommendations. In Mexico, Brazil and Argentina, the contribution of juices and regular sugar beverages (28–41 %) was as important as the water contribution to TFI (17–39 %).

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Mean energy intake from fluids ranged 565–694 kcal/day, and 60–66 % of the adults exceeded the free sugar WHO recommendation.
Conclusions The highest volumes recorded in most of the countries were for water, mean energy intake from fluids was up to 694 kcal/day, and 66 % of adults exceeded the free sugar WHO recommendation solely by fluids. Actions to create an environment in favour of water consumption and reduce sugar intake from fluids therefore are warranted.

Keywords Water · Beverages · Fluids · Adult population · WHO recommendation · Energy intake · Free sugars

Introduction

Total fluid intake (TFI) or its biomarkers have been associated with health outcomes such as the recurrence of kidney stones, renal function, new-onset hyperglycaemia and the prevalence of some components of the metabolic syndrome [1–4]. Therefore, assessing the volume of TFI in populations is important from a public health perspective.

In addition, it is also important to assess the intake of different sources of fluids. During the last decades, the diversity of fluid types with different nutritional composition has increased substantially. These fluids contribute to total intake more than water (e.g. energy, minerals, additives or caffeine), raising the question of their impact on health. In fact, an analysis of NHANES data has demonstrated differences in the risk of chronic kidney disease (CKD) depending on the type of beverages consumed. A low intake of plain water was associated with an increased risk of CKD [adjusted OR for low vs. high intake of plain water = 2.36 (95 % CI 1.10–5.06)], whilst, compared with the highest intake of beverages besides plain water, a low intake was not associated with an increased risk [5].

One explanation for the different health impact of consumption of different fluid types could be due to differences in energy and nutrient content. Recently, different health institutions and nutrition societies have raised concern regarding an excessive intake of energy coming from free sugars, especially present in sugar-sweetened beverages [6]. A meta-analysis of randomised trials and prospective cohort studies showed that among free-living people with ad libitum diets, the intake of free sugars was a determinant of body weight; however, intake was assessed from both food and beverages [7]. In respect of the consumption of sugar-sweetened beverages, there is a substantial scientific evidence relating the frequent intake of this type of beverages and an increased risk of weight gain [8–10], becoming overweight or obese [11–14], developing metabolic syndrome [15–18], type 2 diabetes [19] or other health problems [17, 20, 21] compared with non-regular consumers. This can partly be explained, as described in some cross-sectional and intervention studies, by the observation that frequent consumers of sugar-sweetened beverages had higher total energy intake [22–24]. Given the current obesity pandemic and the estimation by the WHO that diabetes will be the 7th leading cause of death in 2030 [25], it seems relevant to evaluate the daily intake of the different fluid types and their contribution to energy and sugar intake. A recent systematic literature review by Özen et al. [26] reported the fluid intake of adults from 18 different countries. Unfortunately, only 50 % of the 38 surveys included in the review reported the intake of water [26]. In addition, inconsistencies in the study designs, dietary assessment methods used or classification of beverages and age categories limit the comparison of results between countries. Furthermore, most of the surveys designed were originated in the USA and Europe, and it is pertinent in order to have a better understanding of the TFI, types of beverages consumed, and energy and free sugar consumed from beverages to extend the geographical scope of such studies.

Therefore, the aim of the present analysis was: (a) to describe the intake of drinking water and all other type of beverages in adults from 13 countries in three continents including Latin America and Asia, (b) to report energy intake from beverages and (c) to assess the percentage of adults exceeding the WHO recommendations on free sugars intake.

Methods

Design and study population

The present analysis gathers original and published data collected in adults (≥18 years) by 13 different cross-sectional surveys. The surveys were conducted in Latin America (Mexico [27], Brazil and Argentina), Europe (Spain [28], France, UK [29], Germany, Poland and Turkey) and Asia (Iran [30], China [31], Indonesia and Japan). Data collection of the individual surveys was performed between 2008 and 2014 by public (Iranian National Nutrition and Food Technology Research Institute, NNFTRI; and Chinese Centre for Disease Control, CDC) and private organisations. The primary objective of these surveys was to assess the intake of drinking water and different types of beverages. A detailed analysis of the volume of TFI (sum of drinking water and beverages of all types) of these 13 surveys can be found elsewhere [32].

A random recruitment of participants was performed in each country either from a database of volunteers for population surveys, or via systematic door-to-door recruitment until the quotas for age, gender, region, habitat and/or socio-economic characteristics in relation to the total country population were met.

Individuals working in company advertising, marketing, market research, the media, the manufacture, distribution and/or sale of water and all kind of beverages were excluded from participation as these individuals might be more aware of their intakes of fluids. Individuals who were not able to read and write in the language of the questionnaire were not eligible to participate in the survey. Having a specific diagnosed disease and/or following a medically prescribed diet were additional exclusion criteria in UK, Iran and China. The surveys in Argentina, Poland and Japan also excluded participants who had taken part in a survey about non-alcoholic drinks in the previous 6 months. Participants who did not complete the full 7 days of the fluid record, participants reporting a mean total daily fluid intake below 0.4 L/day or higher than 6 L/day or those who had participated in a market research study in the previous 6 months were excluded from the analysis. Pregnancy or lactation was not a specific exclusion in the most countries, except in Iran and China.

The effective sample size for the present analysis was 16,276 participants. Individuals who agreed to be part of the survey received detailed information about the survey's objectives, what was expected from them, and information about the study's provisions to preserve confidentiality, risks and benefits, and a clear explanation about their option to participate voluntarily or not in the study. After being given a fully informed description of the study, following the principles of informed consent, participants were asked for their oral approval to participate. No monetary incentive was offered for taking part in the study. All data were recorded anonymously. Therefore, participants included in the data set cannot be identified, either directly or through identifiers. The survey protocol of the unpublished surveys was reviewed and approved by the University of Arkansas Review Board (ref. 14-12-376).

Assessment of the different fluid types

Participants were provided with a 24-h fluid-specific record to collect information on their intake of all fluid types over 7 consecutive days. The 7-day fluid-specific record was presented in the official country language. In all countries except France, Germany and Japan, a paper version of this 7-day fluid-specific record was delivered and explained to the participants during an initial interview at home. After a period of 7 days, the fluid record was collected from the participant's home by the researcher and checked with the participant. In France, Germany and Japan, participants completed the 7-day fluid-specific record online. On the morning of the first day, these participants received an electronic reminder with written instructions on how to fill in the fluid record. Paper memory cards were made available to the participants so that they could make notes during the day and subsequently complete the fluid record online. Both the paper and online records had the same structure; the participants were asked the type of the beverage, the volume of the intake, whether the beverage was consumed hot or cold, the reason for the intake, and where and when it was consumed. The questionnaire also asked whether the fluid was consumed by itself or with some food, but did not record the food consumed. To assist the participants in estimating how much fluid was consumed, a photographic booklet of standard fluid containers supported the records. The 13 surveys all used this method to assess the fluid intake and were referred to as Liq.In^7 (abbreviation of Liquid Intake over 7 days).

Classification of the fluid types

The fluids recorded were classified into: water (tap and bottled water); milk and milk derivatives; hot beverages (coffee, tea and other hot beverages); juices; regular sweetened beverages (RSB) (carbonated and non-carbonated soft drinks, energy drinks, sports drinks and other sugared soft drinks); diet beverages (diet carbonated soft drinks, diet non-carbonated soft drinks, other diet soft drinks); alcoholic drinks and other beverages. A more detailed classification can be found in supplementary Table 1 of this paper. TFI was defined as the sum of all these categories. In UK, Poland, Indonesia and Japan, the intake of diet beverages was very small, and therefore, they were during the first data treatment included in the RSB category. In Argentina, Iran and Indonesia, only non-alcoholic beverages were recorded. In Spain and France, no fluids were classified into the group "Other beverages".

Assessment of anthropometric variables

Height in metres (m) and weight in kilograms (kg) were self-reported by participants, except in Poland, Iran and China where these variables were measured. The body mass index (BMI) was calculated (kg/m^2). In Mexico, Brazil, Argentina, Indonesia and Japan, no anthropometric data were available.

Calculation of energy and sugar intake from fluids

Energy and sugar intake from different types of beverages was calculated using the updated USDA international food composition tables [33]. Because the quantity consumed of the types of beverages in the category "Other beverages" was very low and these fluids frequently had an unknown food composition, this category was disregarded for the energy and sugar analysis. The percentage of individuals consuming more than 10 % of energy requirements as free sugar, as recommended by WHO, was calculated [6]. WHO strongly recommends the intake of free sugars to less than 10 % of total energy intake and recently even suggested under conditions a further reduction in the intake of free sugars below 5 % of total energy intake [6]. Total energy requirement could not be calculated due to missing data of participants' weight and height in some countries. Therefore, the food balance sheets from the Food and Agriculture Organisation (FAO) were consulted to retrieve the mean energy intake (kcal/capita/day) of the adult population of the countries included in this analysis, which is accepted for ecological studies [34]. This source, however, contained the mean energy intake for total population, not separated by gender. In order to assess the differences in adherence to the WHO recommendation on free sugar intake between genders, the theoretical recommended daily energy requirement published by the Institute of Medicine was used for total population, but not for each country [35].

Statistical analysis

Data are presented either as means and 95 % confidence intervals (CI) for continuous variables, or as numbers and percentages for dichotomous variables. The mean intakes are estimated values of all participants, including non-consumers. We compared the distribution of the selected characteristics between groups Student's *t* tests for continuous variables. All statistical tests were two-tailed, and the significance level was set at $P < 0.05$. A Bonferroni post hoc test was used to correct for multiple comparisons in the online resources 2 and 3. All analyses were performed using the SPSS software version 22.0 (SPSS Inc., Chicago, IL).

Results

The daily water and beverages intake of 16,276 participants (47 % men) of 13 countries was analysed in the present study. The baseline characteristics of the male and female participants are presented in Table 1. The mean age of the male and female participants was 40.6 (40.3, 40.9) and 39.2 (38.9, 39.5) years, respectively. The mean BMI of the male and female participants was 25.6 (25.4, 25.7) and 25.0 (24.8, 25.1) kg/m^2, respectively.

The daily intakes of the different beverage types are presented in Table 2. Among the different fluid types, the highest volumes were observed for water intake, which ranged from 0.27 L/day in Japan to 1.78 L/day in Indonesia. The second type of fluid consumed in terms of volume was hot beverages, with a daily intake ranging from 0.12 L/day in Mexico to 1.03 L/day in UK. RSB was the third mostly fluid consumed with a daily intake ranging from 0.10 L/day in China to 0.57 L/day in Mexico.

Significant gender differences were inconsistently observed across countries for the daily intake of different types of beverages (supplementary Table 2). Water intake was significantly higher among women than men in Germany, Turkey and the total sample, whereas water intake was lower among women than men in Brazil. Women had a significantly higher milk intake then men in Brazil, Germany and the total sample. A higher intake among women than men was also observed for hot beverages in Mexico, Spain, France and Poland. The significant difference in RSB intake between genders was also inconsistent across countries. In Brazil, Spain and Germany, women consumed less RSB than men, whereas in France and China women consumed more RSB than men. The significant gender effect on diet beverages was consistent, yet only present in two countries: women consumed more diet beverages then men in Spain and France. The mean intake of alcoholic beverages was significantly higher among men than women in Mexico, Brazil, Spain, France, Germany, Poland and the total sample. Figure 1 represents the contribution (%) of the different fluid types to TFI. Countries with similar contribution patterns can be identified. Indonesia, China, Spain, Iran, Turkey and France are countries with the largest contribution of water to TFI, ranging from 47 to 78 %. The second largest contributor to TFI, in all these countries, was hot beverages. A different pattern was observed in Mexico and Brazil. In these countries, the contribution of RSB and juices to TFI was as large as the water contribution to TFI. This was also the case of Argentina, where the contribution of juices and RSB is larger than the water contribution; however, hot beverages are the primary contributor to TFI in this country. A high contribution of hot beverages to TFI was also observed among Germany, Poland and UK. However, unlike in Argentina, the contribution of water to TFI was larger than the contribution of RSB and juices. The contribution of water, juices, RSB and alcoholic beverages to TFI was comparable in these three countries (Germany, Poland and UK). The largest contribution of hot beverages (50 %) and alcoholic beverages (14 %) to TFI was observed in Japan.

Table 3 shows the mean energy intake from fluids. Total mean energy intake of total fluid ranged from a minimum of 182 kcal/day in Indonesia to a maximum of 817 kcal/day in Germany. In the total sample, the highest mean energy intake came from the consumption of milk and derivatives, followed by alcoholic beverages and then hot beverages. In Germany, Brazil, Iran, China and Spain, the milk and derivatives consumption represented the highest energy intake of all fluid types (299, 220, 182, 110 and 108 kcal/day, respectively). In France and Japan, the highest energy intake came from alcoholic beverages (95 and 159 kcal/day, respectively), whereas in UK, Poland and Turkey, hot beverages delivered the highest energy intake (205, 146

Table 1 General characteristics of the study population, categorised by country and gender

	n (%)	Age (years)	Age categories (years, %)				Weight (kg)	Height (m)	BMI (kg/m^2)
			18–29	30–39	40–49	≥50			
Mexico, 2012									
Men	574 (38)	38.6 (37.4, 40.0)	35.5	18.3	17.2	28.9	ND	ND	ND
Woman	924 (62)	38.3 (37.5, 39.2)	33.0	22.3	21.0	23.7	ND	ND	ND
Brazil, 2008									
Men	941 (49)	34.5 (33.8, 35.2)	39.5	25.3	25.4	9.8	ND	ND	ND
Woman	983 (51)	34.7 (34.0, 35.4)	36.8	27.7	25.5	10.0	ND	ND	ND
Argentina, 2009									
Men	241 (47)	37.1 (35.3, 38.8)	38.6	21.6	18.3	21.6	ND	ND	ND
Woman	266 (56)	37.8 (36.2, 39.4)	36.5	20.7	17.3	25.6	ND	ND	ND
Spain, 2012									
Men	630 (51)	42.9 (41.8, 44.0)	18.6	25.4	23.3	32.7	78.8 (77.8, 79.8)	1.7 (1.7, 1.7)	26.1 (25.8, 26.4)
Woman	610 (49)	43.0 (41.9, 44.1)	19.5	21.5	26.2	32.8	65.2 (64.3, 66.1)	1.6 (1.6, 1.6)	25.1 (24.7, 25.4)
France, 2012									
Men	804 (52)	47.6 (46.5, 48.6)	15.7	16.8	18.4	49.1	80.5 (79.6, 81.5)	1.7 (1.7, 1.8)	26.1 (25.8, 26.4)
Woman	730 (48)	41.5 (40.5, 42.5)	22.2	23.2	24.5	30.1	65.5 (64.4, 66.6)	1.6 (1.6, 1.6)	24.2 (23.8, 24.6)
UK, 2010									
Men	371 (41)	46.3 (44.7, 47.9)	16.7	20.8	20.2	42.3	ND	ND	28.8 (28.2, 29.5)
Woman	526 (59)	42.2 (41.0, 43.4)	19.6	26.4	25.3	28.7	ND	ND	25.9 (25.3, 26.5)
Germany, 2012									
Men	856 (45)	44.1 (43.2, 44.9)	16.4	20.1	26.5	37.0	81.6 (80.3, 82.8)	1.8 (1.8, 1.8)	25.8 (25.4, 26.2)
Woman	1012 (54)	41.9 (41.2, 42.7)	17.5	22.3	30.6	29.5	77.0 (75.9, 78.2)	1.7 (1.7, 1.7)	27.3 (26.8, 27.7)
Poland, 2014									
Men	517 (49)	46.0 (44.5, 47.4)	19.5	19.0	19.1	42.4	82.8 (81.6, 84.0)	1.8 (1.7, 1.8)	26.6 (26.3, 27.0)
Woman	545 (51)	46.2 (44.8, 47.6)	19.4	20.7	16.5	43.3	70.1 (68.9, 71.3)	1.6 (1.6, 1.7)	25.5 (25.1, 25.9)
Turkey, 2011									
Men	488 (51)	34.4 (33.4, 35.3)	37.7	27.3	24.2	10.9	75.9 (74.8, 77.0)	1.7 (1.7, 1.7)	25.0 (24.7, 25.4)
Woman	473 (49)	34.3 (33.4, 35.3)	38.5	27.9	22.6	11.0	65.8 (64.6, 67.1)	1.6 (1.6, 1.6)	25.0 (24.5, 25.5)
Iran, 2011									
Men	283 (49)	37.3 (35.8, 38.8)	36.7	24.0	19.4	19.8	79.3 (77.7, 81.0)	1.7 (1.7, 1.8)	25.8 (25.3, 26.2)
Woman	289 (51)	36.5 (35.1, 37.9)	35.3	28.0	20.1	16.6	63.9 (62.6, 65.3)	1.6 (1.6, 1.6)	24.9 (24.3, 25.4)
China, 2010									
Men	733 (50)	39.5 (38.6, 40.4)	24.7	25.2	25.8	24.3	67.4 (66.6, 68.2)	1.7 (1.7, 1.7)	23.2 (23.0, 23.5)
Woman	733 (50)	39.3 (38.5, 40.2)	24.7	25.6	25.8	23.9	55.9 (55.3, 56.5)	1.6 (1.6, 1.6)	22.1 (21.9, 22.3)
Indonesia, 2012									
Men	444 (32)	35.5 (34.3, 36.7)	39.4	25.7	16.9	18.0	ND	ND	ND
Woman	922 (68)	35.1 (34.4, 35.8)	39.3	28.5	17.6	14.6	ND	ND	ND
Japan, 2009									
Men	698 (51)	ND	26.6	27.4	21.5	24.5	ND	ND	ND
Woman	683 (49)	ND	26.1	27.1	21.1	25.8	ND	ND	ND
Total population[a]									
Men	7580 (47)	40.6 (40.3, 40.9)	27.0	22.8	22.0	28.3	77.9 (77.5, 78.4)	1.7 (1.7, 1.7)	25.6 (25.4, 25.7)
Woman	8696 (53)	39.2 (38.9, 39.5)	28.0	24.8	23.3	23.9	67.0 (66.6, 67.5)	1.6 (1.6, 1.6)	25.0 (24.8, 25.1)

Data expressed as mean (95 % CI) or percentage

BMI body mass index, *ND* no data

[a] Include only those countries with data available on the presented characteristics

Table 2 Total daily consumption of different types of beverages (L/day) for total population

	Water	Milk and derivates	Hot beverages	Juices	Regular sweetened beverages	Diet beverages	Alcoholic beverages	Other beverages	Total fluid intake
Mexico ($n = 1498$)	0.70 (0.66, 0.73)	0.19 (0.18, 0.20)	0.12 (0.11, 0.13)	0.18 (0.16, 0.19)	0.57 (0.54, 0.59)	0.02 (0.01, 0.02)	0.03 (0.02, 0.04)	0.00 (0.00, 0.00)	1.81 (1.76, 1.86)
Brazil ($n = 1924$)	0.83 (0.80, 0.86)	0.21 (0.20, 0.22)	0.31 (0.28, 0.33)	0.48 (0.46, 0.50)	0.23 (0.21, 0.24)	0.01 (0.00, 0.01)	0.15 (0.13, 0.17)	0.00 (0.00, 0.01)	2.22 (2.17, 2.27)
Argentina ($n = 507$)	0.39 (0.35, 0.43)	0.16 (0.15, 0.18)	0.92 (0.86, 0.98)	0.27 (0.24, 0.31)	0.37 (0.31, 0.42)	0.19 (0.16, 0.22)	ND	0.00 (0.00, 0.00)	2.30 (2.22, 2.39)
Spain ($n = 1240$)	1.01 (0.97, 1.05)	0.10 (0.09, 0.11)	0.30 (0.29, 0.32)	0.09 (0.08, 0.10)	0.16 (0.14, 0.17)	0.04 (0.03, 0.05)	0.20 (0.18, 0.22)	ND	1.90 (1.86, 1.95)
France ($n = 1534$)	0.76 (0.73, 0.78)	0.06 (0.06, 0.07)	0.39 (0.37, 0.41)	0.06 (0.06, 0.06)	0.12 (0.11, 0.13)	0.03 (0.02, 0.03)	0.13 (0.12, 0.14)	ND	1.56 (1.52, 1.59)
UK ($n = 897$)	0.51 (0.46, 0.55)	0.09 (0.08, 1.00)	1.03 (0.98, 1.07)	0.12 (0.1, 0.13)	0.37 (0.33, 0.40)	ND[a]	0.20 (0.18, 0.22)	0.00 (0.00, 0.01)	2.32 (2.26, 2.37)
Germany ($n = 1868$)	0.79 (0.75, 0.82)	0.29 (0.27, 0.31)	0.69 (0.66, 0.72)	0.18 (0.17, 0.20)	0.26 (0.24, 0.28)	0.01 (0.01, 0.01)	0.25 (0.23, 0.26)	0.01 (0.01, 0.01)	2.47 (2.43, 2.52)
Poland ($n = 1062$)	0.46 (0.44, 0.48)	0.08 (0.07, 0.09)	0.73 (0.71, 0.75)	0.09 (0.08, 0.10)	0.17 (0.15, 0.18)	ND[a]	0.10 (0.09, 0.11)	0.01 (0.00, 0.01)	1.64 (1.60, 1.67)
Turkey ($n = 961$)	1.04 (1.00, 1.09)	0.06 (0.05, 0.07)	0.51 (0.48, 0.54)	0.12 (0.11, 0.14)	0.20 (0.18, 0.22)	0.00 (0.00, 0.00)	0.01 (0.01, 0.02)	0.25 (0.23, 0.27)	2.21 (2.15, 2.27)
Iran ($n = 572$)	0.96 (0.91, 1.02)	0.17 (0.16, 0.19)	0.51 (0.48, 0.53)	0.07 (0.06, 0.07)	0.13 (0.11, 0.14)	0.01 (0.01, 0.02)	ND	0.07 (0.06, 0.08)	1.92 (1.86, 1.99)
China ($n = 1466$)	0.96 (0.92, 0.99)	0.10 (0.10, 0.11)	0.45 (0.42, 0.49)	0.02 (0.02, 0.02)	0.10 (0.09, 0.11)	ND[a]	0.09 (0.08, 0.10)	0.03 (0.03, 0.03)	1.76 (1.71, 1.81)
Indonesia ($n = 1366$)	1.78 (1.73, 1.84)	0.05 (0.04, 0.05)	0.26 (0.24, 0.27)	0.02 (0.01, 0.02)	0.17 (0.15, 0.20)	ND[a]	ND	0.01 (0.01, 0.02)	2.28 (2.23, 2.34)
Japan ($n = 1381$)	0.27 (0.25, 0.29)	0.08 (0.07, 0.09)	0.75 (0.73, 0.78)	0.06 (0.05, 0.06)	0.11 (0.10, 0.11)	ND[a]	0.21 (0.19, 0.23)	0.01 (0.01, 0.02)	1.50 (1.46, 1.53)
Total population ($n = 16{,}276$)	0.82 (0.81, 0.84)	0.13 (0.13, 0.14)	0.49 (0.49, 0.50)	0.14 (0.14, 0.15)	0.22 (0.21, 0.22)	0.02 (0.02, 0.02)	0.12 (0.12, 0.12)	0.02 (0.02, 0.02)	1.98 (1.96, 1.99)

Data expressed as mean (95 % CI)

ND no data

[a] In case of UK, Poland, China, Indonesia and Japan, the intake of diet beverages was included in the regular sweetened beverages category

Fig. 1 Contribution of the different types of beverages to TFI stratified by country

