Beverage Type and Hydration Parameters in Older Persons Following a Texture-Modified Diet and Living in Long-term Care Residences

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Abstract

Background: Dehydration due to insufficient fluid intake is a common feature in older adults, a situation that is exacerbated in those who follow a texture modified diet. Most studies have been focused on the total amount of fluid intake without taking into consideration hydration capacities from different beverages. This study aimed to evaluate which is the relationship between the intake of different beverage types and their relationship with hydration parameters in older adults.

Methods: A prospective observational study in 22 volunteers that followed a texture-modified diet and thickened liquids with a monthly follow-up for 4 months was performed with older people living in long-term care residences. Beverage intake was assessed daily, and hydration parameters were determined at the end of each month.

Results: 50% of the volunteers presented an inadequate fluid intake (< 90% of the recommended daily intake of 30 mL/kg of body weight). Gelatine was the preferred hydration drink, providing 54% of the water intake outside the diet, while water and fruit juices constituted approximately 18% of the intake each, and other beverages such as milk and yogurt, the remaining 10%. No correlation was observed between the total amounts of liquids taken during the day with any of the biomarkers of hydration analysed. Contrary, plain water intake inversely correlated with blood levels of sodium (r= -0.25), and Angiotensin-Converting-Enzyme (ACE) activity (r= -0.29); while gelatine directly correlated with haematocrit (r= 0.25). Since different beverages were consumed during the day, cluster analysis was performed to determine patterns of beverage intake. Three patterns of beverage intake were identified, mainly high in plain water, high in gelatine, and mixed beverage intake. The pattern with a higher intake of gelatine, as a source of water, reported the worst parameters of hydration. Similarly, it was observed that a pattern with high plain water intake showed higher levels of fluid intake.

Conclusions: It was concluded that besides the focus on total fluid intake, an appropriate selection of beverages is another important criterion that should be taken into consideration for hydration in older people.

Background

Dehydration due to insufficient fluid intake is a common feature in older adults, and it is associated with an increased risk of adverse health outcomes and death [1]. Reduced fluid intake can be explained by a variety of physiological, medical, and social reasons. Physiologically, water balance is determined by intake (consumed water, beverages, water from foods, and metabolic water formed by oxidation of substrates) and waste (skin, urine, stools, and expired air from lungs). Older individuals have a higher risk of developing dehydration due to both diminished fluid intake and increased water losses. Physiological changes associated with aging include reduced concentration capacity of the kidney, alterations in the secretion, or response to vasopressin, which may induce an altered thirst perception; and decreased body total water content between others.

Additionally, pharmacotherapy, such as diuretics, laxatives, and cardiovascular agents, can also have adverse effects on the control of the body's water balance [2]. Other medical reasons such as dementia, apraxia, cognitive fluctuation, reduced physical mobility, and a high degree of dependency for feeding and medication may reduce older people ability to obtain adequate nutrition and hydration. Texture-modified diets are usually prescribed in such situations and may represent between 8 and 67% of people living in long-term residences [3]. It has been observed in most studies that the fluid intake is lower in residents with a high degree of dependency that follows a texture-modified diet [3, 4]; mainly due to the difficulty in feeding processes and the high degree of dependency during feeding.

Social reasons include environmental characteristics of the living place. Long-term care residents have been described as having a chronic mild state of dehydration, with approximately one-third reported to be dehydrated [5, 6]. Residences that included greater choice and availability of beverages, increased staff awareness, and increased staff assistance with drinking and toileting has been associated with reduced risk of dehydration [7].

In this sense, the best way to reduce dehydration risk has always been focused on improving the consumption of adequate amounts of fluids. Recommendations for total water intake (from foods and drinks) vary within different reference authorities. The European Food Safety Agency recommends a total water intake of 2.0-2.5 L/day for women and men, respectively [8]. However, this recommendation does not take into account individual requirements derived by different needs based on body composition, physical activity, and pathologies, between others. The requirements based on height and weight provide the most individualized recommendation that may facilitate goal setting for the care plan of each older person and assist in the prevention of dehydration. Several formulas have been developed for this purpose [9, 10], being the most widely used the one that estimates 30 mL of water per kg of body weight [11]. Similarly, no formal recommendations on drink intake are raised, but it is suggested that food contributes to around 20% of total water intake. Suggesting that beverages should contribute between 1.6-2 L/day for women and men, respectively [8]. However, most observational studies have observed that water intake from beverages is decreased with increasing age [12].