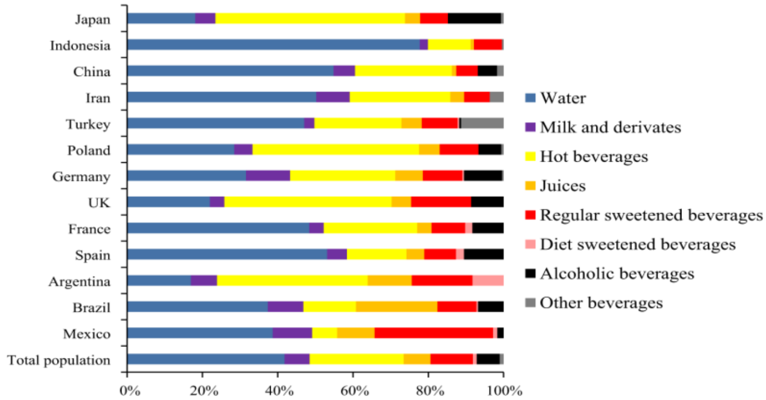

Table 3 Energy intake (in kcal) of different types of fluid intake by country and total population

	Milk and derivates	Hot beverages	Juices	Regular sweetened beverages	Diet beverages	Alcoholic beverages	Total fluid intake
Mexico ($n = 1498$)	200 (189, 211)	25 (23, 27)	80 (74, 86)	232 (220, 243)	3 (2, 3)	25 (19, 30)	565 (547, 583)
Brazil ($n = 1924$)	220 (208, 232)	62 (57, 66)	216 (207, 225)	82 (76, 89)	1 (1, 1)	113 (98, 129)	694 (672, 716)
Argentina ($n = 507$)	168 (153, 183)	184 (172, 197)	123 (108, 139)	147 (124, 170)	27 (23, 31)	ND	649 (622, 676)
Spain ($n = 1240$)	108 (96, 119)	61 (58, 64)	42 (38, 47)	63 (56, 69)	5 (4, 7)	149 (135, 164)	428 (408, 447)
France ($n = 1534$)	66 (59, 73)	78 (75, 82)	27 (25, 29)	52 (48, 57)	4 (3, 5)	95 (87, 103)	329 (318, 340)
UK ($n = 897$)	98 (86, 110)	205 (196, 215)	54 (48, 60)	151 (138, 164)	ND[a]	148 (132, 164)	656 (633, 679)
Germany ($n = 1868$)	299 (279, 318)	138 (133, 143)	81 (75, 88)	108 (100, 116)	2 (1, 2)	187 (174, 199)	817 (792, 842)
Poland ($n = 1062$)	83 (76, 91)	146 (142, 150)	41 (38, 45)	70 (65, 76)	ND[a]	76 (68, 84)	415 (401, 428)
Turkey ($n = 961$)	65 (56, 74)	102 (97, 107)	55 (48, 62)	85 (77, 94)	0 (0, 1)	8 (5, 12)	314 (298, 330)
Iran ($n = 572$)	182 (167, 196)	102 (97, 107)	29 (26, 32)	50 (44, 56)	2 (1, 2)	ND	365 (347, 383)
China ($n = 1466$)	110 (103, 117)	91 (83, 98)	9 (8, 11)	41 (36, 45)	ND[a]	69 (59, 79)	320 (305, 336)
Indonesia ($n = 1366$)	48 (41, 54)	52 (48, 55)	8 (6, 9)	74 (64, 84)	ND[a]	ND	182 (170, 194)
Japan ($n = 1381$)	84 (77, 90)	151 (146, 155)	26 (24, 29)	40 (36, 44)	ND[a]	159 (146, 172)	460 (444, 475)
Total population ($n = 16{,}276$)	140 (137, 144)	99 (97, 101)	64 (62, 66)	91 (88, 93)	2 (2, 3)	91 (87, 94)	490 (483, 496)

Data expressed as mean (95 % CI)

ND no data

[a] In case of UK, Poland, China, Indonesia and Japan, the intake of diet beverages was included in the regular sweetened beverages category

and 102 kcal/day, respectively). In Mexico and Indonesia, the highest energy intake from fluids came from RSB (232 and 74 kcal/day, respectively). Significant gender difference in energy intake provided by the different fluid types was also observed (Supplementary Table 3). In the total sample, men had a significantly higher mean energy intake from RSB and alcoholic beverages than women. Women on the other hand had a higher energy intake provided by milk and derivates than men.

Figure 2 shows the proportion of participants exceeding the WHO recommendation on energy intake provided by free sugar, solely by the intake of fluids. The highest proportion

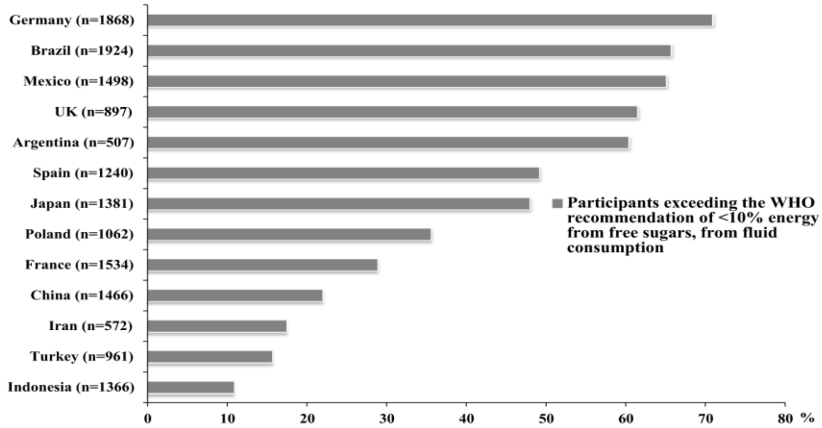

Fig. 2 Participants exceeding WHO recommendations for free sugar (<10 % of energy), considering only fluid intake

of adults exceeding the WHO recommendation was observed in Germany (70.9 %), followed by Brazil (65.7 %), Mexico (65.1 %), UK (61.5 %) and Argentina (60.4 %), whereas the lowest proportion was observed in Indonesia (10.9 %). Considering all countries together, 44.5 % of the population exceeded the WHO recommendations on energy intake provided by free sugar, solely by fluids.

Discussion

The aim of the present analysis was to collate and describe the intake of water and all other fluids of adults of 13 cross-sectional surveys, which used the same 7-day fluid-specific record. This unique compilation of national surveys conducted in large sample of participants from different countries demonstrated that not only the volume, but also the contribution of the different fluid types to TFI varied substantially between countries. Nevertheless, some countries that seemed to be geographically linked share similar patterns. The fluid intake of the countries relatively close to the Mediterranean Sea (Spain, France, Turkey and Iran) and also the two Asian countries (Indonesia and China) was characterised by a high contribution of water to TFI, ranging from 47 to 78 %. In North European countries (UK, Poland and Germany), the highest contribution to TFI came from hot beverages. The fluid intake of the three countries of Latin America was characterised by a high contribution of juices and RSB, which is as important as the contribution of water to TFI. Due to these substantial inter-geographical area differences in fluid intake contribution, the pooled data of all countries should be interpreted with caution. Identifying factors that could explain these observed between-country differences was not the aim of the current analysis, yet several hypotheses can be made. One of the possible factors explaining the between-country differences is climate and seasonality. Studies analysing seasonality of fluid intake indicated that temperature and seasons affected both volume and choice of beverages type [36]. However, Tani et al. [37] reported that in China an increase of 1 °C in the mean outdoor air temperature on the survey day was associated with an increased intake of water from fluids by only 8.4 mL/day ($P < 0.0001$) and that the influence of humidity was non-significant. Therefore, it seems unlikely that the differences observed between countries in volumes of beverage can be explained by climate alone. The impact of seasonality on the reported fluid intake between countries cannot be evaluated in this study, because in each survey data collection took place once during a period of the year with a mild climate (spring or autumn). Other factors to take into consideration when assessing the between-country variability are cultural and traditional habits, which unfortunately were not evaluated in the present study.

The data in the current analysis are in line with data reported in other published surveys. The fluid intake pattern with a high contribution of water to TFI characteristically for the Mediterranean countries was also reported in France by Bellisle et al. [39] and in Italy by Leclercq et al. [38]. Even though Bellisle et al. [39] reported a lower TFI and a higher intake of milk and alcoholic beverages in French adults than observed in our French survey, a pattern characterised by a relatively high contribution of water (43 %) and hot beverages (20 %) was also observed. Furthermore, a high contribution of water to TFI (58 % in men and 67 % in women) was also observed among Italian adults [38]. Although Italy was not included in the current analysis, this beverage pattern was similar than that we observed among the countries relatively close to the Mediterranean Sea.

The intake of the North European countries in the current surveys was characterised by a high intake of hot beverages. The National Nutritional Survey II assessed food intake of 15,371 German adults confirmed a similar contribution of hot beverages (21 %) to TFI, even though they reported higher volumes of all fluid types and a higher contribution of water to TFI (42 vs. 32 % in the present study) than in the current analysis. The contribution of juices and RSB to TFI observed in the present analysis was also different compared with others surveys [40]. These differences can be explained in part because in the present study these fluid types were split; however, the combined contribution (juices plus RSB) of 20 % is comparable to the 17 % observed in previous studies. For the UK, two previously published surveys reported TFI volumes and energy intake provided by beverages among adults that were in line with our observations [22, 41]. A survey performed in another North European country not included in the current analysis, Finland, also showed a fluid intake pattern characterised by a high contribution of water (34 and 51 % for men and women, respectively) and hot beverages (39 and 37 % for men and women, respectively) to TFI [42].

In Latin American countries, publications reporting fluid intake in adults were mainly focussed on the intake of caloric beverages and covered only the Mexican population [43, 44]. These two Mexican surveys described volumes of intake for the different fluid categories comparable to those in the current analysis. However, in both studies mean energy intake from fluids (372 and 382 kcal/day/per capita, respectively) was estimated to be lower than that estimated in the present study, which could be probably explained by a different classification of the beverages and the use of different food composition data.

The results obtained in the present international survey highlight the need to educate adults about the nutritional composition of the different fluids. As observed in previous studies, an accurate education programme and public health actions would be effective to encourage regular consumers to decrease their RSB consumption with water or other non-caloric beverages, in order to decrease the risk of chronic disease such as type 2 diabetes [23, 45] or overweight/obesity [7]. Attention should also be paid to fruit juices, because adult individuals still perceive beverages such as squashes, fruit lemonades and fruit sodas as a healthy option, and they should be advised about the low fruit content and the higher amounts of sugar [46]. In this present analysis, juices and RSB were separated into two different categories, because the nutritional composition is different. 100 % fruit juices could potentially contribute to daily vitamin and antioxidants intake [47]. However, regarding sugar content, RSB and juices are comparable; therefore, an increased intake should not be encouraged.

Several limitations of the fluid surveys or the current analysis need to be discussed. As often happens in nutritional research, the self-reported surveys collecting the intake of fluids are open to potential bias due to the over- or under-reporting of certain fluid types. This limitation can also be related to the current analysis, even though the same 7-day fluid-specific record was used in all the surveys. Another limitation was that the classification of diet beverages was not performed in the same way in all countries and alcoholic beverages were not recorded in some surveys, which limited the comparison between countries. Sugar and energy content per 100 mL of fluid type was used for the estimation of the energy and sugar consumed from each beverage in all countries. These were an approximate estimation of the reality, since the same fluid type of the same brand can have a different nutritional composition depending on the country. Additionally, sugar or other ingredients added by the consumer to the fluids were not taken into account for the calculation of energy intake. Therefore, the energy intake from fluids is likely to be underestimated. For the evaluation of the percentage of energy provided by free sugar, total energy intake had to be estimated since no food data were collected. The lack of food data also limited the interpretation of the data on energy intake from fluids. However, evidence suggested that a fluid-specific record might more accurately estimate fluid intake compared with a food and fluid record [48]. Since the primary aim of all 13 surveys included was to assess fluid intake, the preference was given to record fluids only. Due to the lack of anthropometric data of the participants in certain countries, the calculations had to be based on population means of energy intake. Nevertheless, this assumption was considered to be acceptable in epidemiological studies since the individual surveys aimed at collecting data from a nationally large sample of individuals and also because the energy intake data for the food balance sheets were recorded during the same year of the fluid surveys.

Despite these methodological limitations, this analysis has several strengths. This analysis is unique as it collated data of 13 surveys with relatively large sample sizes and an equal distribution between both genders. The compilation also contains original data from countries, which previously had no internally published fluid intake data available. The third strength is the use of the same 7-day fluid-specific diary in all the surveys that was also supported by a photographic booklet to limit the self-reporting error. Finally, the intake of drinking water and all other fluids were reported, in the 13 surveys except alcoholic beverages in three countries. This is rather exceptional as shown in the systematic review by Özen et al. [26].

In conclusion, the current study shows that intake volumes of the different fluid types differ considerably between countries, but these differences in the contribution to TFI are modest between countries of the same geographical area. Even though the highest volume consumed was recorded for drinking water, the mean energy intake from fluids was higher than expected due to the high consumption of RSB and fruit juices (reached up to 694 kcal/day of energy intake on average). Since the proportion of adults exceeding the WHO recommendation for energy intake provided by free sugars ranged from 11 up to 70.9 %, educating adults about the nutritional composition of the different fluids seems a pertinent step but not only one in terms of public health. Health authorities and food industry should take complementary actions to promote fluids with low sugar content and to create an environment favouring water consumption.

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Conflict of interest IG is an employee of Danone Research. JS-S, JS, LAM, SK, JG, HM are members of advisory board on fluid intake of Danone Research. S.A.K. has received research grants from Danone Research. B.S. has received research grant from R&D AQUA Group, Indonesia. A.M and N.E. are employer at NNFTRI, an instituted which has received a research grant from Damavand mineral water company (a brand of Danone Group in Iran). J.S.-S. and N.B. have received consultancies from Danone S.A. C.F.-P. and J.A. report no conflict of interest.

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Supplementary file 1. Classification of the fluid types

Classification of fluids	**Detailed Fluid types**
Water	Still water, unflavored sparkling water, tap/filtered/boiled water
Milk and derivatives	Low fat and full fat milk, fermented milk, ready-to-drink milk, flavored milk, yogurt milk, *atole/champurado*, raw milk, powder milk, powder/syrup flavored milk, fruit shake with milk, cocoa compound with milk
Hot beverages	Coffee, Coffee from coffee maker (e.g.: homemade coffee, dolce gusto, others), powder coffee, instant coffee, vending machine coffee, restaurant/franchise coffee, homemade hot/cold tea (from tea bags or leaves), infusions (herbal)
Juices	Packages fruits & vegetable juices (packaged juices (fruits or vegetables), packaged orangeade, packaged nectars, Eskimos/smoothies), *aguas frescas*, natural fruits & vegetables juices (natural fruit/vegetable juices, restaurant lemonade/orangeade), sugarcane juice
Regular sweetened beverages	Carbonated sweet beverages (CSB): cola carbonated drinks, flavored carbonated drinks flavored sparkling water, tonic, soda, flavored packaged water, flavored waters made with powder or concentrate/syrup, fruit shake with powder, ready to drink tea, ready to drink ice tea, sports drinks (e.g. Aquarius), vitamin/ functional drinks (fiber, vitamin and cooling drinks, e.g. C1000 Vitamin Lemon), energy drinks, cocoa prepared with water
Diet beverages	Diet sweet beverages (packaged light juices, diet/light/zero cola carbonated drinks, diet/light/zero flavored carbonated drinks)
Alcoholic beverages	Beer, lager, beer mix drinks, wine, champagne, aperitifs and digestives, packaged/canned alcoholic beverages, spirits, cocktails
Other beverages	• Beverages identified by participant as "other than listed above" • Packaged soy drinks, traditional Indonesian drinks, Jamu (Indonesia), Agua de arroz (Mexico), diet drinks as meal replacement(slim fast), Ready to drink soy based juice, Ayran (Turkey)

Supplementary file 2. Total daily consumption of different types of fluids (L/day) stratified by gender

	Water	Milk and derivates	Hot beverages	Juices	Regular sweetened beverages	Diet beverages	Alcoholic beverages	Other beverages	Total Fluid Intake
Mexico									
Men (n=574)	0.64 (0.59, 0.69)[a]	0.20 (0.18, 0.22)	0.11 (0.10, 0.12)[a]	0.18 (0.15, 0.20)	0.58 (0.54, 0.63)	0.01 (0.01, 0.02)	0.05 (0.03, 0.06)[a]	0.00 (0.00, 0.00)	1.77 (1.70, 1.85)
Women (n=924)	0.73 (0.69, 0.78)	0.18 (0.17, 0.20)	0.14 (0.12, 0.15)	0.18 (0.16, 0.19)	0.56 (0.52, 0.59)	0.02 (0.01, 0.03)	0.02 (0.01, 0.03)	0.00 (0.00, 0.00)	1.84 (1.77, 1.90)
Brazil									
Men (n=941)	0.87 (0.83, 0.92)[a]	0.20 (0.18, 0.21)[a]	0.28 (0.25, 0.31)	0.49 (0.46, 0.52)	0.27 (0.24, 0.29)[a]	0.00 (0.00, 0.01)	0.22 (0.18, 0.25)[a]	0.00 (0.00, 0.00)[a]	2.34 (2.27, 2.42)[a]
Women (n=983)	0.78 (0.74, 0.82)	0.22 (0.21, 0.24)	0.33 (0.29, 0.37)	0.47 (0.44, 0.49)	0.19 (0.18, 0.21)	0.01 (0.00, 0.01)	0.08 (0.06, 0.11)	0.01 (0.00, 0.01)	2.10 (2.03, 2.17)
Argentina									
Men (n=241)	0.36 (0.30, 0.42)	0.16 (0.14, 0.18)	0.96 (0.87, 1.05)	0.27 (0.21, 0.32)	0.39 (0.31, 0.47)	0.17 (0.13, 0.20)	ND	0.00 (0.00, 0.01)	2.32 (2.20, 2.44)
Women (n=266)	0.41 (0.35, 0.46)	0.16 (0.14, 0.18)	0.89 (0.80, 0.98)	0.28 (0.24, 0.32)	0.34 (0.27, 0.42)	0.21 (0.17, 0.26)	ND	0.00 (0.00, 0.00)	2.29 (2.17, 2.42)
Spain									
Men (n=630)	0.97 (0.92, 1.02)	0.11 (0.09, 0.13)	0.26 (0.24, 0.28)[a]	0.10 (0.08, 0.12)	0.18 (0.15, 0.20)[a]	0.03 (0.01, 0.04)[a]	0.29 (0.25, 0.32)[a]	ND	1.94 (1.87, 2.00)
Women (n=610)	1.05 (1.00, 1.10)	0.09 (0.08, 0.11)	0.35 (0.32, 0.37)	0.09 (0.08, 0.10)	0.13 (0.11, 0.15)	0.05 (0.03, 0.06)	0.11 (0.09, 0.12)	ND	1.87 (1.80, 1.93)
France									
Men (n=804)	0.75 (0.72, 0.79)	0.07 (0.06, 0.08)	0.35 (0.33, 0.37)[a]	0.06 (0.06, 0.07)	0.11 (0.10, 0.12)[a]	0.02 (0.02, 0.03)[a]	0.17 (0.16, 0.19)[a]	ND	1.55 (1.50, 1.60)
Women (n=730)	0.76 (0.73, 0.80)	0.06 (0.05, 0.07)	0.44 (0.41, 0.47)	0.06 (0.05, 0.06)	0.14 (0.12, 0.15)	0.04 (0.03, 0.04)	0.07 (0.06, 0.08)	ND	1.57 (1.52, 1.62)
UK									
Men (n=371)	0.49 (0.43, 0.56)	0.09 (0.07, 0.10)	1.00 (0.92, 1.07)	0.11 (0.09, 0.13)	0.37 (0.33, 0.42)	ND	0.17 (0.15, 0.20)	0.00 (0.00, 0.00)	2.24 (2.15, 2.32)[a]
Women (n=526)	0.52 (0.46, 0.57)	0.10 (0.08, 0.11)	1.05 (0.99, 1.11)	0.12 (0.11, 0.14)	0.36 (0.32, 0.40)	ND	0.21 (0.18, 0.24)	0.00 (0.00, 0.01)	2.37 (2.30, 2.45)
Germany									
Men (n=856)	0.75 (0.70, 0.81)[a]	0.25 (0.22, 0.28)[a]	0.70 (0.66, 0.74)	0.18 (0.15, 0.20)	0.28 (0.25, 0.32)[a]	0.01 (0.01, 0.01)	0.32 (0.29, 0.38)[a]	0.01 (0.01, 0.02)	2.51 (2.45, 2.57)
Women (n=1012)	0.81 (0.77, 0.86)	0.32 (0.29, 0.34)	0.68 (0.64, 0.72)	0.18 (0.16, 0.20)	0.23 (0.21, 0.26)	0.01 (0.01, 0.02)	0.19 (0.17, 0.21)	0.01 (0.01, 0.01)	2.45 (2.39, 2.50)
Poland									
Men (n=517)	0.48 (0.45, 0.52)	0.08 (0.07, 0.09)	0.71 (0.68, 0.73)[a]	0.10 (0.08, 0.11)	0.18 (0.16, 0.20)	ND	0.15 (0.13, 0.17)[a]	0.00 (0.00, 0.01)	1.70 (1.66, 1.75)[a]
Women (n=545)	0.44 (0.40, 0.47)	0.08 (0.07, 0.09)	0.75 (0.73, 0.78)	0.09 (0.08, 0.10)	0.16 (0.14, 0.17)	ND	0.05 (0.04, 0.06)	0.00 (0.00, 0.01)	1.57 (1.53, 1.62)
Turkey									
Men (n=488)	0.98 (0.92, 1.04)[a]	0.05 (0.04, 0.07)	0.50 (0.47, 0.54)	0.13 (0.11, 0.15)	0.20 (0.18, 0.23)	0.00 (0.00, 0.01)	0.01 (0.00, 0.02)	0.26 (0.23, 0.28)	2.15 (2.07, 2.24)
Women (n=473)	1.11 (1.05, 1.17)	0.07 (0.06, 0.08)	0.52 (0.48, 0.55)	0.11 (0.09, 0.13)	0.20 (0.17, 0.23)	0.00 (0.00, 0.00)	0.01 (0.00, 0.02)	0.25 (0.22, 0.28)	2.27 (2.17, 2.37)
Iran									
Men (n=283)	0.96 (0.89, 1.03)	0.18 (0.16, 0.20)	0.53 (0.49, 0.56)	0.07 (0.06, 0.09)	0.12 (0.11, 0.14)	0.01 (0.01, 0.02)	ND	0.06 (0.05, 0.07)	1.92 (1.83, 2.02)
Women (n=289)	0.97 (0.89, 1.04)	0.17 (0.15, 0.19)	0.49 (0.45, 0.53)	0.06 (0.05, 0.07)	0.13 (0.11, 0.16)	0.02 (0.01, 0.02)	ND	0.08 (0.06, 0.09)	1.92 (1.83, 2.02)
China									
Men (n=733)	0.98 (0.92, 1.03)	0.11 (0.10, 0.12)	0.45 (0.40, 0.51)	0.02 (0.02, 0.02)	0.09 (0.07, 0.10)[a]	ND	0.10 (0.08, 0.12)	0.03 (0.02, 0.03)	1.78 (1.71, 1.85)
Women (n=733)	0.94 (0.89, 0.99)	0.10 (0.09, 0.11)	0.45 (0.40, 0.50)	0.02 (0.02, 0.02)	0.11 (0.09, 0.12)	ND	0.09 (0.07, 0.10)	0.03 (0.03, 0.04)	1.75 (1.68, 1.81)
Indonesia									
Men (n=444)	1.82 (1.72, 1.92)	0.04 (0.03, 0.05)	0.25 (0.22, 0.28)	0.02 (0.01, 0.02)	0.20 (0.15, 0.24)	ND	ND	0.02 (0.01, 0.02)	2.33 (2.23, 2.43)
Women (n=922)	1.76 (1.70, 1.83)	0.05 (0.04, 0.05)	0.26 (0.24, 0.28)	0.02 (0.01, 0.02)	0.17 (0.14, 0.20)	ND	ND	0.01 (0.01, 0.02)	2.26 (2.19, 2.32)
Japan									
Men (n=698)	0.27 (0.24, 0.29)	0.08 (0.07, 0.08)	0.74 (0.71, 0.78)	0.06 (0.05, 0.06)	0.09 (0.08, 0.10)	ND	0.22 (0.19, 0.24)	0.01 (0.01, 0.02)	1.47 (1.42, 1.52)
Women (n=683)	0.28 (0.25, 0.31)	0.08 (0.07, 0.09)	0.76 (0.73, 0.80)	0.07 (0.06, 0.08)	0.11 (0.09, 0.12)	ND	0.20 (0.18, 0.23)	0.02 (0.01, 0.02)	1.52 (1.47, 1.57)
Total population									
Men (n=7580)	0.80 (0.78, 0.81)[a]	0.13 (0.12, 0.13)[a]	0.49 (0.48, 0.50)	0.14 (0.14, 0.15)	0.21 (0.20, 0.22)[a]	0.02 (0.01, 0.02)	0.16 (0.15, 0.17)[a]	0.02 (0.02, 0.03)	1.97 (1.95, 1.99)
Women (n=8696)	0.85 (0.83, 0.86)	0.14 (0.13, 0.14)	0.50 (0.49, 0.51)	0.14 (0.14, 0.15)	0.22 (0.21, 0.23)	0.02 (0.02, 0.02)	0.09 (0.08, 0.09)	0.02 (0.02, 0.02)	1.98 (1.96, 2.00)

Data expressed as mean (95% CI). Abbreviation: ND, no data. [a] P-value <0.05 for men vs. women, with a Bonferroni correction applied during the post-hoc test

Supplementary file 3. Energy intake from different types of fluid intake (kcal/day) stratified by gender

	Milk and derivates	Hot beverages	Juices	Regular sweetened beverages	Diet beverages	Alcoholic beverages	Total Fluid Intake
Mexico							
Men (n=574)	212 (193, 231)	22 (19, 24) [a]	80 (70, 91)	239 (220, 258)	2 (1, 3)	35 (25, 46) [a]	590 (560, 620) [a]
Women (n=924)	192 (179, 206)	27 (24, 30)	80 (72, 87)	229 (214, 244)	3 (2, 4)	18 (12, 24)	549 (526, 572)
Brazil							
Men (n=941)	207 (189, 224) [a]	57 (51, 62)	222 (209, 236)	96 (86, 106) [a]	1 (0, 1)	165 (139, 190) [a]	748 (714, 783) [a]
Women (983)	232 (216, 249)	66 (59, 74)	210 (198, 222)	69 (62, 76)	1 (1, 1)	64 (46, 82)	642 (614, 670)
Argentina							
Men (n=241)	169 (147, 192)	191 (173, 209)	121 (97, 146)	158 (124, 192)	23 (18, 29)	ND	662 (620, 705)
Women (n=266)	168 (147, 188)	178 (160, 195)	125 (107, 144)	136 (106, 167)	30 (24, 36)	ND	637 (603, 671)
Spain							
Men (n=630)	116 (97, 135)	52 (48, 56) [a]	45 (38, 53)	72 (61, 82) [a]	4 (2, 6) [a]	216 (192, 241) [a]	505 (473, 537) [a]
Women (n=610)	100 (87, 112)	70 (65, 74)	39 (34, 44)	52 (44, 59)	7 (5, 9)	80 (67, 94)	348 (328, 368)
France							
Men (n=804)	71 (60, 81)	70 (66, 74) [a]	28 (25, 31)	47 (41, 53) [a]	3 (2, 4) [a]	131 (119, 143) [a]	358 (341, 375) [a]
Women (n=730)	61 (51, 71)	88 (82, 93)	26 (23, 29)	58 (51, 65)	5 (4, 6)	55 (48, 63)	297 (283, 311)
UK							
Men (n=371)	90 (75, 105)	200 (184, 215)	50 (41, 59)	154 (134, 173)	ND	130 (110, 151)	624 (591, 657) [a]
Women (n=526)	104 (87, 120)	210 (197, 222)	56 (48, 65)	148 (130, 166)	ND	160 (138, 183)	678 (646, 711)
Germany							
Men (n=856)	262 (233, 291) [a]	140 (132, 148)	80 (70, 90)	120 (107, 133) [a]	1 (1, 2)	239 (218, 261) [a]	841 (804, 878)
Women (n=1012)	330 (303, 357)	136 (129, 143)	83 (74, 92)	98 (87, 109)	2 (2, 3)	142 (129, 156)	797 (764, 830)
Poland							
Men (n=517)	80 (70, 91)	141 (136, 147) [a]	44 (38, 50)	76 (67, 84)	ND	115 (101, 129) [a]	453 (431, 475) [a]
Women (n=545)	86 (75, 97)	150 (145, 155)	39 (35, 44)	66 (59, 72)	ND	39 (33, 45)	378 (362, 394)
Turkey							
Men (n=488)	57 (45, 70)	101 (94, 108)	60 (50, 70)	86 (75, 97)	1 (0, 1)	9 (3, 15)	300 (278, 322)
Women (n=473)	72 (59, 86)	103 (96, 111)	50 (41, 59)	85 (72, 97)	0 (0, 1)	8 (3, 13)	329 (306, 352)
Iran							
Men (n=283)	186 (165, 206)	106 (98, 113)	29 (25, 34)	45 (37, 52)	2 (1, 2)	ND	368 (343, 394)
Women (n=289)	178 (157, 199)	98 (91, 105)	29 (24, 33)	55 (46, 65)	2 (1, 3)	ND	362 (336, 388)
China							
Men (n=733)	113 (103, 122)	91 (80, 102)	9 (7, 11)	37 (32, 43) [a]	ND	73 (56, 89)	323 (301, 346)
Women (n=733)	107 (97, 117)	90 (80, 101)	9 (7, 11)	47 (41, 53)	ND	65 (52, 78)	318 (296, 340)
Indonesia							
Men (n=444)	45 (35, 56)	51 (45, 56)	8 (5, 10)	82 (63, 101)	ND	ND	186 (164, 209)
Women (n=922)	49 (41, 57)	52 (48, 56)	8 (6, 10)	71 (60, 82)	ND	ND	180 (165, 195)
Japan							
Men (n=698)	80 (72, 88)	148 (141, 155)	25 (22, 28)	37 (32, 42)	ND	165 (146, 183)	455 (433, 478)
Women (n=683)	88 (78, 99)	153 (146, 160)	27 (24, 31)	44 (38, 50)	ND	153 (135, 172)	465 (443, 486)
Total population							
Men (n=7580)	135 (130, 140) [a]	98 (95, 100)	65 (62, 68)	88 (84, 91) [a]	2 (2, 3)	119 (113, 125) [a]	512 (503, 522) [a]
Women (n=8696)	145 (140, 150)	100 (98, 102)	64 (61, 66)	93 (90, 97)	3 (2, 3)	66 (62, 70)	469 (461, 478)

Data expressed as mean (95% CI). Abbreviation: ND, no data. [a] P-value <0.05 for men vs. women, with a Bonferroni correction applied during the post-hoc test

6.6. Frequent consumption of sugar- and artificially sweetened beverages, and natural and bottled fruit juices is associated with an increased risk of metabolic syndrome in a Mediterranean population at high CVD risk.

Ferreira-Pêgo C, Babio N, Bes-Rastrollo M, Corella D,Estruch R, Ros E, Fitó M, Serra-Majem L, Arós F, Fiol M, Santos-Lozano JM, Muñoz-Bravo C, Pintó X, Ruiz-Canela M, Salas-Salvadó J; PREDIMED investigators. J Nutr. 2016; 146(8):1528-36. PMID: 27358413. doi: 10.3945/jn.116.230367.

Study 6 overview. Novelty and significance.
What is already known?
- MetS entails an increased risk of T2DM, CVD and cause-specific mortality. - Most of the studies relating the consumption of sweetened beverages and MetS are cross-sectional, so their potential for discerning relationships is limited. To date, only four prospective studies had investigated the association between the consumption of sweetened beverages and MetS incidence, with contradictory results.
What this study adds?
- Individuals consuming >5 servings/week of total SSBs had a higher risk of MetS as a whole [HR: 1.43, 95% CI: 1.00-2.15] and some of its components as low HDL-cholesterol and high blood pressure, compared to those consuming fewer than one per week. - Similar results were found also for artificially sweetened beverages [HR: 1.74, 95% CI: 1.26-2.41], natural fruit juices [HR: 1.30, 95% CI: 1.00-1.69] and bottled fruit juices [HR: 1.14, 95% CI: 1.04-1.65]. - A higher risk between the frequent consumption of artificially sweetened beverages and abdominal obesity and hypertriglyceridemia was also found. - Frequent consumption of bottled fruit juices was related with a higher risk of hypertriglyceridemia, and natural fruit juices frequent consumption increased the risk of abdominal obesity, both components of MetS.
Summary
- This study provided further evidence of the positive relationship between the frequency of sugar- and artificially sweetened beverages and natural and bottled fruit juices consumption and the risk of MetS and its components in a Mediterranean population at high cardiovascular risk.

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Frequent Consumption of Sugar- and Artificially Sweetened Beverages and Natural and Bottled Fruit Juices Is Associated with an Increased Risk of Metabolic Syndrome in a Mediterranean Population at High Cardiovascular Disease Risk[1–3]

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Abstract

Background: The relation between the consumption of sweetened beverages and metabolic syndrome (MetS) is controversial.

Objective: This analysis evaluated the associations between intakes of sugar-sweetened beverages (SSBs), artificially sweetened beverages, and natural and bottled fruit juices and the incidence of MetS in elderly individuals at high risk of cardiovascular disease (CVD) and without MetS at baseline.

Methods: We prospectively examined 1868 participants free of MetS at baseline from the PREDIMED (PREvención con DIeta MEDiterránea) study. MetS was defined by using the updated harmonized criteria of the International Diabetes Federation, the American Heart Association, and National Heart, Lung, and Blood Institute. Energy and nutrient intakes were evaluated at baseline and then yearly by using a validated 137-item food-frequency questionnaire. Multivariable-adjusted HRs for MetS and its components were estimated from mean intakes during follow-up. We compared the 2 highest consumption categories (1–5 and >5 servings/wk) with the lowest category (<1 serving/wk).

Results: A total of 930 incident cases of MetS were documented during a median follow-up of 3.24 y. When we compared consumption of >5 servings/wk with consumption of <1 serving/wk, multivariable HRs (95% CIs) for MetS incidence were 1.43 (1.00, 2.15), 1.74 (1.26, 2.41), 1.30 (1.00, 1.69), and 1.14 (1.04, 1.65) for SSBs, artificially sweetened beverages, natural fruit juices, and bottled fruit juices, respectively.

Conclusions: The occasional consumption of SSBs and artificially sweetened beverages (1–5 servings/wk) was not associated with the incidence of MetS in middle-aged and elderly individuals at high risk of CVD. The consumption of >5 servings/wk of all of the types of beverages analyzed was associated with an increased risk of MetS and some of its components. However, for SSBs and bottled fruit juices these associations must be interpreted with caution because of the low frequency of consumption in this population. This trial was registered at clinicaltrials.gov as ISRCTN35739639. *J Nutr* doi: 10.3945/jn.116.230367.

Keywords: sugar-sweetened beverages, artificially sweetened beverages, fruit juices, metabolic syndrome, metabolic syndrome components, PREDIMED study

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Introduction

Metabolic syndrome (MetS)[19] is a cluster of metabolic alterations associated with visceral obesity, including atherogenic dyslipidemia, high fasting plasma glucose, and increased blood pressure (1). The disorder entails an increased risk of type 2 diabetes (T2D), cardiovascular disease (CVD), and cause-specific mortality (1–3). Because the incidence of MetS is increasing in industrialized countries in parallel with the obesity epidemic, this disorder has become a major public health concern in developed countries (4). Lifestyle modifications, such as engaging in more physical activity, adopting a healthy dietary pattern, and maintaining normal weight, are the first-line measures for both prevention (5–7) and treatment of MetS (8).

In recent years, the intake of sugar- and artificially sweetened beverages and fruit juices has steadily increased worldwide among children, adolescents, and adults (9–12). An increase in the intake of sweetened beverages has also been observed in consumers of the Mediterranean diet (13), although it remains lower than in other industrialized countries (14).

In recent decades, the relation between the consumption of sweetened beverages and the development of MetS has been investigated in epidemiologic studies. However, most of these were cross-sectional (5, 15–19), so their potential for discerning relations is limited. To date, to our knowledge, only 4 prospective studies have investigated the association between the consumption of sweetened beverages and MetS incidence, with contradictory results (20–23). Three of these were part of a meta-analysis (24) that concluded that a higher consumption of sugar-sweetened beverages (SSBs) was associated with the development of MetS. The fourth, not included in the aforementioned meta-analysis, was conducted in a Mediterranean population (20) and suggested a positive association between changes in the consumption of SSBs and incident MetS in university graduates.

To our knowledge, no studies have been performed on the association between the mean consumption during the follow-up of sweetened beverages and incident MetS in a Mediterranean population of middle-aged to elderly adults. Therefore, the aim of the present study was to examine the associations between the average consumption of SSBs, artificially sweetened beverages, and natural and bottled fruit juices and the risk of MetS in the PREDIMED (PREvención con DIeta MEDiterránea) cohort of middle-aged and elderly individuals at high risk of CVD.

Methods

Design and study population. The present study (clinicaltrials.gov; ISRCTN35739639) was conducted within the framework of the PREDIMED trial. Full details of the study design and protocol have been published elsewhere (25, 26) and are available on the PREDIMED study's website (27). The PREDIMED study is a large, multicenter, randomized parallel-group and controlled field trial conducted in Spain for the primary prevention of cardiovascular events (a list of the PREDIMED Investigators can be found in **Supplemental Text**). The main results of the PREDIMED trial at the primary endpoints (a composite of myocardial infarction, stroke, and cardiovascular mortality) have been published (28). Briefly, between October 2003 and June 2009, a total of 7447 participants (men aged 55–80 y and women aged 60–80 y) were randomly assigned to 1 of the 3 intervention groups: a Mediterranean diet supplemented with extra-virgin olive oil (~50 mL/d), a Mediterranean diet supplemented with mixed nuts (15 g walnuts, 7.5 g hazelnuts, and 7.5 g almonds daily), or advice on a low-fat diet (control group). Participants had no history of CVD at baseline but were at high cardiovascular risk because of the presence of T2D or ≥3 of the following risk factors: current smoking (>1 cigarette/d during the past month), hypertension (systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or taking antihypertensive medication), high LDL cholesterol (≥160 mg/dL), low HDL cholesterol (<40 mg/dL for men or <50 mg/dL for women), overweight or obese [BMI (in kg/m^2) ≥25], or family history of premature CVD. Participants with severe chronic illness, drug or alcohol addiction, history of allergy or intolerance to olive oil or nuts, and a low predicted likelihood of changing dietary habits according to Prochaska and DiClemente's stages-of-change model (29) were excluded from the study. The institutional review boards of each recruitment center approved the protocol, and all of the subjects provided written informed consent. The study follow-up ended in December 2010.

The present data were analyzed by using an observational prospective design, and participants were selected from all of the PREDIMED recruitment centers with biochemical determinations available for a follow-up of ≥2 y (n = 5801). The main aim of the present report was to explore the associations between the consumption of SSBs, artificially sweetened beverages, and natural and bottled fruit juices and the incidence of MetS. For this reason, participants with MetS at baseline (n = 3707) were excluded. Those who did not complete the baseline FFQ or who reported implausible total energy intakes (≤500 and ≥3500 kcal/d in women and ≤800 and ≥4000 kcal/d in men) were also excluded. Of a total of 2094 participants fulfilling these characteristics, 226 were excluded because of missing data that prevented MetS from being diagnosed. Of the 5801 participants, 1019, 1766, 1804, 240, and 1269 did not meet the MetS criteria of abdominal obesity, hypertriglyceridemia, low HDL cholesterol, high blood pressure, and high fasting plasma glucose concentrations at baseline. Finally, 1868 participants were included in the present analysis.

MetS. MetS was defined in accordance with the updated harmonized criteria of the International Diabetes Federation, the American Heart Association, and National Heart, Lung, and Blood Institute (1). Participants were considered to have MetS if they had ≥3 of the following: abdominal obesity for European individuals (waist circumference ≥88 cm

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[2] Author disclosures: C Ferreira-Pêgo, M Bes-Rastrollo, D Corella, M Fitó, M Fiol, JM Santos-Lozano, C Muñoz-Bravo, and M Ruiz-Canela, no conflicts of interest. N Babio has received travel and grant support through her institution from Danone. R Estruch reports serving on the board of and receiving lecture fees from the Research Foundation on Wine and Nutrition (FIVIN), serving on the boards of the Beer and Health Foundation and the European Foundation for Alcohol Research (ERAB), receiving lecture fees from Cerveceros de España and Lilly, and receiving grant support through his institution from Novartis. E Ros reports serving on the board of and receiving travel and grant support through his institution from the California Walnut Commission and Alexion, serving on the board of and receiving grant support through his institution from Amgen, receiving lecture fees and grant support through his institution from Sanofi Regeneron and Merck, receiving lecture fees and payment for the development of educational presentations as well as grant support through his institution from Ferrer, and receiving grant support through his institution from Pfizer. L Serra-Majem is a member of the Scientific Advisory Board and has received consulting fees and grant support from the European Hydration Institute; he has received lecture fees from the International Nut Council and travel support for conferences from Nestlé. F Arós has received payment for the development of educational presentations from Menarini and Astra Zeneca. X Pintó received grants for research through his institution from Amgen, Sanofi-Aventis, Rubió, and Mylan and received lecture fees from Lácer. J Salas-Salvadó reports serving on the board of Instituto Danone España and receiving grant support through his institution from Danone, Eroski, and Nestlé. None of the funding sources played a role in the design, collection, analysis, or interpretation of the data or in the decision to submit the manuscript for publication. CIBERobn is an initiative of ISCIII, Spain.
[3] Supplemental Tables 1–3 and Supplemental Text are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.
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[19] Abbreviations used: CVD, cardiovascular disease; ICC, intraclass correlation coefficient; MetS, metabolic syndrome; PREDIMED, Prevención con Dieta Mediterránea; SSB, sugar-sweetened beverage; T2D, type 2 diabetes.

in women and ≥102 cm in men), hypertriglyceridemia (≥150 g/dL) or drug treatment for high plasma TG concentrations, low HDL cholesterol (<50 mg/dL in women and <40 mg/dL in men), high blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg) or antihypertensive drug treatment, or high fasting glucose (≥100 mg/dL) or drug treatment for T2D.

Dietary assessment. Dietary intake was assessed by trained dietitians with the use of a 137-item semiquantitative FFQ validated for the PREDIMED study (30), which was administered at baseline and yearly during follow-up. The reproducibility and relative validity of the FFQ used in the present study were assessed for several nutrients and food groups (30). The reproducibility and relative validity of the FFQ were also assessed in relation to the consumption of SSBs, artificially sweetened beverages, natural fruit juices (freshly extracted juice, for which the only procedure accepted was the squeezing of the whole piece of fruit), and bottled fruit juices (natural fruit juice that has been chemically changed by using authorized methods and packed and commercialized for subsequent consumption). By using the intraclass correlation coefficients (ICCs) between the FFQ and dietary records, the following reliabilities were found: 0.67 for SSBs, 0.46 for artificially sweetened beverages, 0.81 for natural fruit juices, and 0.88 for bottled fruit juices. In the reproducibility analysis, the ICCs were 0.69 for SSBs, 0.63 for artificially sweetened beverages, 0.71 for natural fruit juices, and 0.48 for bottled fruit juices.

The intake of sweetened beverages and fruit juices was assessed yearly by using 5 items (SSBs, artificially sweetened beverages, bottled fruit juices, natural orange juice, and natural juices from other fruit) from the FFQ. To assess habitual intake during the previous year, frequencies of consumption were measured in 9 categories (from never or almost never to >6 servings/d) for each FFQ item. The responses to individual items were then converted into mean daily consumption (mL/d) during the follow-up by multiplying the typical portion sizes (mL) by the consumption frequency for each food and making the appropriate division for the period assessed to obtain the daily consumption. Each serving of sweetened beverages was considered to be 200 mL. In the present analysis the categories were SSBs, artificially sweetened beverages, natural fruit juices (the result of combining natural orange fruit juice and other natural fruit juices), and bottled fruit juices. Energy and nutrient intakes were calculated by using Spanish food-composition tables (31, 32).

Anthropometric, biochemical, and lifestyle measurements. At baseline and yearly, participants completed the following: *1*) a questionnaire on medical history, medication use, and lifestyle variables; *2*) a 14-item validated questionnaire designed to assess adherence to the Mediterranean diet (33); and *3*) a validated Spanish version of the Minnesota Leisure Time Physical Activity Questionnaire (34). In addition, at baseline and yearly thereafter, trained personnel measured weight and height with the use of calibrated scales and a wall-mounted stadiometer. Participants wore light clothing and no shoes. Waist circumference was measured by using an anthropometric tape midway between the lower rib and the superior border of the iliac crest. Blood pressure was measured in triplicate after 5 min of rest by using a validated semiautomatic sphygmomanometer (HEM-705CP; Omron), and the mean of these measurements was recorded. Blood samples were collected after an overnight fast, coded, shipped to a central laboratory, and stored at −80°C until analysis. Biochemical analysis was performed in local laboratories. Plasma glucose was analyzed by glucose-oxidase methodology, serum cholesterol by esterase-oxidase-peroxidase, serum TGs by glycerol-phosphate oxidase-peroxidase, and serum HDL cholesterol mainly by direct measurement, or precipitation methodology. All local laboratories satisfied external quality-control requirements. A concordance study of 9 laboratories was conducted. From each study, a mean of 200 samples was analyzed for total cholesterol, HDL cholesterol, and TGs. The laboratory of the Medical Research Institute of the Del Mar Hospital, which used ABX-Horiba commercial kits in a PENTRA-400 autoanalyzer (ABX-Horiba), was used as a reference. One center was unable to provide samples for the concordance study. The concordance analysis of lipid measurements showed the following values: r^2 [ICC (95% CI)] values between 0.85 and 0.97 [0.85 (0.77, 0.90) and 0.97 (0.95, 0.98)] for total cholesterol, between 0.82 and 0.92 [0.81 (0.78, 0.83) and 0.92 (0.89, 0.95)] for HDL cholesterol, between 0.81 and 0.99 [0.81 (0.73, 0.87) and 0.99 (0.99, 0.99)] for TGs, and between 0.82 and 0.96 [0.82 (0.74, 0.88) and 0.99 (0.99, 0.99)] for glucose.