Understanding the characteristics and patterns of drinking and beverages associated with better fluid intake and reducing dehydration may help to identify ways to support older adults to drink well and remain hydrated. Several types of beverages are usually offered in long-term care residences. Soft drinks, flavoured gelatine, fruit juices, between others, are often used as sources of additional fluids for persons at risk of or with mild dehydration. However, the use of these products may not be the best choice since their electrolyte content or osmolality may be inappropriate.

Based on this, this study aimed to determine beverage type and fluid intake in older adults living in long-term care residential that follow a texture-modified diet and its relationships with hydration parameters. A four months prospective observational study was conducted in two nursing home residences, where the amount and type of beverage were recorded daily. Further, a cluster analysis was performed to determine if the intake of different types of beverages and patterns were associated with biochemical hydration status variables as well as its relation with dehydration complications.

Methods

Aim, design, and setting of the study.

The main objective of the study was to determine fluid and beverage intake in older adults living in long-term care residential that follow a texture-modified diet and its relationships with hydration parameters. A prospective observational study with a 4 months follow-up, between August 2017 and November 2017 was performed for that purpose. The study was conducted in two long-term geriatric residences at Lleida, Spain. Local public sanitary authorities administer both residences. The total number of residents that can attend both residences is 156 which are characterized to have a high degree of dependency.

Participants characteristics

Around 54 residents followed a texture-modified diet at the time the study was initiated. Total fluid intake was used as a parameter to estimate study sample size, a precision of 10% (150 mL of 1500 mL mean fluid intake), and a 95% confidence was established. It was expected that the proportion of volunteers with a texture-modified diet that may not fulfill beverage intake recommendations could be 6.7% following previous studies observations [3]. Taking into account a 10% study dropout, it was estimated initial recruitment of 21 volunteers. Inclusion criteria included older people (age > 65 years) from both sexes that followed a texture-modified diet; while exclusion criteria include chronic malnutrition (body mass index below 18), active neoplasm, life expectancy less than one year. A total of 27 volunteers were recruited, of which 5 did not complete the observational period due to exitus. Finally, a total of 22 volunteers were included in the analysis (7 males and 15 females), which represents 14% of the total resident population.

Dietary analysis

Resident caregiver's daily-recorded food and beverage intake. Food intake was recorded as a percentage of food consumed during each mealtime. Nutritional values of texture-modified diets were as follow: water 71.8% (95% CI of the mean 66.6–77.0); sodium 0.24% (95% CI of the mean 0.18–0.29); energy 2297 kcal/day (95% CI of the mean 2186–2408 kcal); protein 94 g/day (95% CI of the mean 86–103 g/day); carbohydrates 294 g (95% CI 271–316 g/day); and fat 74 g (95% CI of the mean 70–78 g/day). Beverages were thickened with a commercial thickener (Nutilis, Nutricia, Milupa GmbH, Fulda, Germany) based on maltodextrin, modified corn starch, tara, xanthan, and guar gums. The consumption of each beverage was recorded individually throughout the day. The leading drinks were plain water, gelatine, fruit juices, milk, liquid yogurt, and infusions. Soft-drinks and alcoholic beverages were not consumed by the volunteers during the whole experimental period. Glasses with volumetric marks were used to determine the total intake of each drink. A special form was designed for that purpose, and days with missing data were excluded from the analysis. Total food and beverage intake during the month were divided by the number of days with appropriate records. Weekly supervision with caregivers was performed to verify the quality of the dietary records. Total fluid intake was determined by the sum of beverage consumption during the day.