Statistical analyses. Intakes reported during the baseline interview and yearly during follow-up were averaged. The participants were classified according to the frequency of servings of different beverages. To better represent the long-term consumption of the different types of beverage, we used the mean beverage consumption for all analyses on the basis of assessments of items from all FFQs, which were made at baseline and yearly during the follow-up for participants who did not develop MetS. For those who did develop MetS, and because participants could have changed their dietary pattern after developing MetS, we used only data from all of the available FFQs until the year before MetS was diagnosed. The baseline characteristics of the participants are expressed as means ± SDs or as medians (IQRs) for continuous variables and number and percentages for categorical variables. Chi-square and 1-factor ANOVA tests were used to assess differences in the baseline characteristics of the study population. Multivariable time-dependent Cox proportional regression models were fitted to assess the HRs for the incidence of MetS and its components during the follow-up according to servings (200 mL) of SSBs, artificially sweetened beverages, natural fruit juices, and bottled fruit juices. Both of the highest categories (1–5 servings/wk and >5 servings/wk) were compared with the lowest category (<1 serving/wk) as a reference. The assumption of proportional hazards was tested with time-dependent covariates. The time variable was defined as the interval between random assignment and the date of the last follow-up or the last recorded clinical event (MetS incidence) of participants who were still alive, whichever occurred first. Participants who were free of MetS or who were lost to follow-up were censored at the date of the last visit.

Three different Cox regression models were adjusted for potential confounders. Model 1 adjusted for intervention group, age in years, sex, leisure-time physical activity (metabolic equivalent tasks/d) measured by the Minnesota Leisure Time Physical Activity Questionnaire, BMI (kg/m^2), and smoking status (never, current, or former) at baseline. Model 2 additionally adjusted for total energy intake (in kcal/d) and average consumption (g/d) during follow-up of vegetables, legumes, fruit, cereals, meat, fish, bakery products, dairy products, olive oil, nuts, and alcohol (with a quadratic form being added only in the case of alcohol consumption). Model 3 additionally adjusted for the prevalence of MetS components at baseline, including abdominal obesity (yes or no), hypertriglyceridemia or drug treatment for elevated TGs (yes or no), low HDL cholesterol (yes or no), hypertension or antihypertensive treatment (yes or no), and high fasting plasma glucose or medication for hyperglycemia (yes or no). When the association between the intake of sweetened beverages and the incidence of each component of MetS was assessed, the components were excluded from the analysis, and model 2 represented the fully adjusted model. Statistical interactions between categories of sweetened beverage intake and potential effect-modifying variables such as sex, intervention group, diabetes, and smoking status were assessed by including product terms in the models; no significant interactions were found.

To assess the linear trend, the median value of each category of each type of sweetened beverage analyzed was assigned and used as a continuous variable in the Cox regression models. The level of significance for all statistical tests was set at $P < 0.05$ for bilateral contrast. All of the analyses were performed with SPSS software, version 22.0.

Results

The present analysis was conducted in 1868 participants, of whom 930 (430 men and 500 women) without MetS at baseline developed new-onset MetS during a median follow-up time of 3.24 y (IQR: 1.91–5.80). The mean daily intakes during follow-up were 14.5 mL, 17.1 mL, 29.3 mL, and 16.6 mL for SSBs, artificially sweetened beverages, natural fruit juices, and bottled fruit juices, respectively.

The baseline characteristics of the population in terms of total consumption of SSBs are shown in **Table 1**. Compared with those in the lowest category, participants in the highest category of SSB consumption were younger and presented higher diastolic blood pressure and TG concentrations. Those who consumed more SSBs also showed lower adherence to the Mediterranean diet and consumed less fruit and more baked products, alcohol, and total energy than did participants who consumed <3 servings/mo. The baseline characteristics of the population in terms of artificially sweetened beverages, natural fruit juices, and bottled fruit juices are shown in **Supplemental Tables 1–3**, respectively.

Table 2 shows the multivariable-adjusted HRs (95% CIs) for MetS incidence for mean servings of various beverages during follow-up. After adjusting for potential confounders, individuals who consumed >5 servings total SSBs/wk had a higher risk of MetS (HR: 1.43; 95% CI: 1.00, 2.15; *P*-trend = 0.27) than those who consumed <1 serving/wk. A positive association was also found between consumption of artificially sweetened beverages and incidence of MetS for participants who consumed >5 servings/wk compared with those who consumed <1 serving/wk (HR: 1.74; 95% CI: 1.26, 2.41; *P*-trend = 0.004). An average consumption of 1–5 servings natural fruit juices/wk during follow-up was associated with a decreased risk of MetS (HR: 0.77; 95% CI: 0.65, 0.93). However, the risk was higher when consumption was >5 servings/wk (HR: 1.30; 95% CI: 1.00, 1.69; *P*-trend = 0.39). An average consumption of 1–5 servings of bottled fruit juices/wk was inversely associated with MetS incidence (HR: 0.66; 95% CI: 0.53, 0.81). However, when intake was >5 servings/wk the association was positive (HR: 1.14; 95% CI: 1.04, 1.65; *P*-trend = 0.311).

The association between average beverage consumption during follow-up and components of MetS is presented in **Table 3**. Consumption of >5 servings SSBs/wk was associated with a higher risk of low HDL cholesterol (HR: 1.18; 95% CI: 1.06, 2.11; *P*-trend = 0.71) and high blood pressure (HR: 1.09; 95% CI: 1.04, 2.80; *P*-trend = 0.39) than was consumption of <1 serving/wk. Individuals who consumed 1–5 servings SSBs/wk also had a higher risk of high blood pressure than did those who rarely consumed SSBs (HR: 1.89; 95% CI: 1.14, 3.13). Consumption of >5 servings artificially sweetened beverages/wk was associated with an increased risk of developing abdominal obesity (HR: 1.82; 95% CI: 1.13, 2.92; *P*-trend = 0.039) and the hypertriglyceridemia component of MetS (HR: 1.52; 95% CI: 1.00, 2.37; *P*-trend = 0.08). The results for the hypertriglyceridemia component were similar for bottled fruit juices when consumption during follow-up was >5 servings/wk (HR: 1.51; 95% CI: 1.03, 2.46; *P*-trend = 0.23). A positive association between the intake of >5 servings natural fruit juices/wk and abdominal obesity was also observed (HR: 1.52; 95% CI: 1.02, 2.25; *P*-trend = 0.08).

Discussion

In the present longitudinal analysis conducted in a middle-aged and elderly Mediterranean population at high risk of CVD, we evaluated the consumption of SSBs, artificially sweetened beverages, natural fruit juices, and bottled fruit juices and their association with the risk of MetS. The results showed that participants who consumed >5 servings/wk of all of these types of beverage had an increased risk of MetS.

Those participants who consumed >5 servings SSBs/wk during follow-up had a 43% higher risk of developing MetS than those who did not consume or rarely consumed SSBs. These results are consistent with the meta-analysis by Malik et al. (24) of studies on different races and ethnicities in which individuals in the highest category of SSB intake showed a 20% greater risk of MetS than those in the lowest category. In contrast, our results are not in agreement with the findings of the only study not included in the meta-analysis by Malik et al. and conducted in a Mediterranean population [the SUN (Seguimiento Universidad de Navarra) cohort] in which no association was reported between baseline intake of SSBs and risk of MetS (20). These discrepancies may be due to differences in the age and type of participants. Frequent consumption of SSBs has been related to an increased risk of weight gain and obesity due to the high amount of added sugar, which, when consumed in liquid form, shows a lack of satiety signals (35–37). Most SSBs contain high amounts of fructose, and various studies suggest that high-fructose corn syrup, the primary sweetener used in SSBs, may have particularly deleterious metabolic effects (38), because it increases the risk of both low HDL-cholesterol concentrations (39, 40) and hypertension (21, 23), MetS components that in our study were related to the consumption of SSBs. Furthermore, consumption of high-fructose corn syrup has also been related to other components of MetS such as insulin resistance (41, 42) and hypertriglyceridemia (39, 43). However, in the present cohort study, these metabolic abnormalities were not significantly related to SSB consumption.

To the best of our knowledge, the present analysis is the first to show a positive relation between consumption of natural and bottled fruit juice analyzed separately and the incidence of MetS. In our study, consumption of 1–5 servings fruit juice/wk, regardless of whether natural or bottled (containing added sugar or not), was inversely related to incident MetS. However, when consumption of both types of fruit juice was >5 servings/wk, the association was positive and the risk of MetS increased. The lack of a dose response might be due to the high content of antioxidants in fruit juices, which counteracts the possible harmful effects of the sugar content when these beverages are consumed in small amounts (44). However, as observed in the present study, when fruit juices are consumed frequently, this inverse response may disappear, thus increasing the risk of MetS.

The observed association between fruit juice consumption and MetS could be attributed to an associated unhealthy lifestyle. Individuals with a higher intake of sweetened beverages, including SSBs and fruit juices, are known to have higher intakes of fat and sugar-rich products and lower intakes of fiber, and they tend to be less physically active (45, 46). However, we adjusted our analyses for such confounding factors and still observed a significant association between consumption of fruit juices and MetS incidence. In addition, consumption of fruit in liquid form has been associated with a lower degree of energy compensation than when fruit is consumed in solid form, thus promoting the overconsumption of energy. In other words, energy intake in subsequent meals is not adjusted to previous consumption (47, 48). Therefore, fruit juice consumption seems to induce less satiety than solid fruit (20).

Epidemiologic studies have suggested that there is an association between the regular intake of sweetened beverages and risk of T2D (24, 49). We found no association between consumption of any of the beverages analyzed and impaired glucose metabolism. Furthermore, concentrations of baseline fasting glucose tended to be lower in the highest category of consumption. Similar results were also observed by other authors (16), which may be due to reverse causation, because patients aware of their hyperglycemia may reduce their consumption of beverages containing sugar.

TABLE 1 Baseline characteristics of the study participants by servings of sugar-sweetened beverages[1]

	Servings (200 mL)			
	<1/wk (*n* = 1601)	1–5/wk (*n* = 184)	>5/wk (*n* = 83)	P^2
Sugar-sweetened beverage intake, mL/d	1.6 ± 4.4	51.9 ± 28.1	254 ± 127	
Age, y	67.1 ± 6.1	65.0 ± 5.6	67.0 ± 6.4	<0.001
Women, % (*n*)	52.8 (846)	51.6 (95)	47.0 (39)	0.56
Waist circumference, cm				
Women	91.7 ± 10.4	96.3 ± 10.8	95.4 ± 10.8	<0.001
Men	97.7 ± 7.6	99.9 ± 7.9	98.5 ± 7.7	0.041
BMI, kg/m^2	28.2 ± 3.5	29.3 ± 3.6	28.8 ± 3.2	<0.001
Leisure-time physical activity, MET-min/d	275 ± 252	269 ± 282	269 ± 231	0.93
Smoking habit, % (*n*)				0.62
Never	58.9 (943)	57.6 (106)	51.8 (43)	
Current	15.2 (244)	17.4 (32)	20.5 (17)	
Former	25.9 (414)	25.0 (46)	27.7 (23)	
Blood pressure, mm Hg				
Systolic	146 ± 20.3	144 ± 21.3	148 ± 22.4	0.28
Diastolic	81.8 ± 10.6	82.8 ± 11.2	84.6 ± 12.0	0.040
Biochemical variables, mg/dL				
Plasma glucose	105 ± 35.0	96.3 ± 21.2	92.8 ± 15.6	<0.001
Serum HDL cholesterol	58.6 (51.0–68.0)	56.0 (48.8–65.0)	57.0 (50.9–67.0)	0.047
Serum TGs	95.0 (74.0–118)	99.0 (74.2–125)	108 (74.0–130)	0.035
Use of medication, % (*n*)				
Oral antidiabetic drugs	15.6 (249)	6.5 (12)	8.4 (7)	0.001
Fibrates	0.1 (1)	0 (0)	0 (0)	0.92
Antihypertensive agents	64.8 (1037)	66.3 (122)	71.1 (59)	0.75
Insulin	5.0 (80)	0.0 (0)	1.2 (1)	0.002
MetS components,[3] % (*n*)				
Abdominal obesity	42.4 (674)	55.2 (100)	48.2 (40)	0.003
Hypertriglyceridemia	4.7 (75)	7.6 (14)	9.6 (8)	0.042
Low HDL cholesterol	2.7 (43)	3.8 (7)	7.2 (6)	0.049
High blood pressure	87.1 (1393)	85.3 (157)	90.4 (75)	0.52
High fasting glucose	33.8 (539)	21.4 (39)	13.3 (11)	<0.001
Intervention group, % (*n*)				0.16
Mediterranean diet + EVOO	35.1 (562)	34.8 (64)	24.1 (20)	
Mediterranean diet + nuts	33.6 (538)	35.9 (66)	45.8 (38)	
Control group	31.3 (501)	29.3 (54)	30.1 (25)	
Mediterranean diet score (14-point score)	9.0 ± 1.9	8.7 ± 1.9	7.8 ± 2.0	<0.001
Total energy intake, kcal/d	2295 ± 521	2447 ± 569	2579 ± 551	<0.001
Food consumption, g/d				
Vegetables	338 ± 142	343 ± 171	322 ± 144	0.56
Fruit	386 ± 209	380 ± 200	312 ± 188	0.007
Legumes	21 ± 14	20 ± 14	20 ± 10	0.52
Dairy products	390 ± 228	379 ± 215	368 ± 263	0.58
Total meat	129 ± 57	132 ± 58	134 ± 66	0.59
Fish	102 ± 47	104 ± 45	102 ± 44	0.88
Cereals	230 ± 103	237 ± 108	223 ± 108	0.51
Bakery	22 ± 28	31 ± 33	34 ± 33	<0.001
Nuts	12 ± 15	11 ± 11	11 ± 15	0.45
Total olive oil	42 ± 17	41 ± 17	40 ± 19	0.48
Alcohol	10 ± 15	11 ± 14	14 ± 19	0.027

[1] Continuous variables are expressed as means ± SDs or as medians (IQRs); categorical variables are expressed as percentages (*n*). EVOO, extra-virgin olive oil; MET-min, metabolic equivalent task-minutes; MetS, metabolic syndrome.
[2] *P* values for differences between categories were calculated by using chi-square tests for categorical variables and ANOVA tests for continuous variables.
[3] Definition of MetS components: abdominal obesity for European individuals (waist circumference ≥88 cm in women and ≥102 cm in men), hypertriglyceridemia (≥150 g/dL) or drug treatment for high plasma TG concentration, low HDL cholesterol (<50 mg/dL in women and <40 mg/dL in men), high blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg) or antihypertensive drug treatment, or high fasting glucose (≥100 mg/dL) or drug treatment for type 2 diabetes.

In this longitudinal analysis, individuals who consumed >5 servings artificially sweetened beverages/wk presented a 74% higher risk of MetS than did those who rarely consumed these beverages. This association can be explained by the fact that, in the present study, hypertriglyceridemia and abdominal obesity, both components of MetS, were also observed to be associated

TABLE 2 HRs (95% CIs) for MetS incidence by servings of sugar- and artificially sweetened beverages and fruit juices in the PREDIMED cohort[1]

	Servings (200 mL)			
	<1/wk	1–5/wk	>5/wk	*P*-trend
Sugar-sweetened beverages[2]				
MetS incidence, %	48.6	54.9	69.0	0.010
Crude model	1 (ref)	1.06 (0.87, 1.30)	1.81 (1.24, 2.64)	0.004
Adjusted model 1	1 (ref)	0.98 (0.80, 1.19)	1.87 (1.28, 2.73)	0.010
Adjusted model 2	1 (ref)	0.93 (0.76, 1.13)	1.38 (0.93, 2.07)	0.30
Fully adjusted model	1 (ref)	0.91 (0.74, 1.12)	1.43 (1.00, 2.15)	0.27
Artificially sweetened beverages[3]				
MetS incidence, %	49.0	49.7	71.7	0.003
Crude model	1 (ref)	0.93 (0.75, 1.16)	2.15 (1.57, 2.94)	<0.001
Adjusted model 1	1 (ref)	0.95 (0.76, 1.18)	2.02 (1.47, 2.78)	<0.001
Adjusted model 2	1 (ref)	0.94 (0.76, 1.18)	1.97 (1.43, 2.71)	<0.001
Fully adjusted model	1 (ref)	0.93 (0.75, 1.17)	1.74 (1.26, 2.41)	0.004
Natural fruit juices[4]				
MetS incidence, %	51.4	42.8	53.2	0.009
Crude model	1 (ref)	0.73 (0.62, 0.87)	1.10 (0.86, 1.42)	0.64
Adjusted model 1	1 (ref)	0.71 (0.60, 0.85)	1.13 (0.88, 1.46)	0.69
Adjusted model 2	1 (ref)	0.75 (0.63, 0.89)	1.22 (0.94, 1.59)	0.75
Fully adjusted model	1 (ref)	0.77 (0.65, 0.93)	1.30 (1.00, 1.69)	0.39
Bottled fruit juices[5]				
MetS incidence, %	50.7	40.3	69.8	<0.001
Crude model	1 (ref)	0.71 (0.58, 0.87)	1.80 (1.28, 2.53)	0.24
Adjusted model 1	1 (ref)	0.68 (0.56, 0.84)	1.60 (1.13, 2.27)	0.63
Adjusted model 2	1 (ref)	0.64 (0.52, 0.78)	1.26 (1.08, 1.81)	0.46
Fully adjusted model	1 (ref)	0.66 (0.53, 0.81)	1.14 (1.04, 1.65)	0.31
Total sweetened beverages[6]				
MetS incidence, %	53.2	43.2	53.8	<0.001
Crude model	1 (ref)	0.69 (0.59, 1.80)	1.00 (0.84, 1.19)	0.880
Adjusted model 1	1 (ref)	0.66 (0.57, 1.77)	0.97 (0.81, 1.15)	0.575
Adjusted model 2	1 (ref)	0.67 (0.56, 1.79)	0.88 (0.73, 1.06)	0.160
Fully adjusted model	1 (ref)	0.69 (0.59, 1.81)	0.90 (0.74, 1.09)	0.227

[1] Consumption data are means determined during the follow-up period. Model 1 adjusted for intervention group, age in years, sex, leisure-time physical activity (metabolic equivalent tasks/d), BMI (kg/m^2), and smoking status (never, former, or current). Model 2 additionally adjusted for cumulative average consumption of dietary variables in continuous (vegetables, legumes, fruit, cereals, meat, fish, bakery, dairy products, olive oil, and nuts), cumulative total energy intake, alcohol, and alcohol squared in grams per day. Model 3 (fully adjusted model): additionally adjusted for MetS components at baseline (yes or no). MetS, metabolic syndrome; PREDIMED, Prevención con Dieta Mediterránea; ref, reference.

[2] *n* = 1610, 216, and 42 for <1 serving/wk, 1–5 servings/wk, and >5 servings/wk, respectively.

[3] *n* = 1625, 183, and 60 for <1 serving/wk, 1–5 servings/wk, and >5 servings/wk, respectively.

[4] *n* = 1361, 381, and 126 for <1 serving/wk, 1–5 servings/wk, and >5 servings/wk, respectively.

[5] *n* = 1547, 268, and 53 for <1 serving/wk, 1–5 servings/wk, and >5 servings/wk, respectively.

[6] *n* = 841, 657, and 370 for <1 serving/wk, 1–5 servings/wk, and >5 servings/wk, respectively.

with a higher consumption of this type of beverage. These results concur with those recently reported by Crichton et al. (5), which showed that Americans who consumed ≥1 serving artificially sweetened beverages/d had 2.2 times the risk of MetS than did those who rarely consumed this type of beverage. Similar results were found by the same authors in the Luxembourg cohort of healthy individuals who consumed ≥2 servings artificially sweetened beverages/d (5). Cross-sectional and longitudinal analyses in the Framingham Heart Study cohort also reported a positive association between consumption of 1 serving artificially sweetened beverages/d and MetS (23). To date, it has been suggested that 3 mechanisms may explain these associations: *1*) artificial sweeteners can interfere with learned responses that help to control glucose and energy homeostasis (50), *2*) artificial sweeteners interact with sweet-taste receptors that are expressed throughout the digestive system and that may play a role in glucose absorption and trigger insulin secretion (21), and *3*) artificial sweeteners (e.g., saccharin, sucralose, or aspartame) can interfere with the gut microbiota, thus decreasing glucose sensitivity and favoring MetS development (21, 50–52).

Our study has several strengths: it uses yearly repeated measurements of diet as exposure, and data are adjusted for a sizable number of potential confounders. However, it also has some limitations. First, the incidence of MetS was not a primary endpoint of the PREDIMED cohort, so our results are only exploratory. Second, our study subjects were elderly individuals at high risk of CVD, making it difficult to generalize the results to other populations. Third, consumption of the various types of SSBs was very low among our participants, so the categories of consumption were heterogeneous with respect to the number of participants, and the attributable risk associated with the consumption of sweetened beverages is also low. In addition, the frequency of SSBs in the highest category of consumption in our

TABLE 3 HRs (95% CIs) for incidence of MetS components by servings of sugar- and artificially sweetened beverages and fruit juices in the PREDIMED cohort[1]

		Servings (200 mL)			
	Incidence, %	<1/wk	1–5/wk	>5/wk	*P*-trend
Abdominal obesity (*n* = 1019)					
Sugar-sweetened beverages	48.6	1 (ref)	1.13 (0.81, 1.57)	1.20 (0.62, 2.30)	0.42
Artificially sweetened beverages	50.0	1 (ref)	0.91 (0.65, 1.28)	1.82 (1.13, 2.92)	0.039
Natural fruit juices	46.9	1 (ref)	0.97 (0.76, 1.24)	1.52 (1.02, 2.25)	0.08
Bottled fruit juices	41.5	1 (ref)	0.96 (0.72, 1.29)	0.46 (0.21, 1.03)	0.08
Total sweetened beverages	45.8	1 (ref)	0.94 (0.75, 1.17)	1.23 (0.93, 1.62)	0.164
Hypertriglyceridemia (*n* = 1766)					
Sugar-sweetened beverages	35.3	1 (ref)	1.22 (0.94, 1.59)	1.48 (0.87, 2.53)	0.06
Artificially sweetened beverages	31.6	1 (ref)	0.99 (0.73, 1.33)	1.52 (1.00, 2.37)	0.08
Natural fruit juices	27.3	1 (ref)	0.81 (0.63, 1.03)	1.16 (0.80, 1.68)	0.85
Bottled fruit juices	30.8	1 (ref)	0.94 (0.72, 1.22)	1.51 (1.03, 2.46)	0.23
Total sweetened beverages	28.4	1 (ref)	0.75 (0.60,1.03)	1.13 (0.88, 1.45)	0.344
Low HDL cholesterol (*n* = 1804)					
Sugar-sweetened beverages	28.0	1 (ref)	0.97 (0.72, 1.29)	1.18 (1.06, 2.11)	0.71
Artificially sweetened beverages	26.1	1 (ref)	0.92 (0.66, 1.27)	1.08 (0.66, 1.78)	0.87
Natural fruit juices	22.1	1 (ref)	0.84 (0.65, 1.08)	0.74 (0.47, 1.16)	0.11
Bottled fruit juices	25.2	1 (ref)	0.77 (0.57, 1.04)	1.08 (0.62, 1.85)	0.63
Total sweetened beverages	23.9	1 (ref)	0.76 (0.61, 1.04)	0.66 (0.49, 1.08)	0.003
High blood pressure (*n* = 240)					
Sugar-sweetened beverages	86.2	1 (ref)	1.89 (1.14, 3.13)	1.09 (1.04, 2.80)	0.39
Artificially sweetened beverages	74.4	1 (ref)	0.91 (0.51, 1.62)	1.00 (0.45, 2.20)	0.92
Natural fruit juices	83.6	1 (ref)	1.11 (0.73, 1.68)	1.04 (0.58, 1.86)	0.82
Bottled fruit juices	80.2	1 (ref)	0.94 (0.57, 1.54)	2.18 (0.74, 6.42)	0.31
Total sweetened beverages	81.8	1 (ref)	1.06 (0.71, 1.57)	1.22 (0.79, 1.91)	0.360
High fasting glucose (*n* = 1269)					
Sugar-sweetened beverages	44.7	1 (ref)	1.03 (0.80, 1.33)	1.02 (0.61, 1.70)	0.88
Artificially sweetened beverages	42.5	1 (ref)	0.87 (0.65, 1.17)	1.66 (0.97, 2.85)	0.24
Natural fruit juices	41.1	1 (ref)	0.80 (0.63, 1.00)	1.18 (0.84, 1.65)	0.74
Bottled fruit juices	44.4	1 (ref)	0.69 (0.53, 1.90)	1.15 (0.69, 1.91)	0.45
Total sweetened beverages	41.7	1 (ref)	0.77 (0.63, 1.05)	0.96 (0.74, 1.23)	0.781

[1] Consumption data are means determined during the follow-up period. All of the data shown were adjusted for intervention group, age in years, sex, leisure-time physical activity (metabolic equivalent tasks/d), BMI (kg/m^2), smoking status (never, former, or current), average consumption during the follow-up of dietary variables as continuous variables (vegetables, legumes, fruit, cereals, meat, fish, baked products, dairy products, olive oil, and nuts), average total energy intake during follow-up, alcohol, and alcohol squared in grams per day. MetS, metabolic syndrome; PREDIMED, Prevención con Dieta Mediterránea; ref, reference.

population was low; therefore, even if the associations observed are causal, the implications for intervention are limited to a few individuals. Fourth, because of the limited number of individuals in the highest categories of consumption and the adjustment for many variables, it is not clear that all of the models of SSBs and bottled fruit juices are robust enough. Fifth, although the types of beverage and food consumption were assessed with a validated FFQ, measurement errors might have occurred. Nevertheless, to minimize the measurement error caused by within-person variations, the average consumption during the follow-up was calculated. Finally, although individual laboratory methods and procedures were subject to quality control, the fact that biochemical measurements were made in different centers means that we cannot discount a certain degree of measurement bias between laboratories, because the measurements were not standardized. Even so, the concordance analysis of lipid and glucose measurements revealed correlation coefficients >0.81.

The present study is the first, to our knowledge, to make a separate analysis of the association between categories of each type of sweetened beverage and MetS risk. Occasional consumption (1–5 servings/wk) of SSBs and artificially sweetened beverages was not associated with overall MetS. Consumption of >5 servings/wk of all of the types of beverages analyzed was associated with an increased risk of MetS and some of its components in middle-aged and elderly individuals at high risk of CVD. However, these associations (especially in the case of SSBs and bottled fruit juices) should be interpreted with caution because of the low frequency of consumption in our population. Furthermore, consumption of 1–5 servings of natural and bottled fruit juices/wk may reduce the risk of MetS.

Acknowledgments

DC, RE, ER, M Fitó, LS-M, FA, and JS-S designed the PREDIMED study; CF-P, NB, MB-R, DC, RE, ER, M Fitó, LS-M, FA, M Fiol, JMS-L, CM-B, XP, MR-C, and JS-S conducted the research; CF-P and NB analyzed the data; CF-P, NB, and JS-S wrote the manuscript; DC, RE, ER, M Fitó, and LS-M were the coordinators of subject recruitment and follow-up at the outpatient clinics; and NB and JS-S had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

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Supplemental Table 1. Baseline characteristics of the study participants according to servings (200mL) of artificially-sweetened beverages[1]

	Servings (200mL) of artificially-sweetened beverages			
	<1/ week (*n*=1648)	1-5/ week (*n*=137)	> 5/ week (*n*=83)	*P*-value[2]
Artificially-sweetened beverage intake (mL/d)	0.7 ± 3.0	58.6 ± 28.6	294 ± 210	
Age, years	67.0 ± 6.2	66.2 ± 5.7	66.2 ± 5.2	0.18
Women, % (n)	52.5 (866)	53.3 (73)	49.4 (41)	0.84
Waist circumference, cm				
Women	92.0 ± 10.5	93.4 ± 10.8	97.1 ± 9.8	0.007
Men	97.9 ± 7.4	99.7 ± 10.1	96.7 ± 6.4	0.10
BMI, kg/m^2	28.3 ± 3.5	28.9 ± 3.7	28.5 ± 3.8	0.16
Leisure time physical activity, METs-min/d	275 ± 253	254 ± 231	287 ± 305	0.58
Smoking habit, % (n)				0.81
Never	58.3 (960)	57.7 (79)	63.9 (53)	
Current	16.0 (263)	14.6 (20)	12.0 (10)	
Former	25.8 (425)	27.7 (38)	24.1 (20)	
Blood pressure, mmHg				
Systolic	146 ± 20.4	147 ± 21.5	146 ± 20.7	0.95
Diastolic	81.9 ± 10.7	83.2 ± 10.1	83.0 ± 12.4	0.26
Biochemical parameters, mg/dL				
Plasma glucose	104 ± 33.0	102 ± 29.6	109 ± 45.1	0.30
Serum HDL-Cholesterol	58.0 [51.0-68.0]	57.0 [50.0-66.4]	58.0 [49.0-66.8]	0.79
Serum triglycerides	96.0 [75.0-119]	91.0 [70.0-123]	95.0 [74.5-119]	0.83
Use of medication, % (n)				
Oral anti-diabetic drugs	13.8 (227)	19.1 (26)	18.1 (15)	0.14
Fibrates	0.1 (1)	0.0 (0)	0.0 (0)	0.93
Antihypertensive agents	66.0 (1088)	60.6 (83)	56.6 (47)	0.18
Insulin	4.4 (72)	2.2 (3)	7.2 (6)	0.21
Metabolic Syndrome components, % (n)[3]				
Abdominal obesity	42.9 (702)	53.7 (73)	47.0 (39)	0.044
Hypertriglyceridemia	5.3 (87)	5.8 (8)	2.4 (2)	0.48
Low HDL-cholesterol	2.7 (45)	4.4 (6)	6.0 (5)	0.14
High blood pressure	87.5 (1441)	85.4 (117)	80.7 (67)	0.16
High plasma glucose	31.5 (516)	32.1 (44)	34.9 (29)	0.80
Intervention group, % (n)				0.15
Mediterranean diet + EVOO	35.3 (581)	29.9 (41)	28.9 (24)	
Mediterranean diet + nuts	33.6 (553)	37.2 (51)	45.8 (38)	
Control group	31.2 (514)	32.8 (45)	25.3 (21)	
Mediterranean diet score (14-point score)	8.9 ± 1.9	8.8 ± 1.9	8.6 ± 2.0	0.33
Total energy intake (kcal/d)	2309 ± 529	2455 ± 539	2370 ± 535	0.006
Food consumption (g/d)				
Vegetables	337 ± 147	340 ± 127	350 ± 139	0.72
Fruit	382 ± 207	359 ± 175	414 ± 266	0.16
Legumes	21 ± 13	21 ± 16	20 ± 11	0.83
Dairy products	391 ± 230	370 ± 204	363 ± 221	0.34
Total meat	128 ± 56	141 ± 65	136 ± 73	0.019
Fish	101 ± 46	107 ± 48	110 ± 53	0.10
Cereals	230 ± 104	240 ± 107	217 ± 97	0.28
Baked products	23 ± 28	25 ± 28	29 ± 45	0.15
Nuts	12 ± 15	13 ± 18	14 ± 17	0.28
Total olive oil	42 ± 17	44 ± 18	41 ± 17	0.36
Alcohol	10 ± 15	11 ± 14	11 ± 13	0.50

Abbreviations: BMI, body mass index; EVOO, Extra Virgin Olive Oil; HDL, high-density lipoprotein.

[1]Continuous variables are expressed as means ± standard deviation or median [IQR, interquartile range] and categorical variables as a percentage and number (n).

[2]*P*-values for differences between categories were calculated by chi-square tests for categorical variables and ANOVA tests for continuous variables.

[3]Definition of MetS components: Abdominal obesity for European individuals (waist circumferences ≥88 cm in women and ≥102cm in men), hypertriglyceridemia (≥150 g/dL) or drug treatment for high plasma triglyceride (TG) concentration, low HDL-cholesterol (<50 mg/dL in women and <40 mg/dL in men), high blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg) or antihypertensive drug treatment, or high fasting glucose (≥100 mg/dL) or drug treatment for T2DM.

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Supplemental Table 2. Baseline characteristics of the study participants according to servings (200mL) of bottled fruit juices[1]

	Servings (200mL) of bottled fruit juices			
	<1/ week (*n*=1608)	1-5/ week (*n*=168)	> 5/ week (*n*=92)	*P*-value[2]
Bottled fruit-juice intake (mL/d)	0.9 ± 3.4	58.8 ± 28.6	210 ± 79.1	
Age, years	67.0 ± 6.1	66.7 ± 6.1	66.1 ± 6.5	0.34
Women, % (n)	51.6 (829)	56.5 (95)	60.9 (56)	0.12
Waist circumference, cm				
Women	92.0 ± 10.6	94.1 ± 9.7	93.4 ± 11.5	0.16
Men	97.9 ± 7.6	98.7 ± 7.7	98.3 ± 8.9	0.72
BMI, kg/m^2	28.3 ± 3.4	28.8 ± 3.6	29.1 ± 4.3	0.024
Leisure time physical activity, METs-min/d	277 ± 254	238 ± 243	292 ± 259	0.13
Smoking habit, % (n)				0.54
Never	58.1 (934)	63.7 (107)	55.4 (51)	
Current	15.7 (253)	13.1 (22)	19.6 (18)	
Former	26.2 (421)	23.2 (39)	25.0 (23)	
Blood pressure, mmHg				
Systolic	146 ± 20.6	147 ± 20.2	144 ± 19.6	0.41
Diastolic	81.9 ± 10.7	83.9 ± 10.8	81.0 ± 10.9	0.042
Biochemical parameters, mg/dL				
Plasma glucose	105 ± 34.1	99.1 ± 26.9	99.9 ± 31.9	0.06
Serum HDL-Cholesterol	58.0 [50.8-67.6]	57.0 [51.0-66.0]	58.0 [51.0-68.5]	0.98
Serum triglycerides	96.0 [74.0-120]	98.5 [77.2-120]	93.5 [78.5-117]	0.83
Use of medication, % (n)				
Oral anti-diabetic drugs	15.0 (240)	11.3 (19)	9.8 (9)	0.19
Fibrates	0.1 (1)	0 (0)	0 (0)	0.92
Antihypertensive agents	65.0 (1045)	66.7 (112)	66.3 (61)	0.95
Insulin	4.7 (76)	1.8 (3)	2.2 (2)	0.12
Metabolic Syndrome components, % (n)[3]				
Abdominal obesity	42.7 (683)	51.5 (86)	50.0 (45)	0.046
Hypertriglyceridemia	5.2 (84)	6.0 (10)	3.3 (3)	0.64
Low HDL-cholesterol	3.0 (49)	3.0 (5)	2.2 (2)	0.89
High blood pressure	87.2 (1400)	86.9 (146)	85.9 (79)	0.93
High fasting glucose	32.6 (521)	23.8 (40)	30.8 (28)	0.07
Intervention group, % (n)				0.001
Mediterranean diet + EVOO	33.8 (543)	47.6 (80)	25.0 (23)	
Mediterranean diet + nuts	34.7 (558)	26.2 (44)	43.5 (40)	
Control group	31.5 (507)	26.2 (44)	31.5 (29)	
Mediterranean diet score (14-point score)	9.0 ± 1.9	8.8 ± 2.0	8.5 ± 2.0	0.030
Total energy intake (kcal/d)	2307 ± 534	2404 ± 508	2444 ± 507	0.006
Food consumption (g/d)				
Vegetables	339 ± 146	330 ± 126	330 ± 160	0.66
Fruit	383 ± 206	373 ± 196	381 ± 254	0.84
Legumes	21 ± 12	22 ± 17	27 ± 27	<0.001
Dairy products	384 ± 230	397 ± 200	444 ± 232	0.042
Total meat	130 ± 57	130 ± 60	120 ± 57	0.29
Fish	102 ± 46	101 ± 47	98 ± 50	0.68
Cereals	232 ± 10	224 ± 98	206 ± 97	0.051
Baked products	22 ± 28	28 ± 34	29 ± 37	0.008
Nuts	12 ± 15	13 ± 17	12 ± 15	0.60
Total olive oil	42 ± 17	39 ± 17	39 ± 20	0.034
Alcohol	10 ± 15	7 ± 11	9 ± 15	0.006

Abbreviations: BMI, body mass index; EVOO, Extra Virgin Olive Oil; HDL, high-density lipoprotein.
[1]Continuous variables are expressed as means ± standard deviation or median [IQR, interquartile range] and categorical variables as a percentage and number (n).
[2]*P*-values for differences between categories were calculated by chi-square tests for categorical variables and ANOVA tests for continuous variables.
[3]Definition of MetS components: Abdominal obesity for European individuals (waist circumferences ≥88 cm in women and ≥102cm in men), hypertriglyceridemia (≥150 g/dL) or drug treatment for high plasma triglyceride (TG) concentration, low HDL-cholesterol (<50 mg/dL in women and <40 mg/dL in men), high blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg) or antihypertensive drug treatment, or high fasting glucose (≥100 mg/dL) or drug treatment for T2DM.

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Supplemental Table 3. Baseline characteristics of the study participants according to servings (200mL) of natural fruit juices[1]

	Servings (200mL) of natural fruit juices			
	<1/ week (*n*=1457)	1-5/ week (*n*=228)	> 5/ week (*n*=183)	*P*-value[2]
Natural fruit-juice intake (mL/d)	1.7 ± 4.7	62.5 ± 28.6	210 ± 66.1	
Age, years	67.1 ± 6.1	65.8 ± 5.9	66.9 ± 6.0	0.011
Women, % (n)	51.1 (745)	57.5 (131)	56.8 (104)	0.09
Waist circumference, cm				
Women	92.5 ± 10.6	91.7 ± 10.6	91.8 ± 10.4	0.63
Men	98.0 ± 7.6	97.7 ± 8.1	98.6 ± 7.6	0.74
BMI, kg/m^2	28.4 ± 3.5	28.2 ± 3.6	28.3 ± 3.5	0.89
Leisure time physical activity, METs-min/d	274 ± 253	286 ± 265	262 ± 249	0.62
Smoking habit, % (n)				0.59
Never	58.4 (851)	57.0 (130)	60.7 (111)	
Current	15.8 (230)	18.0 (41)	12.0 (22)	
Former	25.8 (376)	25.0 (57)	27.3 (50)	
Blood pressure, mmHg				
Systolic	147 ± 20.9	144 ± 19.3	145 ± 18.9	0.15
Diastolic	81.9 ± 10.9	82.1 ± 10.8	82.6 ± 9.7	0.72
Biochemical parameters, mg/dL				
Plasma glucose	105 ± 35.0	101 ± 29.7	98.2 ± 23.2	0.011
Serum HDL-Cholesterol	58.0 [50.4-67.0]	59.5 [52.0-68.0]	59.0 [52.0-68.2]	0.19
Serum triglycerides	96.0 [74.9-120]	96.5[77.0-121]	93.0 [72.0-114]	0.37
Use of medication, % (n)				
Oral anti-diabetic drugs	15.6 (227)	12.7 (29)	6.6 (12)	0.003
Fibrates	0 (0)	0.4 (1)	0 (0)	0.027
Antihypertensive agents	64.6 (941)	64.9 (148)	70.5 (129)	0.51
Insulin	4.8 (70)	2.6 (6)	2.7 (5)	0.17
Metabolic Syndrome components, % (n)[3]				
Abdominal obesity	43.0 (623)	46.2 (104)	48.1 (87)	0.32
Hypertriglyceridemia	5.6 (81)	4.4 (10)	3.3 (6)	0.36
Low HDL-cholesterol	2.8 (41)	2.6 (6)	4.9 (9)	0.27
High blood pressure	86.8 (1263)	87.7 (200)	88.5 (162)	0.77
High plasma glucose	33.1 (480)	29.2 (66)	23.6 (43)	0.024
Intervention group, % (n)				0.44
Mediterranean diet + EVOO	34.1 (497)	36.8 (84)	35.5 (65)	
Mediterranean diet + nuts	33.8 (492)	36.8 (84)	36.1 (66)	
Control group	32.1 (468)	26.3 (60)	28.4 (52)	
Mediterranean diet score (14-point score)	8.8 ± 1.9	9.0 ± 2.1	9.5 ± 1.8	<0.001
Total energy intake (kcal/d)	2294 ± 531	2398 ± 511	2461 ± 533	<0.001
Food consumption (g/d)				
Vegetables	330 ± 141	354 ± 143	377 ± 171	<0.001
Fruit	375 ± 208	373 ± 185	450 ± 220	<0.001
Legumes	20 ± 12	23 ± 18	24 ± 16	<0.001
Dairy products	382 ± 226	398 ± 222	422 ± 249	0.07
Total meat	130 ± 57	129 ± 58	119 ± 56	0.05
Fish	100 ± 45	109 ± 48	113 ± 47	<0.001
Cereals	234 ± 106	215 ± 92	217 ± 100	0.008
Baked products	23 ± 30	26 ± 25	23 ± 24	0.27
Nuts	11 ± 15	14 ± 16	15 ± 17	0.002
Total olive oil	42 ± 17	40 ± 18	43 ± 17	0.39
Alcohol	10 ± 15	10 ± 15	9 ± 12	0.61

Abbreviations: BMI, body mass index; EVOO, Extra Virgin Olive Oil; HDL, high-density lipoprotein.
[1]Continuous variables are expressed as means ± standard deviation or median [IQR, interquartile range] and categorical variables as a percentage and number (n).
[2]*P*-values for differences between categories were calculated by chi-square tests for categorical variables and ANOVA tests for continuous variables.
[3]Definition of MetS components: Abdominal obesity for European individuals (waist circumferences ≥88 cm in women and ≥102cm in men), hypertriglyceridemia (≥150 g/dL) or drug treatment for high plasma triglyceride (TG) concentration, low HDL-cholesterol (<50 mg/dL in women and <40 mg/dL in men), high blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg) or antihypertensive drug treatment, or high fasting glucose (≥100 mg/dL) or drug treatment for T2DM.

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7. DISCUSSION

7. DISCUSSION

Beverage intake has been recognized as an important issue in the promotion of health and prevention of disease. For this reason, the focus of the present thesis was on three dimensions: the assessment of fluid intake and the evaluation of the association between fluid and beverage intake and lifestyle and its relation with health. First, a fluid-specific assessment questionnaire was designed in Spanish language and validated in a middle-age and elderly Spanish population, for a better beverage assessment. In addition, we assessed the total fluid intake in adults from Spain and other 12 worldwide countries in order to: a) describe and compare the beverage consumption pattern between countries; b) compare the fluid intake coming only from beverages with EFSA fluid adequate intake values; c) compare the free-sugar coming only from beverages with the WHO recommendations; and d) describe the associations between the beverage consumption and some lifestyle variables, such as MedDiet adherence and physical activity practice. Additionally we analysed the association between the frequency of consumption of sweetened beverages and MetS incidence in middle-age and elderly individuals at high CVD risk.

7.1. A new method for assessing fluid intake: The Spanish fluid-specific assessment questionnaire

Given the difficulty to assess fluid consumption of population and because there is not any validate tool to assess it, we designed the first fluid-specific questionnaire in Spanish language and validated in PREDIMED-PLUS cohort. Throughout the present thesis we found that in the articles published assessing fluid intake have been used different methodologies and tools, conducting probably to the controversial results observed [203,316,317]. Due to the difficulties found in assessing the real fluid pattern, we tried to fill the need of a unique and valid method exclusive for fluid intake assessment. For this reason, we designed a fluid-specific questionnaire aimed to measure the habitual consumption of drinking water and different types of beverage in Spanish adults. We report for the first time that the use of a fluid-specific questionnaire in Spanish language and designed for the Spanish population seems to be highly repeatable, and relatively valid for estimating the daily intake of water from beverages. This tool may be useful for clinicians and researchers interested in assessing habitual water-drinking and beverage-consumption patterns, particularly in large-scale investigations, in which other resource-intensive dietary intake assessment techniques are not so accurate [36]. Although the present fluid-specific questionnaire is the only one validated in Spanish, other questionnaires designed to evaluate beverage intake have been published and validated by a variety of different methods [34,36,37,318]. However, to date and to the best of our knowledge, only one questionnaire has been validated using hydration indices with 24-hour urine samples [29]. In 2012, Malisova and colleagues developed a "water balance questionnaire", designed to evaluate water drinking and also water intake from solids and other beverages [29]. The validity and reliability of the Spanish fluid-specific assessment questionnaire makes it useful for large-scales surveys, as well as for use by practitioners. This low-resource tool will enable researchers and practitioners to rapidly assess beverages intake, and to determine possible associations of beverage consumption with health related outcomes.

The relative validity and repeatability analysis of the Spanish fluid-specific questionnaire performed within the PREDIMED-PLUS study presents several strengths and potential limitations. The first limitation observed, is that the fluid-specific questionnaire may underestimate certain beverage categories because of the serving sizes established (for example, water intake [tap and bottled]). Besides, due to the fact that our population was middle-aged and elderly presenting MetS, future studies should focus on healthy adults and children and other minorities to determine if the fluid-specific questionnaire is a valid tool across other population groups. Another limitation was the lack of a measure to assure the completeness of the 24 hour urine samples. However, at the moment that urine was brought, we had asked the participants whether they had followed the instructions and whether they had any problem with the collection. A final limitation was the use of frozen samples. It has been suggested that freezing urine samples generates urinary sediments that consist predominantly of endogenous calcium oxalate dehydrate and amorphous calcium crystals [319] and that this may account for the changes in osmolality observed after freezing. However, several studies have shown that the changes in frozen urine osmolality are trivial and physiologically irrelevant, especially because daily variations in urine osmolality are considerably larger than these changes [320,321]. The long-term stability and measurement validity for frozen urine were found to be good without the addition of a preservative. The prospective storage of frozen urine aliquots, even exceeding 10 years, appears to be an acceptable and valid tool in epidemiological settings for subsequent urine analysis [322]. Nevertheless, in the present study we measured osmolality levels in a subsample of urine just after the collection (n=59), without freezing, and no significant differences were found (data not shown).

On the other hand, regarding the relative validity and repeatability analysis of the Spanish fluid-specific questionnaire performed within the PREDIMED-PLUS clinical trial some strengths also deserve comment: The ability to accurately assess the validity and repeatability of a questionnaire relies on having a large sample and using multiple statistical methods, which has been achieved in this present study. The second strength was the use of hydration biomarkers instead of dietary intake methods to determine the validity of the analysis. Biomarkers make it possible to improve validation, as they avoid bias caused by measurement errors (memory of the interviewers, errors in estimating food intake), which impact on the statistical power of the study. Finally, another important strength of the present analysis was that the questionnaire was completed by trained dietitians, which avoided the use of self-reported data and then we significantly reduced the risk of underreporting errors.

7.2. Beverage consumption in 13 countries worldwide, comparison with EFSA total water and WHO free-sugars recommendations and its relation with lifestyle

For the first time, we also described exclusively the fluid and beverage intake in Spanish adult population, and we related it with some lifestyle and demographic variables. We have observed, for the first time that of 1262 Spanish adults from the Liq.In[7] study with a mean age of 43 years old, approximately half of those do not covered the total water intake values recommended by EFSA. Our results are in agreement with those published [323] evaluating fluid consumption in 13 European countries and which show that only Denmark and Germany consumed a mean of at least two litters of water per individual from all types of beverages. In our study, fluid consumption, type of beverage, moment of consumption and the amount of sugar added by hand was assessed with a 24h fluid-specific diary over 7-consecutive days. The same methodology was used in a French study, and both studies found that water consumption represented more than 50% of the total daily fluid intake in all age groups and in both genders [324]. This is important because plain water is regarded as the healthiest option for hydration, and increasing water consumption is a recommended strategy for reducing energy intake [325]. Total fluid intake in our study was non-significantly higher in men than in women, being consistent with the results found by other studies evaluating fluid intake in different populations [30,326,327]. However, we found that the percentage of individuals who met the EFSA recommendations was higher in women than in men (58.4% and 40.8%, respectively). Men generally consumed more of all type of beverages with some exceptions: for example, total water (tap water or mineral water), hot beverages and sweet light beverages, all without or few calories. These finding have also been observed in other populations [328], which suggests that women are more aware of the need to consume fewer calories in the form of drinks to avoid overweight or obesity [329,330]. Because beverages can account for a substantial share of daily calories, we also assessed the percentage of population complying with WHO free-sugar recommendations, and we found that approximately 27% of our study population consumed more sugar than recommended only from the sugar in beverages (intrinsic or added). When we analysed the 13 countries altogether, a mean of 44.5% of the population exceeded the WHO free-sugar recommendations, solely by fluids. These results are alarming if it is taken into account that other studies show that an excessive consumption of calories from sugar has unhealthy effects [212,317,331], and show a clear need to educate adults about the nutritional composition of the different fluids. Age was also an important determinant of the general fluid pattern. As in other studies [324,332,333], the mean total fluid intake in our study progressively decreased as age increased. This can probably be explained by a decrease in the perception of thirst in elderly people [13,334], but social determinants cannot be discounted. The type of beverage consumed also changed with age. We reported for the first time that the intake of milk, juices, and sweetened beverages (sugar or artificially) decreased with age, whereas the intake of hot beverages increased. This decrease in the mean milk intake observed in our population may be partly due to the fact that the percentage of individuals with lactase deficiency is higher in elderly people [335,336]. Furthermore, in the Spanish cohort, we reported for the first time that healthy individuals with the highest scores for MedDiet adherence and higher physical exercise practice presented a healthier beverage pattern. Although our results are in agreement with those reported by other researchers [328,337,338], to the best of our knowledge the present study is the first assessing different types of beverages consumption and total daily fluid intake using a specific questionnaire designed to prospectively record beverage consumption and sugar added by hand to beverages. Individuals engaging in a higher adherence to MedDiet presented a higher consumption of water and red wine and a low intake in SSBs, compared to those in the lowest adherence category. The regular consumption of wine, mainly with meals, and a lower intake of SSBs were considered key elements in defining the traditional MedDiet [297]. Although the cross-sectional design of the analysis, the increased consumption of drinking water in those individuals in the highest category of MedDiet adherence suggests that it must be regarded as another key element when defining the MedDiet in the future. To the best of our knowledge, the possible associations between physical exercise and total fluid intake or different types of beverages consumption have not been subject to a great deal of research among the general populations to date. In our study, individuals who engaged in most physical exercise presented a higher total daily fluid and drinking water consumption, probably due to an increased fluid loss and consequently a higher demand of fluid intake [13,339]. Besides that, individuals who engaged in most physical exercise also consume greater amount of wine, milk and dairy products and fewer SSBs. Although there is no physiological explanation, a higher consumption of milk and dairy products in more active individuals, has also been previously described in some populations [49, 50]. Likewise, as it was previously noted, the moderate intake of wine and the lower consumption of SSBs was perceived in the general population as a healthier lifestyle.

Besides, our study was the first describing that the compliance with the EFSA fluid intake and WHO free-sugars recommendations were mainly associated with a greater adherence to the MedDiet and physical exercise practice. These results suggest that changing the fluid intake would have beneficial effects on other lifestyle parameters. In the analysis including 13 countries worldwide, we found similar results regarding the adherence to the EFSA fluid intake recommendations. We report that less than 50% of the women and approximately 60% of the men from the different countries did not comply with the AI values of water from fluids. Our study is the first that enables total fluid intake to be compared between countries because the same methodology of data recording was used in all the surveys. However, as expected total daily fluid intake was different between each country, and it is difficult to find a physiological reason for these between-country differences. Well-known and described differences in climate conditions (temperature and humidity) between countries probably cannot explain the differences found in our study because some warm countries (where fluid demands should be higher) had lower total fluid intakes than cold ones. However, these differences may be partly explained by the fact that not all surveys were carried out in the same season, even though all surveys aimed to perform data collection during the period of mild climate (spring or autumn). Nevertheless, we cannot discount that other social determinants of fluid intake may explain some of these differences observed [328,340]. As occurred in the Spanish population, no significant differences in total fluid intake between genders were found in most of the 13 countries analysed, however women were more likely to comply with AI of fluid. This adds further weight to the argument that social or educational aspects may play an important role in determining total fluid consumption. However, men and elderly individuals had an increased risk of not complying with the EFSA AI of water from fluids. These results mean that a considerable portion of the study populations would be potentially in risk of hydration-related health consequences such as CKD [341]. This unique compilation of national surveys conducted in large sample of participants from different countries demonstrated that not only the volume, but also the contribution of the different fluid types to TFI varied substantially between countries. Nevertheless, some countries that seems to be geographically linked share similar patterns. The fluid intake of the countries relatively close to the Mediterranean Sea (Spain, France, Turkey and Iran) but also the two Asian countries (Indonesia and China) was characterised by a high contribution of water to TFI, ranging from 47 to 78%. In North European countries (UK, Poland and Germany), the highest contribution to TFI came from hot beverages. The fluid intake of the three countries of Latin America was characterised by a high contribution of juices and SSBs, which is as important as the contribution of water to TFI. One of the possible factors explaining these between-country differences is climate and seasonality, as stated before, however other factors that should be taken into consideration when assessing the between-country variability are cultural and traditional habits, which unfortunately were not evaluated in the present study.

Several strengths and potential limitations of this study need to be addressed. One of the main limitations of the Liq.In^7 study was that the samples analyzed are not fully representative of the general population of the respective countries. Although all samples were randomly selected from a database of volunteers for population-based surveys or through a door-to-door recruitment process using the same quota sample method, which led to a large sample of adults in each country for the stratum considered. Despite this, the final distribution of the individuals studied among age groups, gender, region and educational categories was very similar to the real distribution of the population of each country. The second limitation was its cross-sectional design, which means that no conclusions about cause/effect relationships can be drawn. Third, the fact that anthropometric measures, physical exercise and intake of fluids were self-reported and not registered by a trained dietitian, which may produce some bias. In addition, although fluid intake was assessed in moderate climate temperature conditions (spring and autumn), we cannot assume that total fluid and type of beverage consumed were representative of whole year. Another limitation was that we have only assessed the total fluid intake and no biomarkers of hydration status were used, for this reason no conclusions about the risk of dehydration and health can be drawn. Further, the 24-hours fluid-specific diary over 7 consecutive days must be validated in the future with gold standard methods, so that total fluid intake can be reliably assessed. Finally, sugar and energy content per 100mL of fluid type was used for the estimation of the energy and sugar consumed from each beverage in all countries. These were an approximate estimation of the reality, since the same fluid type of the same brand can have a different nutritional composition depending on the country.

On the other hand, the Liq.In^7 study has also some strengths. The first one, was that it uses a 24-hour fluid-specific diary over 7 consecutive days that allows to assess the total fluid intake and real fluid pattern, and was supported by visual aids, to facilitate recall and recording. In addition, the population was randomly recruited using the quota based sample method from a database of volunteers for population surveys, which led to a large sample of individuals in the different countries studied. Moreover, this study was the first one design for the specific description of total fluid intake in Spain and another 12 other countries worldwide using the same methodological approach, and relating it with some lifestyle variables such as MedDiet and exercise practice.

7.3. Effect of sweetened beverages consumption in MetS

The research findings obtained in the present thesis make an important contribution to the existing scientific evidence in the field of beverage and fluid intake. In particular, we have analysed, for the first time, the association between the frequency of SSBs, artificially sweetened beverages, and natural and bottled fruit juices consumption and MetS incidence and its components in a population at high risk of CVD. The current prospective study was conducted on Mediterranean individuals where the intake of sweetened beverages, such as SSBs or artificially sweetened beverages and natural or bottled fruit juices, is relatively low compared to other regions of the world or age ranges. We have observed that after a median of 3.24 years of follow-up, the average consumption of SSBs and artificially sweetened beverages and bottled and natural fruit juices during the follow-up was positively associated with the incidence of MetS but also with some of its components. Our results expand the existing literature on the importance of reduce the consumption of sweetened beverages as part of a healthy lifestyle pattern, including high adherence to the MedDiet and physical exercise practice. Those participants who consumed more than 5 servings of SSBs per week during the follow-up, had a 43% higher risk of developing MetS than those who did not consume or rarely consumed it. These results are consistent with the meta-analysis published by Malik et al. [212] of studies on different races and ethnicities in which individuals in the highest category of SSB intake showed a 20% greater risk of MetS than those in the lowest category. Frequent consumption of SSBs has been related to an increased risk of weight gain and obesity due to the high amount of added sugar, which, when consumed in liquid form, shows a lack of satiety signals [243,342,343]. Most SSBs contain high amounts of fructose, and various studies suggest that high-fructose corn syrup, the primary sweetener used in SSBs, may have particularly deleterious metabolic effects [344], such as low HDL-cholesterol concentrations [345,346], hypertension [209,210], insulin resistance [347,348] and hypertriglyceridemia [217,345]. It is also very important to mention that there is still a popular belief that artificially sweetened beverages and fruit juices do not affect health, because of its non or low content of sugar or because they are considered as healthy as a piece of fruit. However, the scientific evidence suggests that the frequent consumption of these types of beverages might even have some adverse effects on health, such as T2DM [216], hypertension [229] or waist circumference [240]. To the best of our knowledge, the present analysis was the first one that showed a positive relationship between the consumption of more than 5 servings of 200mL per week of natural and bottled fruit juice (analysed separately) and the incidence of MetS. Furthermore, we found that a consumption of 1 to 5 servings of fruit juice/week, regardless of whether natural or bottled (containing added sugar or not), was inversely related with MetS incidence. The nonlinearity response be due to the high content of antioxidants in fruit juices, which counteracts the possible harmful effects of the sugar content when these beverages are consumed in small amounts [349]. However, as observed in the present study, when fruit juices were consumed frequently, this inverse response disappeared, thus increasing the risk of MetS. Probably, the relationship between the consumption of fruit juices and the incidence of MetS could also be explained by the fact that individuals with higher consumption of this type of beverages may have a worse dietary pattern, such as a higher intake of fat and sugar-rich products and lower intakes of fibre, and they tend to be less physically active [350,351]. However, we adjusted our analyses for such confounding factors and these associations remained significant. In addition, there is evidence that consumption of fruit in liquid form has been associated with a lower degree of energy compensation than when fruit is consumed in solid form, thus promoting the overconsumption of energy. In other words, energy intake in subsequent meals is not adjusted to previous consumption [198,352]. Therefore, fruit juice consumption seems to induce less satiety than solid fruit [208]. Finally, in this longitudinal analysis, individuals who consumed >5 servings of artificially sweetened beverages per week presented a 74% higher risk of MetS than did those who rarely consumed these beverages. These results support those recently reported by Crichton et al. [202], which showed that Americans who consumed ≥1 serving of artificially sweetened beverages per day had 2.2 times higher risk of MetS than those who rarely consumed this type of beverage. Three possible mechanisms may explain the association between artificially sweetened beverages and MetS incidence: 1) artificial sweeteners can interfere with learned responses that help to control glucose and energy homeostasis [249], 2) artificial sweeteners interact with sweet-taste receptors that are expressed throughout the digestive system and that may play a role in glucose absorption and trigger insulin secretion [209], and 3) artificial sweeteners (e.g., saccharin, sucralose, or aspartame) can interfere with the gut microbiota, thus decreasing glucose sensitivity and favouring MetS development [209,249,353,354]. Even though, there is an emerging body of evidence demonstrating the positive associations between SSB, and a few between artificially-sweetened beverages, and MetS [202–206,208–211,355,356], to date, none of the previous studies had analysed these associations in a Mediterranean, middle age and elderly population at high cardiovascular risk. In addition, most of the studies had made no distinction between different types of beverages (SSBs, artificially sweetened beverages, natural fruit juices and bottled fruit juices). In contrast, our study have differentiated between these types of beverages in the analyses.

The present analysis performed within the PREDIMED study has several strengths and some potential limitations. First, the incidence of MetS was not a primary endpoint of the PREDIMED cohort, so our results were only exploratory. Second, our study subjects were elderly individuals at high risk of CVD, making it difficult to generalize the results to other populations. Third, consumption of the various types of sweetened beverages was very low among our participants, so the categories of consumption were heterogeneous with respect to the number of participants, thus the attributable risk associated with the consumption of these beverages was also low. Because of this limited number of individuals in the highest categories of consumption and also the adjustment for many variables, it was not clear that all of the models of SSBs and bottled fruit juices have been robust enough. In addition, the frequency of SSBs in the highest category of consumption in our population was low; therefore, even if the associations observed were causal, the implications for intervention were limited to a few individuals. Fourth, although the types of beverage and food consumption were assessed with a validated FFQ, measurement errors might have occurred. Nevertheless, in order to minimize the measurement error caused by within-person variations, the average consumption during the follow-up was calculated. Finally, although individual laboratory methods and procedures were subject to quality control, the fact that biochemical measurements were made in different centers means that we cannot discount a certain degree of measurement bias between laboratories, because the measurements were not standardized. Even so, the concordance analysis of lipid and glucose measurements revealed correlation coefficients >0.81.

On the other hand, taking into account the analysis performed within the PREDIMED study, the main strength of our manuscript was the use of yearly repeated measurements of diet as exposure, and data was adjusted for a sizable number of potential confounders.

7.4. Global and future perspective

As a global perspective, the total fluid intake and the association between the beverage pattern consumption and health or disease is an important issue to explore worldwide in the future. The results of this research are relevant because they emphasise the importance of correctly assess total fluid and beverages intake and relating it with lifestyle and health. In the last years, a change in the beverage intake and fluid pattern of the population worldwide occurred. The intake of water, milk and dairy products has been replaced by the consumption of SSBs and fruit juices in some parts of the globe [357]. The changes in fluid pattern combined with a more sedentary lifestyle, both at work and in leisure time activities, and a worst diet quality may be a possible explanation about obesity epidemic, the risk of CVD and MetS observed in past years [358,359]. Therefore, the scientific evidence already demonstrated and supported the benefits and importance of a good hydration and a sufficient intake of plain water [6,17,19]. However, the effect of other types of beverages in health is still not well known. We have contributed to investigate the associations between some types of beverages, such as SSBs, artificially sweetened beverages and fruit juices and MetS incidence in a Mediterranean population at high cardiovascular risk. Public health policies and appropriate nutritional recommendations to promote a healthier beverage pattern at different levels (schools, universities, primary care centres, hospitals, etc.) should be performed for prevention of chronic disease at a national and international level. As stated by our group in the present thesis fluid intake is related with lifestyle, so these public health policies may also have beneficial effects in increasing the quality of diet and physical exercise practice. Establishing and maintaining a culture of "hydration awareness" may require changing of habitual behaviours in relation to the timing, type and quantity of fluid ingestion. However, before performing any public health policy is very important to really know the beverage pattern of a population, as we did for the first time in Spain. The essential in fluid intake assessment is the availability of a validated gold standard method, that can be used for accurately assess beverages intake as a cross-sectional or prospective analysis. Nowadays in Spain this issue is solved, and a more real and accurate description of beverages intake can be performed in future.

From the findings of the present work, we could consider several future hypotheses that will help complete and understand the current knowledge on fluid pattern and beverages intake. In addition, a better understanding of the mechanisms that could explain the associations especially between artificially-sweetened beverages and fruit juices and MetS incidence, reported in the present thesis, will be an important point to investigate in future. Further epidemiological studies to extrapolate our results, regarding the relation between sweetened beverages and risk of MetS, to other populations such as healthy and younger individuals, overweight or obesity, no having CVD risk and even from other European countries, will be of great interest to perform. Besides, it is known that MetS entails an increased risk of CVD, cardiovascular death and cause-specific mortality [199–201]. For this reason, and because we described in the present thesis an increased risk of MetS with a frequent consumption of sweetened beverages, it will be of great interest to investigate the relation existent between SSBs, artificially sweetened beverages and fruit juices (bottled and natural) and the risk of CVD, cardiovascular death and all-cause death in the same Mediterranean middle-age and elderly population. Furthermore, future analysis regarding other types of beverages and MetS incidence or CVD and cardiovascular death, and even other diseases and disorders, can now be performed thanks to the availability of the Spanish fluid-specific questionnaire, which is now validated. These analyses can be performed within the PREDIMED-PLUS study or in another clinical trial with a long-term follow-up time and large population samples. The results presented in this thesis are the first ones from the Liq.In[7] study, which was a pilot trial. In the future, the limitations will be corrected and some improvements will be done, in order to have a more solid results and a real fluid pattern from a representative sample of the population. Upcoming in the next months, a new fluid intake report will be performed to describe the consumption in 2015 and to compare it will the already published results from 2012. Finally, the findings of the present thesis combined with the near-future research on fluid intake will help provide strong scientific evidence to develop and promote public health actions based on beverage and hydration changes.

As final comments, the results of this work support the adverse effects of the consumption of SSBs, artificially sweetened beverages and bottled and natural fruit juices on the incidence of MetS in a middle age and elderly population at high cardiovascular risk. Fluid intake assessment and beverages pattern play important roles in lifestyle, probably modulating the quality of diet and physical exercise practice, and in disease. This work has contributed to add new knowledge on the effect of specific beverages — SSBs, artificially-sweetened beverages, natural fruit juices and bottled fruit juices — on MetS, but also to alert for the importance of an accurate fluid intake assessment and for the need of a validated tool to record the real beverage consumption at a population level. This is very important from a public health point of view, due to the relevance of the negative effects of some beverages, which can entail in a great expense, both for financial and human burden. Politicians, medical doctors, researchers, industries and registered dieticians should paid more attention on the amount of fluid intake, fluid pattern and types of beverages consumed.

8. CONCLUSIONS

8. CONCLUSIONS

We designed and validated a Spanish fluid-specific frequency questionnaire that is relatively valid and highly reliable for assessing the intake of water and other types of beverages in Spanish adults.

Approximately half of the Spanish population does not meet the EFSA recommendations for total fluid intake. Water was the main beverage consumed, but a significant amount of dietary calories were provided by other beverages. A quarter of the studied population consumed more free-sugars from beverages than recommended by WHO.

Spanish participants who adhered more closely to the MedDiet and who engaged in more physical exercise had a healthier fluid intake pattern, characterized by a high consumption of water, moderate in wine and low in SSBs. Participants with a healthier lifestyle had a greater probability of complying with EFSA total daily fluid intake and WHO free-sugar intake recommendations.

According to the results from 13 countries surveys worldwide, only 40% of men and 60% of women complied with EFSA adequate intake of water from fluids. In most countries, men and elderly individuals had an increased risk of not complying with these AIs.

TFI and types of beverages consumption differs considerably between countries, but it seems to exist a similar geographical pattern. Drinking water was the most consumed beverage worldwide, however the consumption of SSBs and fruit juices highly contributed, in some countries, to total energy intake. When comparing countries, the proportion of adults exceeding the WHO recommendation for energy intake provided by free sugars ranged from 11 up to 70.9%.

In a middle-aged and elderly Mediterranean population at high cardiovascular risk, occasional consumption (1–5 servings/week) of SSBs and artificially sweetened beverages was not associated with overall MetS incidence. The consumption of 1–5 servings of natural and bottled fruit juices/week may reduce the risk of MetS. Consumption of more than five servings per week of all of the types of beverages analysed (SSBs, artificially sweetened beverages, bottled and natural fruit juices) was associated with an increased risk of MetS and some of its components.

9. REFERENCES

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10. APPENDICES

Appendix 1. Physical activity questionnaire

predimed plus

CUESTIONARIO DE ACTIVIDAD FÍSICA EN EL TIEMPO LIBRE DE MINNESOTA

A continuación encontrará un cuadro con un listado de actividades físicas y unas columnas con períodos de tiempo de realización de las mismas (semana y año). Cada columna está dividida en días y minutos.

1. Leer atentamente cada actividad una a una y cuando se encuentre una que se haya realizado durante la última semana, con números claros y sin salirse del recuadro, se rellenan las casillas correspondientes a los días y minutos.
2. Seguidamente se repite la misma acción para actividades realizadas el último año.

Para asegurar la uniformidad de la información recogida consideramos que:

- cada piso de escaleras = 1/2 min.
- una vuelta en esquí acuático = 5 min.
- un set de tennis individual = 20 min.
- un set de tenis dobles = 15 min.
- golf 9 hoyos = 90 min.

Ejemplo:

Una persona que:

- durante la última semana ha ido a caminar media hora cada día menos el fin de semana, tiene que anotar un 5 en la columna de días de práctica a la semana y 30 en minutos/día de práctica. Si durante el último año también ha ido a caminar pero durante 2 meses en el verano no ha hecho esta actividad, tendrá que anotar 200 en la columna de días de práctica al año y 30 en minutos / día de práctica.
- durante la última semana ha subido 2 veces al día 2 pisos por la escalera, tiene que anotar un 7 en la columna de días de práctica a la semana y 2 a minutos/ día de práctica. Si esta actividad la repite todo el año, tendrá que anotar 365 en la columna días de práctica al año y 2 en minutos / día de práctica.

ACTIVIDADES FÍSICAS	SEMANA		AÑO	
	Días de práctica	Minutos/día	Días de práctica	Minutos/día
ANDAR/BAILAR/SUBIR ESCALERAS				
1. Pasear	5	30	200	30
2. Andar de casa/ trabajo o trabajo/casa	7	2		2

ACTIVIDADES FÍSICAS	SEMANA		AÑO	
	Días de práctica	Minutos/día	Días de práctica	Minutos/día
ANDAR/BAILAR/SUBIR ESCALERAS				
1. Pasear				
2. Andar de casa/ trabajo o trabajo/casa				
3. Andar (carrito compras)				
4. Andar (bolsas compras)				
5. Subir escaleras				
6. Andar campo a través				
7. Excursiones con mochila				
8. Escalar montañas				
9. Ir en bicicleta al trabajo				
10. Bailar				
11. Aeróbic o ballet				
12. Jugar con los niños				

P 2 Estudio   Nodo-Paciente   Visita   Fecha

predimed plus

ACTIVIDADES FÍSICAS	SEMANA		AÑO	
	Días de práctica	Minutos/día	Días de práctica	Minutos/día
EJERCICIOS DE MANTENIMIENTO GENERAL				
13. Hacer ejercicio en casa				
14. Hacer ejercicio en un GYM				
15. Caminar deprisa				
16. Trotar (jogging)				
17. Correr 8-11 km /h				
18. Correr 12-16 km/h				
19. Levantar pesas				
ACTIVIDADES ACUÁTICAS				
20. Esquí acuático				
21. Surf				
22. Navegar a vela				
23. Ir en canoa o remar por distracción				
24. Ir en canoa o remar por competición				
25. Hacer un viaje en canoa				
26. Nadar				
27. Nadar en el mar				
28. Bucear				
DEPORTES DE INVIERNO				
29. Esquiar				
30. Esquí de fondo				
31. Patinar (ruedas o hielo)				
OTRAS ACTIVIDADES				
32. Montar a caballo				
33. Jugar a los bolos				
34. Balonvolea				
35. Tenis de mesa				
36. Tenis individual				
37. Tenis dobles				
38. Bádminton				
39. Baloncesto (sin jugar partido)				
40. Baloncesto (jugando partido)				
41. Baloncesto (actuando de árbitro)				
42. Squash				
43. Fútbol				
44. Golf (llevando carrito)				
45. Golf (andando y llevando palos)				
46. Balonmano				
47. Petanca				
48. Artes marciales				
49. Motociclismo				
50. Ciclismo de carretera o montaña				

P	2								

Estudio   Nodo-Paciente   Visita   Fecha

predimed plus

ACTIVIDADES FÍSICAS	SEMANA		AÑO	
	Días de práctica	Minutos/día	Días de práctica	Minutos/día
ACTIVIDADES EN EL JARDÍN				
51. Cortar el césped con máquina				
52. Cortar el césped manualmente				
53. Limpiar y arreglar el jardín				
54. Cavar el huerto				
55. Quitar nieve con pala				
TRABAJOS Y ACTIVIDADES CASERAS				
56. Trabajos de carpintería dentro de casa				
57. Trabajos de carpintería (exterior)				
58. Pintar dentro de casa				
59. Pintar fuera de casa				
60. Limpiar la casa				
61. Mover muebles				
CAZA Y PESCA				
62. Tiro con pistola				
63. Tiro con arco				
64. Pescar en la orilla del mar				
65. Pescar con botas altas dentro del río				
66. Caza menor				
67. Caza mayor (ciervos...)				
OTROS (SIN ESPECIFICAR)				

P	2								

Estudio Nodo-Paciente Visita Fecha

Appendix 2. 14-items MedDiet adherence questionnaire

predimed plus

CUESTIONARIO DE ADHESIÓN A LA DIETA MEDITERRÁNEA *(14 PUNTOS DE PREDIMED, SÓLO GRUPO CONTROL)*

1. ¿Usa usted el aceite de oliva como principal grasa para cocinar?:	Sí= 1 punto	☐
2. ¿Cuánto aceite de oliva consume en total al día?: (incluyendo el usado para freir, comidas fuera de casa, ensaladas, etc.)	4 o más cucharadas= 1 punto	☐
3. ¿Cuántas raciones de verdura u hortalizas consume al día?: (las guarniciones o acompañamientos= 1/2 ración)1 ración= 200 g.	2 o más (al menos una de ellas en ensalada o crudas)= 1 punto	☐
4. ¿Cuántas piezas de fruta (incluyendo zumo natural) consume al día?:	3 o más al día= 1 punto	☐
5. ¿Cuántas raciones de carnes rojas, hamburguesas, salchichas o embutidos consume al día?: (ración= 100 - 150 g.)	Menos de 1 al día= 1 punto	☐
6. ¿Cuántas raciones de mantequilla, margarina o nata consume al día?: (porción individual=12 g.)	Menos de 1 al día= 1 punto	☐
7. ¿Cuántas bebidas carbonatadas y/o azucaradas (refrescos, colas, tónicas, bitter) consume al día?:	Menos de 1 al día= 1 punto	☐
8. ¿Bebe usted vino? ¿Cuánto consume a la semana?:	7 o más vasos a la semana= 1 punto	☐
9. ¿Cuántas raciones de legumbres consume a la semana?: (1 plato o ración de 150 g.)	3 o más a la semana= 1 punto	☐
10. ¿Cuántas raciones de pescado - mariscos consume a la semana?: (1 plato, pieza o ración= 100 - 150 g. de pescado o 4 - 5 piezas o 200 g. de marisco)	3 o más a la semana= 1 punto	☐
11. ¿Cuántas veces consume repostería comercial (no casera) como galletas, flanes, dulces o pasteles a la semana?:	Menos de 2 a la semana= 1 punto	☐
12. ¿Cuántas veces consume frutos secos a la semana?: (ración 30 g.)	3 o más a la semana= 1 punto	☐
13. ¿Consume usted preferentemente carne de pollo, pavo o conejo en vez de ternera, cerdo, hamburguesas o salchichas?: (carne de pollo= 1 pieza o ración de 100 - 150 g.)	Sí= 1 punto	☐
14. ¿Cuántas veces a la semana consume los vegetales cocinados, la pasta, arroz u otros platos aderezados con salsa de tomate, ajo, cebolla o puerro elaborada a fuego lento con aceite de oliva (sofrito)?:	2 o más a la semana= 1 punto	☐
PUNTUACIÓN TOTAL:		☐☐

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Appendix 3. 17-items MedDiet adherence questionnaire

predimed plus

CUESTIONARIO DE 17 ÍTEMS DE ADHESIÓN A LA DIETA MEDITERRÁNEA HIPOCALÓRICA
(HAY QUE PASARLO A LOS DOS GRUPOS)

1. ¿Usa usted el aceite de oliva virgen extra como principal grasa para cocinar?:	Sí= 1 punto	
2. ¿Cuántas raciones de verdura u hortalizas consume al día?: (las guarniciones o acompañamientos= 1/2 ración)1 ración= 200 g.	2 o más (al menos una de ellas en ensalada o crudas)= 1 punto	
3. ¿Cuántas piezas de fruta (incluyendo zumo natural) consume al día?:	3 o más al día= 1 punto	
4. ¿Cuántas raciones de carnes rojas, hamburguesas, salchichas, jamón o embutidos consume a la semana?: (ración= 100 - 150 g.)	1 o menos a la semana= 1 punto	
5. ¿Cuántas raciones de mantequilla, margarina o nata consume a la semana?: (porción individual=12 g.)	Menos de 1 a la semana= 1 punto	
6. ¿Cuántas bebidas azucaradas (refrescos, colas, tónicas, bitter, zumos de frutas con azúcar añadido) consume a la semana?:	Menos de 1 a la semana= 1 punto	
7. ¿Cuántas raciones de legumbres consume a la semana?: (1 plato o ración de 150 g.)	3 o más a la semana= 1 punto	
8. ¿Cuántas raciones de pescado o mariscos consume a la semana?: (1 plato, pieza o ración= 100 - 150 g. de pescado o 4 - 5 piezas o 200 g. de marisco)	3 o más a la semana= 1 punto	
9. ¿Cuántas veces consume repostería tal como galletas, flanes, dulces o pasteles a la semana?:	Menos de 3 a la semana= 1 punto	
10. ¿Cuántas veces consume frutos secos a la semana?: (ración 30 g.)	3 o más a la semana= 1 punto	
11. ¿Consume usted preferentemente carne de pollo, pavo o conejo en vez de ternera, cerdo, hamburguesas o salchichas?: (carne de pollo= 1 pieza o ración de 100 - 150 g.)	Sí= 1 punto	
12. ¿Cuántas veces a la semana consume los vegetales cocinados, la pasta, arroz u otros platos aderezados con salsa de tomate, ajo, cebolla o puerro elaborada a fuego lento con aceite de oliva (sofrito)?:	2 o más a la semana= 1 punto	
13. ¿Añade usted azúcar a las bebidas (café, té)?:	No/No, utilizo edulcorantes acalóricos= 1 punto	
14. ¿Cuántas raciones de pan blanco consume al día?: (1 ración=75g.)	1 o menos al día= 1 punto	
15. ¿Cuántas raciones de cereales y alimentos integrales (pan, arroz, pasta) consume a la semana?:	5 o más a la semana= 1 punto	
16. ¿Cuántas raciones de pan, arroz y/o pasta refinados consume a la semana?:	Menos de 3 a la semana= 1 punto	
17. ¿Bebe usted vino? ¿Cuánto consume a la semana?	Hombre entre 2 y 3 vasos al día y mujer entre 1 y 2 vasos al día= 1 punto	
PUNTUACIÓN TOTAL:		

3125195488

Appendix 4. Spanish beverages intake assessment questionnaire

predimed plus

CUESTIONARIO DE VALORACIÓN DE INGESTA DE BEBIDAS

Instrucciones:

Por favor indique su respuesta haciendo referencia al mes pasado.
Por cada tipo de bebida consumida, marque la casilla con la cantidad de veces al día o a la semana, y a continuación el momento en que la bebió.
Por ejemplo, si usted bebió 2 vasos de vino por semana, marque en "veces", en la columna "a la semana", la casilla que corresponde al intervalo 1-2. Si se trata de una bebida que consume todos los días, por ejemplo, 6 vasos de agua, marque el intervalo de 6-7 veces al día.
No cuente los líquidos utilizados en la cocina o en otras preparaciones, como por ejemplo al preparar una salsa o un postre casero.
Si consume el café con leche, márquelo en la categoría de bebidas "café con leche" y no en las categorías de leche.

Nodo | Paciente | Visita | Fecha actual (Día, Mes, Año)

marque así — así no marque

TIPO DE BEBIDA	FRECUENCIA DE CONSUMO																
	VECES								MOMENTO								
	Nunca o casi nunca	A la semana			Al día				Antes del desayuno	Con el desayuno	Entre des. y comida	Con la comida	Entre comida y cena	Con la cena	Después de la cena	Durante la noche
		1-2	3-4	≥5	1-3	4-5	6-7	≥8								
Agua de grifo — *1 botellín o 1 vaso: 200 cc*																
Agua embotellada (con gas/sin gas) — *1 botellín o 1 vaso: 200 cc*																
Zumos naturales de frutas — *1 vaso: 200 cc*																
Zumos envasados de frutas — *1 vaso: 200 cc*																
Zumos vegetales naturales (gazpacho, de tomate…) — *1 vaso: 200 cc*																
Zumos vegetales envasados (gazpacho, de tomate…) — *1 vaso: 200 cc*																
Leche entera — *1 vaso o taza: 200 cc*																
Leche semidesnatada — *1 vaso o taza: 200 cc*																
Leche desnatada — *1 vaso o taza: 200 cc*																
Lácteos bebibles — *1 botellín: 100 cc*																
1 botellín o 1 vaso: 200 cc																
Batidos lácteos — *1 vaso: 200 cc*																
Bebidas vegetales (bebida de soja, almendras, almendrina…) — *1 vaso: 200 cc*																
Sopas y caldos — *1 taza o plato: 200 cc*																
Sorbetes, gelatinas — *1 unidad: 120 cc*																
Refrescos — *1 botellín o 1 vaso: 200 cc*																
1 lata: 330 cc																
Refrescos Light/Zero — *1 lata: 330 cc*																
1 botellín o 1 vaso: 200 cc																

	FRECUENCIA DE CONSUMO																
	VECES								MOMENTO								
	Nunca o casi nunca	A la semana			Al día				Antes del desayuno	Con el desayuno	Entre des. y comida	Con la comida	Entre comida y cena	Con la cena	Después de la cena	Durante la noche
TIPO DE BEBIDA		1-2	3-4	≥5	1-3	4-5	6-7	≥8									
Café sólo o cortado con azúcar *1 taza: 30-50 cc*																	
Café sólo o cortado sin azúcar, con/sin edulcorante artificial *1 taza: 30-50 cc*																	
Café con leche o americano con azúcar *1 taza: 125 cc*																	
Café con leche o americano sin azúcar, con/sin edulcorante artificial *1 taza: 125 cc*																	
Té con azúcar *1 taza: 200 cc*																	
Té sin azúcar, con/sin edulcorante artificial *1 taza: 200 cc*																	
Otras infusiones con azúcar *1 taza: 200 cc*																	
Otras infusiones sin azúcar *1 taza: 200 cc*																	
Cerveza, Sidra *1 botellín o 1 vaso: 200 cc*																	
1 lata: 330 cc																	
Cerveza sin alcohol o Light *1 lata: 330 cc*																	
1 botellín o 1 vaso: 200 cc																	
Vino (tinto, rosado o blanco), cava *1 vaso: 120 cc*																	
Bebidas alcohólicas de alta graduación (whisky, ron, vodka, ginebra) *1 copa 50 cc*																	
Bebidas alcohólicas combinadas (cubata, gintonic, piña colada, daikiri, otras) *1 vaso: 200 cc*																	
Bebidas energéticas (Red Bull, Burn,...) *1 vaso: 200 cc*																	
Bebidas para deportistas/isotónicas *1 vaso: 200 cc*																	
1 lata: 330 cc																	
Batidos sustitutivos de comidas/híper proteicos *1 vaso: 200 cc*																	

¡GRACIAS POR SU COLABORACIÓN!

Appendix 5. Fluid specific record.

Manual
Diario de Bebidas
(Instrucciones para rellenar el diario)

Nota: *Si el consumidor tiene 15 años o menos, el consumo del niño/a debe ser cumplimentado por la madre, padre o tutor.*

Este diario está diseñado para recoger de forma detallada y día tras día (durante 7 días) todos sus consumos de bebidas de todo tipo a lo largo del día:

- ✓ **Justo al levantarse** *(antes del desayuno)*
- ✓ **En el desayuno**
- ✓ **Durante la mañana** *(entre el desayuno y la comida)*
- ✓ **Justo antes de la comida**
- ✓ **En la comida**
- ✓ **Durante la tarde** (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)
- ✓ **Justo antes de cenar**
- ✓ **En la cena**
- ✓ **Después de cenar**
- ✓ **Antes de acostarse** (justo antes de ir a la cama)
- ✓ **Durante la noche** *(Si se levanta de la cama para beber algo durante la noche)*

Es MUY IMPORTANTE que, por favor, anote TODO su consumo de bebidas a lo largo de todo el día, independientemente del tipo de bebida, momento del día,...

A continuación se detallan las instrucciones para completar cada bloque mencionado:

A - Momento del día en el que ha tomado la bebida

Localice el momento del día adecuado en el cuestionario y anote las bebidas consumidas en el apartado correspondiente, como verá cada hoja se corresponde a un día completo y en el figuran todos los momentos del día que le mencionamos.

Nota: *Si no ha bebido nada en un momento determinado del día deje ese apartado en blanco/sin rellenar*

1. **Justo al levantarse** *(antes del desayuno)*
2. **En el desayuno**
3. **Durante la mañana** *(entre el desayuno y la comida)*
4. **Justo antes de la comida**
5. **En la comida**
6. **Durante la tarde** (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)
7. **Justo antes de cenar**
8. **En la cena**
9. **Después de cenar**
10. **Antes de acostarse** (justo antes de ir a la cama)
11. **Durante la noche** *(Si se levanta de la cama para beber algo durante la noche)*

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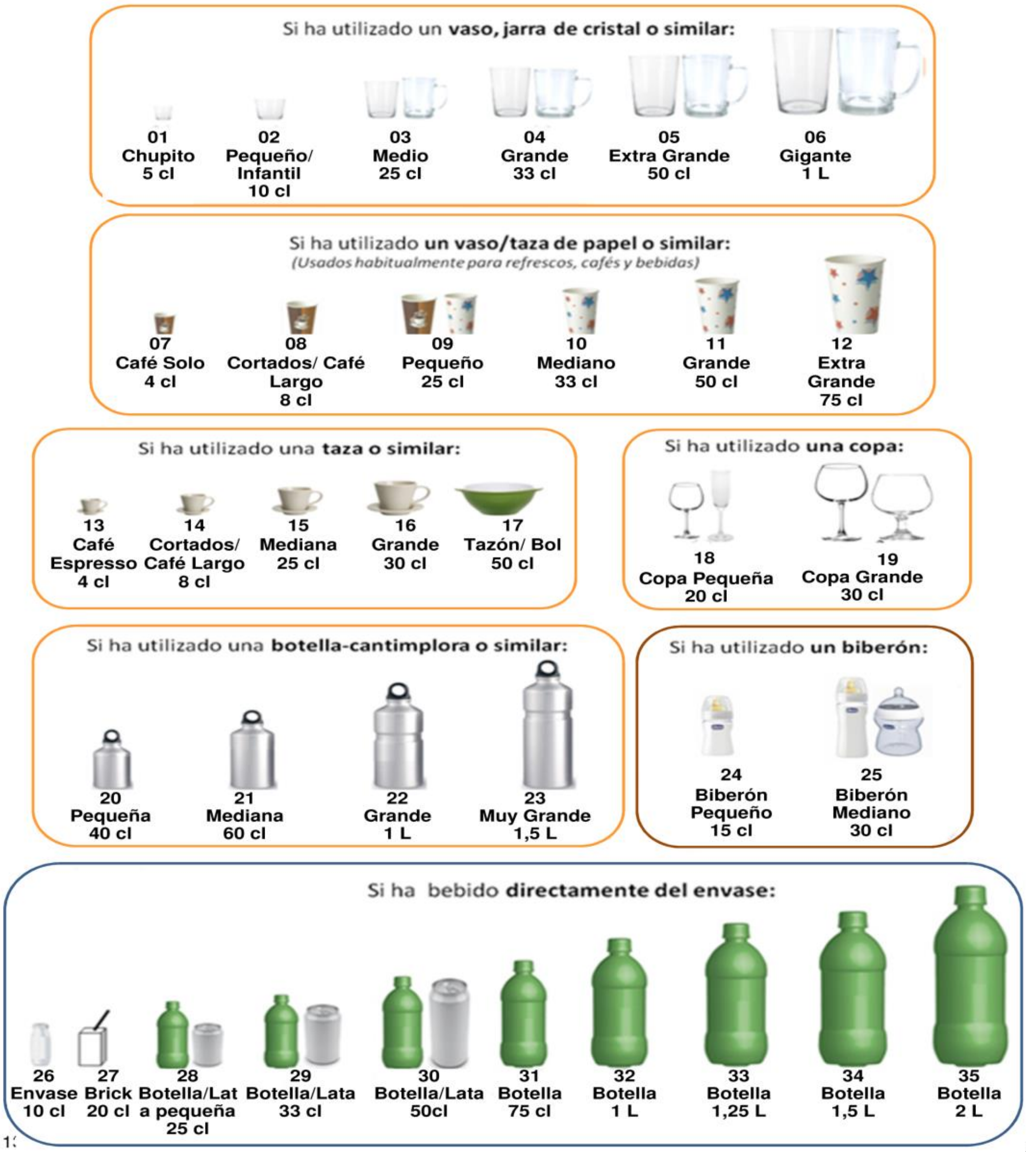
B - ¿Qué tipo de bebidas ha consumido en ese momento?
Para completar el tipo de bebida que ha consumido en cada momento, por favor,
complete el/los espacio/s reservado/s con los siguientes códigos de bebida:

Aguas	
Agua del grifo	01
Agua del grifo filtrada (tipo jarra Brita, Osmosis, otros filtros)	02
Agua de una fuente	03
Aguas mineral SIN gas	04
Agua mineral CON gas	05
Agua con sabor	06
Bebidas Calientes	
Café / Café con leche / Cortado / Capuccino / ...	07
Té caliente	08
Bebidas a base de cereales solubles (tipo Eko,...)	09
Otras Infusiones y bebidas calientes	10
Leche - bebidas lácteas	
Leche Materna/Pecho	11
Leches infantiles (formula de inicio 1º etapa, continuación 2ª etapa o crecimiento 3ª etapa)	12
Leche	13
Batidos de sabores cacao, fresa,... (preparados o solúbles)	14
Batidos a base de leche y zumos	15
Yogur líquido tipo Danup, Actimel,...	16
Otras bebidas lácteas (leche condensada, en polvo, de soja...)	17
Zumos y bebidas de frutas	
Naturales / Recién exprimidos	18
Zumo (tipo Juver 100%, Juver Exprimido, Pascual Solo Zumo, Tropicana Pure Premium, Granini Oro, etc.)	19
Nectar (tipo Juver Nectar, Fruco, Lambda, Granini, Hero, Minute Maid, etc.)	20
Nectar SIN azúcar añadido (tipo Don Simón, Zumosol Ligero, Hero Sin, Juver Disfruta, etc.)	21
Otras bebidas a base de frutas	22
Refrescos CON GAS	
Refrescos con gas sabor cola	23
Refrescos con gas sabor naranja	24
Refrescos con gas sabor limón	25
Bitter (tipo Kas, Cinzano, etc.)	26
Tónica	27
Gaseosa	28
Refrescos con gas de otros sabores	29
Refrescos con GAS LIGHT	
Refrescos con gas sabor cola light (tipo Coca-cola light, Coca-cola Zero, Tab, etc.)	30
Refrescos con gas sabor naranja light	31
Refrescos con gas sabor limón light	32
Refrescos con gas de otros sabores light	33
Refrescos/Bebidas SIN GAS	
Refrescos sin gas naranja (tipo Trina Fanta sin burbujas, etc.)	34
Refrescos sin gas limón (tipo Trina, Fanta sin burbujas, etc.)	35
Bebidas Isotónicas (tipo Aquarius, Gatorade,...)	36
Bebidas energéticas (tipo Red Bull, Burn,...)	37
Té frio (tipo Nestea, etc.)	38
Otras bebidas sin gas	39
Refrescos/Bebidas SIN GAS LIGHT	
Refrescos sin gas naranja LIGHT	40
Refrescos sin gas limón LIGHT	41
Té frio LIGHT (tipo Trina T!, etc.)	42
Otras bebidas sin gas LIGHT	43
Otros tipos de bebidas con/sin alcohol	
Cerveza	44
Cerveza sin alcohol	45
Cerveza con Limón/Gaseosa	46
Vino	47
Vino con Gaseosa	48
"Cubatas" (cualquier combinación de bebidas con alcohol como por ejemplo Ron, Ginebra, Vodka, etc. con refrescos de cola, naranja, limón, etc.)	49
Otras bebidas con alcohol (licores, cava,...)	50

G-Tipo de recipiente / contenedor UTILIZADO PARA BEBER

A continuación del tipo de bebida, por favor, anote **el tipo de recipiente donde la ha tomado, independientemente del envase original, salvo que la haya tomado directamente del envase original o haya rellenado algún envase**. Lo que nos importa es cómo la ha tomado. Para ello utilice la siguiente lista de códigos para recipientes:

Nota: Si en esta lista no esta exactamente el recipiente utilizado por favor utilice el que más se le parezca tanto en formato como en capacidad.



tns

Para cualquier bebida:

I – Cantidad bebida/consumida

También necesitaremos que nos detalle la cantidad que ha bebido en número de recipientes o envases. Por favor, tenga en cuenta si llegó a consumir toda la bebida del recipiente / envase o sólo una parte.
(OJO los códigos a utilizar no son consecutivos)

Nº de recipientes o envases	Código a utilizar
¼ (Una cuarta parte)	14
½ (La mitad)	12
1	01
1 y Medio	*15*
2	02
2 y Medio	*25*
3	03
3 y Medio	*35*
4	04
4 y Medio	*45*
5	05
Más de 5	*55*

tns

O - ¿Le añadió algo a esta bebida?

Por favor, indique con el código correspondiente si le añadió algo a la bebida en el momento de tomársela:
(Indique lo que corresponda)

Código

1. Azúcar (½ cucharada de café)
2. Azúcar (1 cucharada de café)
3. Azúcar (1 cucharada y ½ de café)
4. Azúcar (2 cucharadas de café)
5. Azúcar (2 cucharadas y ½ de café)
6. Azúcar (3 cucharadas de café)
7. Azúcar (más de 3 cucharadas de café)
8. Edulcorantes (Sacarina, Aspartamo, etc.)
9. Limón/Lima
10. Cubitos de hielo
11. Alguna otra cosa
12. Nada, no añadí nada

tns

RECUERDE

Se le recomienda completar el diario cada día y, muy especialmente, en cada momento que beba cualquier cosa.

Le recomendamos que lleve consigo este diario, si es posible, sin esperar al final del día, pues podría olvidar algunas bebidas o no recordar algunos detalles importantes, como por ejemplo la cantidad que ha consumido.

Nota: *Si el consumidor tiene 15 años o menos, el consumo del niño/a debe ser cumplimentado por la madre, padre o tutor.*

Es muy importante para nosotros que anote **todas** las bebidas que consuma.

Pasados los 7 días, un/a entrevistador/a recogerá el diario que Ud. ha estado completando (deberá entregarle las 7 hojas) y le hará unas preguntas.

Le agradecemos mucho su participación ya que conocer los hábitos de los consumidores como Ud. es clave para que los fabricantes adapten mejor los productos a las necesidades de las personas.

¡MUCHAS GRACIAS POR SU PARTICIPACIÓN!

GRACIAS

NORDEN:

DIARIO DE BEBIDAS

ENTREVISTADOR DEBE COMPLETAR LA INFORMACIÓN DE IDENTIFICACIÓN ANTES DE ENTREGAR EL DIARIO

NOMBRE DEL ENTREVISTADOR: ______________________

NOMBRE DEL COLABORADOR: ______________________

TELÉFONO DEL COLABORADOR: ______________________

	Fecha	Hora
ENTREGA DEL DIARIO:		
RECOGIDA PREVISTA DEL DIARIO:		
RECOGIDA REAL DEL DIARIO:		

SI EL CONSUMIDOR TIENE 14 AÑOS O MENOS, ESTE DIARIO DEBE SER CUMPLIMENTADO POR LA MADRE, PADRE O TUTOR

NOMBRE DEL NIÑO/A: ______________________

SI TIENE CUALQUIER DUDA PUEDE CONSULTAR AL TELÉFONO **900 150 288 de lunes a viernes de 9 a 18 h**
O AL E-MAIL **informacion.es@tnsglobal.com**

1106113

Fecha: | ____ | 03 | 2012

DIA DE LA SEMANA: (Circule lo que corresponda)
Lunes..... 1 Martes.... 2 Miércoles.. 3 Jueves..... 4
Viernes .... 5 Sábado.... 6 Domingo .. 7

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)							
Indique la bebida tomada en el momento del día adecuado ↓	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON-SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE-RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
1	JUSTO AL LEVANTARSE (antes del desayuno)															
	Nº1															
	Nº2															
	Nº3															
2	EN EL DESAYUNO															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
3	DURANTE LA MAÑANA (entre el desayuno y la comida)															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
4	JUSTO ANTES DE LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
5	EN LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	Anote según LISTA Q (1 respuesta)
6	DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
7	JUSTO ANTES DE CENAR															
	Nº1															
	Nº2															
	Nº3															
8	EN LA CENA															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
9	DESPUÉS DE CENAR															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
10	ANTES DE ACOSTARSE (justo antes de ir a la cama)															
	Nº1															
	Nº2															
	Nº3															
11	DURANTE LA NOCHE (si se levanta de la cama para beber algo durante la noche)															
	Nº1															
	Nº2															
	Nº3															

Fecha: | ____ | 03 | 2012

DIA DE LA SEMANA: (Circule lo que corresponda)
Lunes..... 1 Martes.... 2 Miércoles.. 3 Jueves..... 4
Viernes .... 5 Sábado.... 6 Domingo .. 7

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Indique la bebida tomada en el momento del día adecuado ↓		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)							
	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON- SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE- RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
1	JUSTO AL LEVANTARSE (antes del desayuno)															
	Nº1															
	Nº2															
	Nº3															
2	EN EL DESAYUNO															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
3	DURANTE LA MAÑANA (entre el desayuno y la comida)															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
4	JUSTO ANTES DE LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
5	EN LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	Anote según LISTA Q (1 respuesta)
6	DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
7	JUSTO ANTES DE CENAR															
	Nº1															
	Nº2															
	Nº3															
8	EN LA CENA															
	Nº1															
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9	DESPUÉS DE CENAR															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
10	ANTES DE ACOSTARSE (justo antes de ir a la cama)															
	Nº1															
	Nº2															
	Nº3															
11	DURANTE LA NOCHE (si se levanta de la cama para beber algo durante la noche)															
	Nº1															
	Nº2															
	Nº3															

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DIA DE LA SEMANA: (Circule lo que corresponda)
Lunes..... 1 Martes.... 2 Miércoles.. 3 Jueves..... 4
Viernes .... 5 Sábado.... 6 Domingo .. 7

A	B	C	D	E	F	G	H	I	J						K						L	M	N	O	P				Q
Indique la bebida tomada en el momento del día adecuado ↓		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)																				
	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON-SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE-RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas)				ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
									1	2	3	4	5	6	1	2	3	4	5	6					1	2	3	4	
1	JUSTO AL LEVANTARSE (antes del desayuno)																												
	Nº1																												
	Nº2																												
	Nº3																												
2	EN EL DESAYUNO																												
	Nº1																												
	Nº2																												
	Nº3																												
	Nº4																												
	Nº5																												
3	DURANTE LA MAÑANA (entre el desayuno y la comida)																												
	Nº1																												
	Nº2																												
	Nº3																												
	Nº4																												
	Nº5																												
4	JUSTO ANTES DE LA COMIDA																												
	Nº1																												
	Nº2																												
	Nº3																												
5	EN LA COMIDA																												
	Nº1																												
	Nº2																												
	Nº3																												
	Nº4																												
	Nº5																												

A	B	C	D	E	F	G	H	I	J						K						L	M	N	O	P				Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas)				Anote según LISTA Q (1 respuesta)
									1	2	3	4	5	6	1	2	3	4	5	6					1	2	3	4	
6	DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)																												
	Nº1																												
	Nº2																												
	Nº3																												
	Nº4																												
	Nº5																												
7	JUSTO ANTES DE CENAR																												
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8	EN LA CENA																												
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9	DESPUÉS DE CENAR																												
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	Nº4																												
	Nº5																												
10	ANTES DE ACOSTARSE (justo antes de ir a la cama)																												
	Nº1																												
	Nº2																												
	Nº3																												
11	DURANTE LA NOCHE (si se levanta de la cama para beber algo durante la noche)																												
	Nº1																												
	Nº2																												
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DIA DE LA SEMANA: (Circule lo que corresponda) Lunes. . . . . 1 Martes . . . . 2 Miércoles. . 3 Jueves . . . . . 4 Viernes . . . . 5 Sábado. . . . 6 Domingo . . 7

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Indique la bebida tomada en el momento del día adecuado ↓		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)							
	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON-SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE-RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
1	JUSTO AL LEVANTARSE (antes del desayuno)															
	Nº1															
	Nº2															
	Nº3															
2	EN EL DESAYUNO															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
3	DURANTE LA MAÑANA (entre el desayuno y la comida)															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
4	JUSTO ANTES DE LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
5	EN LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
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	Nº5															

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	Anote según LISTA Q (1 respuesta)
6	DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)															
	Nº1															
	Nº2															
	Nº3															
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	Nº5															
7	JUSTO ANTES DE CENAR															
	Nº1															
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8	EN LA CENA															
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9	DESPUÉS DE CENAR															
	Nº1															
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	Nº4															
	Nº5															
10	ANTES DE ACOSTARSE (justo antes de ir a la cama)															
	Nº1															
	Nº2															
	Nº3															
11	DURANTE LA NOCHE (si se levanta de la cama para beber algo durante la noche)															
	Nº1															
	Nº2															
	Nº3															

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DIA DE LA SEMANA: (Circule lo que corresponda)

Lunes. . . . . 1 Martes . . . . 2 Miércoles. . 3 Jueves 4
Viernes . . . . 5 Sábado. . . . 6 Domingo . . 7

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Indique la bebida tomada en el momento del día adecuado		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)							
	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON-SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE-RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
1	JUSTO AL LEVANTARSE (antes del desayuno)															
	Nº1															
	Nº2															
	Nº3															
2	EN EL DESAYUNO															
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	Nº3															
	Nº4															
	Nº5															
3	DURANTE LA MAÑANA (entre el desayuno y la comida)															
	Nº1															
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	Nº3															
	Nº4															
	Nº5															
4	JUSTO ANTES DE LA COMIDA															
	Nº1															
	Nº2															
	Nº3															
5	EN LA COMIDA															
	Nº1															
	Nº2															
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	Nº4															
	Nº5															

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	Anote según LISTA Q (1 respuesta)
6	DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)															
	Nº1															
	Nº2															
	Nº3															
	Nº4															
	Nº5															
7	JUSTO ANTES DE CENAR															
	Nº1															
	Nº2															
	Nº3															
8	EN LA CENA															
	Nº1															
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	Nº5															
9	DESPUÉS DE CENAR															
	Nº1															
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	Nº3															
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	Nº5															
10	ANTES DE ACOSTARSE (justo antes de ir a la cama)															
	Nº1															
	Nº2															
	Nº3															
11	DURANTE LA NOCHE (si se levanta de la cama para beber algo durante la noche)															
	Nº1															
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	Nº3															

Fecha: | ____ | 03 | 2012

DIA DE LA SEMANA: (Circule lo que corresponda)
Lunes..... 1 Martes.... 2 Miércoles.. 3 Jueves..... 4
Viernes .... 5 Sábado.... 6 Domingo .. 7

A	B	C	D	E	F	G	H	I	J						K						L	M	N	O	P				Q
		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)																				
Indique la bebida tomada en el momento del día adecuado ↓	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON-SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE-RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas)				ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
									1	2	3	4	5	6	1	2	3	4	5	6					1	2	3	4	
1	JUSTO AL LEVANTARSE (antes del desayuno)																												
	Nº1																												
	Nº2																												
	Nº3																												
2	EN EL DESAYUNO																												
	Nº1																												
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3	DURANTE LA MAÑANA (entre el desayuno y la comida)																												
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	Nº1																												
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A	B	C	D	E	F	G	H	I	J						K						L	M	N	O	P				Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas)						Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas)				Anote según LISTA Q (1 respuesta)
									1	2	3	4	5	6	1	2	3	4	5	6					1	2	3	4	
6	DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)																												
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10	ANTES DE ACOSTARSE (justo antes de ir a la cama)																												
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DIA DE LA SEMANA: Lunes..... 1 Martes.... 2 Miércoles.. 3 Jueves..... 4
(Circule lo que corresponda) Viernes .... 5 Sábado.... 6 Domingo .. 7

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Indique la bebida tomada en el momento del día adecuado		Sólo si Agua embotellada (cód. 04, 05 ó 06) o Refrescos (cód. del 23 al 43) en columna B		Sólo si código 04 en columna B	Sólo si código 05 en columna B		Sólo códigos del 28 a 35 en columna G		Contestar a estas preguntas SOLO los 3 primeros días en los que rellene este diario. (Si tiene 14 años o menos, por favor no conteste estas preguntas)							
	BEBIDA CONSUMIDA Anote según LISTA B (1 respuesta)	ENVASE ORIGINAL Anote según LISTA C (1 respuesta)	LUGAR DE COMPRA Anote según LISTA D (1 respuesta)	MARCA AGUA ENVASADA SIN GAS Anote según LISTA E (1 respuesta)	MARCA AGUA ENVASADA CON GAS Anote según LISTA F (1 respuesta)	TIPO DE RECIPIENTE/ CONTENEDOR UTILIZADO PARA BEBER Anote según LISTA G (1 respuesta)	¿UTILIZÓ EL TAPÓN SPORT/ BIBERÓN? Anote según LISTA H (1 respuesta)	CANTIDAD BEBIDA/ CON-SUMIDA Anote según LISTA I (1 respuesta)	RAZONES PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	MOTIVOS PARA CONSUMIR ESTA BEBIDA EN ESE MOMENTO Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	LUGAR CONSUMO Anote según LISTA L (1 respuesta)	TEMPE-RATURA Anote según LISTA M (1 respuesta)	SOLA O CON COMIDA Anote según LISTA N (1 respuesta)	¿LE AÑADIÓ ALGO? Anote según LISTA O (máx 2 respuestas)	¿CON QUIÉN? Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	ACTIVIDAD MIENTRAS BEBÍA Anote según LISTA Q (1 respuesta)
1 JUSTO AL LEVANTARSE (antes del desayuno)																
Nº1																
Nº2																
Nº3																
2 EN EL DESAYUNO																
Nº1																
Nº2																
Nº3																
Nº4																
Nº5																
3 DURANTE LA MAÑANA (entre el desayuno y la comida)																
Nº1																
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Nº3																
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4 JUSTO ANTES DE LA COMIDA																
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Nº5																

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Anote según LISTA B (1 respuesta)	Anote según LISTA C (1 respuesta)	Anote según LISTA D (1 respuesta)	Anote según LISTA E (1 respuesta)	Anote según LISTA F (1 respuesta)	Anote según LISTA G (1 respuesta)	Anote según LISTA H (1 respuesta)	Anote según LISTA I (1 respuesta)	Anote según LISTA J (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA K (mínimo 2 ó 3 respuestas, máximo 6 respuestas) 1 2 3 4 5 6	Anote según LISTA L (1 respuesta)	Anote según LISTA M (1 respuesta)	Anote según LISTA N (1 respuesta)	Anote según LISTA O (máx 2 respuestas)	Anote según LISTA P (máximo 4 respuestas) 1 2 3 4	Anote según LISTA Q (1 respuesta)
6 DURANTE LA TARDE (a lo largo de la tarde, después de la comida, incluye picoteo y merienda)																
Nº1																
Nº2																
Nº3																
Nº4																
Nº5																
7 JUSTO ANTES DE CENAR																
Nº1																
Nº2																
Nº3																
8 EN LA CENA																
Nº1																
Nº2																
Nº3																
Nº4																
Nº5																
9 DESPUÉS DE CENAR																
Nº1																
Nº2																
Nº3																
Nº4																
Nº5																
10 ANTES DE ACOSTARSE (justo antes de ir a la cama)																
Nº1																
Nº2																
Nº3																
11 DURANTE LA NOCHE (si se levanta de la cama para beber algo durante la noche)																
Nº1																
Nº2																
Nº3																

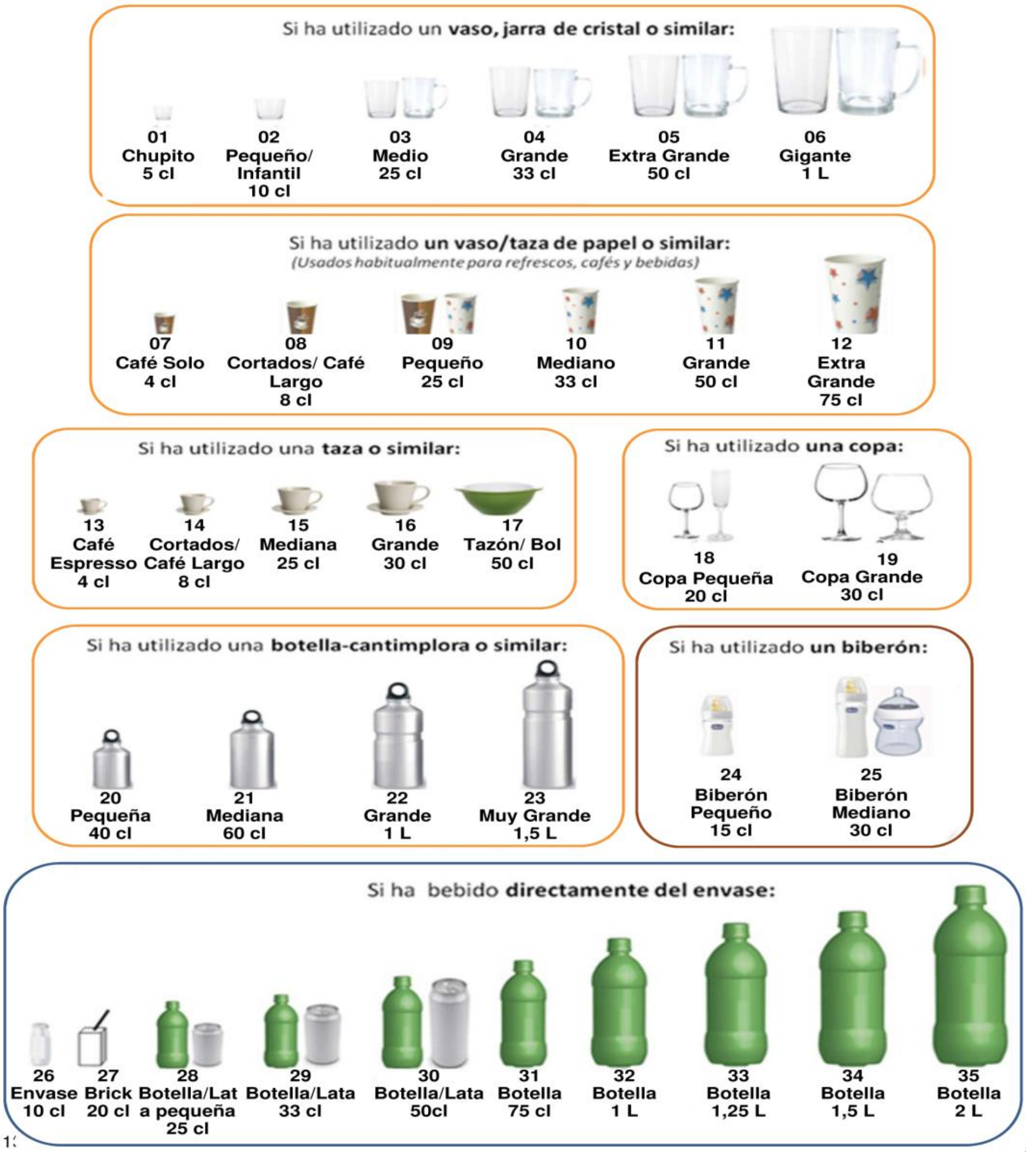
Appendix 6. Booklet photo.

tns

G-Tipo de recipiente / contenedor UTILIZADO PARA BEBER

A continuación del tipo de bebida, por favor, anote **el tipo de recipiente donde la ha tomado, independientemente del envase original, salvo que la haya tomado directamente del envase original o haya rellenado algún envase**. Lo que nos importa es cómo la ha tomado. Para ello utilice la siguiente lista de códigos para recipientes:

Nota: Si en esta lista no esta exactamente el recipiente utilizado por favor utilice el que más se le parezca tanto en formato como en capacidad.



110611:

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10.2. Scientific contributions

10.2.1. Publications derived from the present work

- **Ferreira-Pêgo C,** Nissensohn M, Kavouras SA, Babio N, Serra-Majem L, Martín-Águila A, Mauromoustakos A, Salas-Salvadó J. **Beverage Intake Assessment Questionnaire: Relative Validity and Repeatability in a Spanish Population with Metabolic Syndrome from the PREDIMED-PLUS Study.** Nutrients. 2016;8(8). PMID: 27483318

- **Ferreira-Pêgo C**, Babio N, Fenández-Alvira JM, Iglesia I, Moreno LA, Salas-Salvadó J. **Fluid intake from beverages in Spanish adults; cross-sectional study.** Nutr Hosp. 2014;29(5):1171-8. PMID: 24952000.

- **Ferreira-Pêgo C**, Babio N, Salas-Salvadó J. **A higher Mediterranean diet adherence and exercise practice are associated with a healthier drinking profile in a healthy Spanish adult population.** Eur J Nutr. 2015;[Epub ahead of print]. PMID: 26646673.

- **Ferreira-Pêgo C**, Guelinckx I, Moreno LA, Kavouras SA, Gandy J, Martinez H, Bardosono S, Abdollahi M, Nasseri E, Jarosz A, Babio N, Salas-Salvadó J. **Total fluid intake and its determinants: cross-sectional surveys among adults in 13 countries worldwide.** Eur J Nutr. 2015;54 Suppl 2:35-43. PMID: 26066354.

- Guelinckx I, **Ferreira-Pêgo C**, Moreno LA, Kavouras SA, Gandy J, Martinez H, Bardosono S, Abdollahi M, Nasseri E, Jarosz A, Ma G, Carmuega E, Babio N, Salas-Salvadó J. **Intake of water and different beverages in adults across 13 countries.** Eur J Nutr. 2015;54 Suppl 2:45-55. PMID: 26072214.

- **Ferreira-Pêgo C**, Babio N, Bes-Rastrollo M, Corella D,Estruch R, Ros E, Fitó M, Serra-Majem L, Arós F, Fiol M, Santos-Lozano JM, Muñoz-Bravo C, Pintó X, Ruiz-Canela M, Salas-Salvadó J. **Frequent consumption of sugar- and artificially sweetened beverages, and natural and**

bottled fruit juices is associated with an increased risk of metabolic syndrome in a mediterranean population at high CVD risk. J Nutr. 2016; [Epub ahead of print]. PMID: 27358413.

10.2.2. Other publications

- Fenández-Alvira JM, Iglesia I, **Ferreira-Pêgo C**, Babio N, Salas-Salvadó J, Moreno LA; **Fluid intake in Spanish children and adolescents; a cross-sectional study.** Nutr Hosp. 2014;29(5):1163-70. PMID: 24951999.

- Vitoria I, Maraver F, **Ferreira-Pêgo C**, Armijo F, Moreno Aznar L, Salas-Salvadó J; **The calcium concentration of public drinking waters and bottled mineral waters in Spain and its contribution to satisfying nutritional needs.** Nutr Hosp. 2014;30(1):188-99. PMID: 25137280.

- Maraver F, Vitoria I, **Ferreira-Pêgo C**, Armijo F, Salas-Salvadó J; **Magnesium in tap and bottled mineral water in Spain and its contribution to nutritional recommendations.** Nutr Hosp. 2015;31(5):2297-312. PMID: 25929407.

- **Ferreira-Pêgo C**, Babio N, Maraver F, Vitoria I, Salas-Salvadó J; **Water mineralization and its importance for health.** Alim. Nutri. Salud. 2016; 23(1):4-18.

- **Ferreira-Pêgo C**, Babio N, Salas-Salvadó J; **Letter to the Editor Re: Nissensohn M. et al.; Nutrients 2016, 8, 232.** Nutrients. 2016; 8(8): 453. PMID: 27472360

10.3. Participation in national and international conferences

Conference: III World Congress of Public Health Nutrition. Las Palmas de Gran Canaria (Spain), 9-12th November 2014.

Authors: **Ferreira-Pêgo C,** Babio N, Fernández-Alvira JF, Iglesia I, Moreno LA, Salas-Salvadó J.

Title: *Fluid intake from beverages in Spanish adults: cross-sectional study.*

Format: Poster.

Publication: Nutr Hosp. 2014;29(5):1171-8.

Conference: III World Congress of Public Health Nutrition. Las Palmas de Gran Canaria (Spain), 9-12th November 2014.

Authors: **Ferreira-Pêgo C,** Babio N, Salas-Salvadó J.

Title: *A healthier lifestyle is associated with a healthier drinking profile.*

Format: Poster.

Publication: Eur J Nutr. 2015;[Epub ahead of print].

Conference: CCNIEC (Centre Català de la Nutrició de l'Institut d'Estudis Catalans) Scientific session 2015 "Nutrition, food and metabolic syndrome". Barcelona (Spain), 7th April 2015.

Authors: **Ferreira-Pêgo C,** Babio N, Salas-Salvadó J.

Title: *Sugar sweetened beverages intake and Metabolic Syndrome*

Format: Oral communication.

Conference: 34th International Symposium on Diabetes and Nutrition. Prague (Czech Republic), 29th June -1st July 2016.

Authors: **Ferreira-Pêgo C,** Babio N, Bes-Rastrollo M, Corella D, Estruch R, Ros E, Fitó M, Serra-Majem L, Arós F, Fiol M, Santos-Lozano JM, Muñoz-Bravo C, Pintó X, Ruiz-Canela M, Salas-Salvadó J; on the behalf of PREDIMED Investigators.

Title: *Frequent consumption of sugar and artificially sweetened beverages, and natural and bottled fruit juices are associated with an increased risk of Metabolic Syndrome in a Mediterranean population at high CVD risk.*

Format: Poster.

Publication: J Nutr. 2016;146(8):1528-36.

10.4. Mobility

Length: 3 months (January 2016 – April 2016).

Institution: University of Arkansas (Fayetteville, AR, USA).

Supervisor: Prof. Stavros A. Kavouras

Objective: Learning statistical methodology to validate a fluid-specific assessment questionnaire using Uosm and 24-hour urine volume as a biomarker. Participate in the confection of a scientific paper regarding the validation of this questionnaire in the context of the PREDIMED-PLUS study.