Blood biochemical analysis

Blood samples were collected monthly. Venous blood samples were collected in serum separator tubes (BD, Ref. 367953) at 8:00 am, after 12 h fast (food and beverages), in the supine position, and between 15 to 30 minutes after wake-up. Immediately after (within 1 hour), venous blood samples were sent to a certified analytical laboratory. Plasma osmolality was calculated following the equation described by Siervo et al, 2014 [13]; briefly Osmolality (mOsm/L) = 2*Sodium(mEq/L) + 1.15*Glucose(mg/dL)/18 + blood urea (mg/dL)/2.8.

Anthropometrical analysis

A trained nutritionist following the guidelines for older persons recorded anthropometrical data monthly. Body composition was assessed by bioelectrical impedance. Body resistance was determined by 50 kHz signal through 2 outlier pairs of electrodes placed on the right wrist and right ankle with a Bodystat 1500 (Bodystat Limited, United Kingdom).

Statistical analysis

Data are presented as mean ± standard deviation and 95% confidence interval of the mean (95% CI min-max). Comparisons between two groups were performed by the two-tail t-Student test. Three or more groups were compared by one-way ANOVA, and multiple comparisons were performed by Fisher's LSD test. Incidence comparison was performed by the Chi-square test. Correlation analysis between beverage type intake and hydration parameters was performed by Pearson's correlation analysis. The Univariate general linear model analysis was performed as a response parameter the calculated plasma osmolality and as covariates the daily intake of each beverage. In all cases, the cut-off to determine significant differences between groups was set at a p-value below 0.05. The cluster analysis was performed by the K-means test and further validated by Partial Least Square Discriminant Analysis. Clustering accuracy, correlation (R2), and predictive accuracy (Q2), as well as Radom Forrest out-of-bag error, were determined to establish clustering discriminative capacity. Metaboanalyst 3.0 online software (www.metaboanalyst.ca) was used to perform clustering analysis. Other statistical analyses and graphs were performed with GraphPad Prism v6, SPSS v17.0, and R.

Results

Volunteer's nutritional and hydration biomarkers characteristics

The demographic characteristics of the volunteers included in the study are described in Table 1. Most of the volunteers showed an adequate nutritional status. Regarding anthropometric parameters, both the

95% CI for the body mass index and the z-score for the mid-arm circumference and triceps skinfold were within normal levels. However, it was observed that the z-scores for triceps skinfold were higher than the reported values for the age, while the mid-arm circumference values were lower. All these suggest a higher body fat percentage in the study population, which may influence the total body water content. Regarding blood biochemistry parameters related to nutritional status, both albumin levels and total plasma proteins were at age-appropriate levels.

The calculated blood osmolality was taken as a reference parameter for hydration classification. Osmolality values above 295 mOsm/L were taken as a cut-off for possible dehydration [13]. In this sense, 61% of the analyses done throughout the 4 months were indicators of plausible dehydration. Similarly, with other biomarkers of hydration status such as blood sodium (normal values 135–142 mEq/L), only 27% of the analyses showed adequate sodium levels; 40% with a diagnosis of hypernatremia and 33% with hyponatremia. Both situations, hyponatremia and hypernatremia, in addition to increasing health risk, are indicators of hydro-electrolyte imbalance in this population group [14]. Other biomarkers of hydration status, such as haematocrit showed normal values in most of the population (95% CI values between 39.3 and 41.0).

In addition to the biomarkers previously described, the body's total water content was determined by bioelectrical impedance analysis. Resistance measurements reflect extracellular space, while the reactance indicates cellular activity. Adequate fluid intake is associated with lower resistance, being 550 ohms the cut-off for the diagnosis of hypovolemia [15]. Few cases showed resistances above 550 ohms, reducing the rate of diagnosis of water imbalance through this method. Finally, other parameters related to hydration, such as stool deposition, presented on average 0.7 depositions per day, most of them with a normal consistency and a few of them as fecolith, as well as liquid and semiliquid consistency.

Table 1
Demographic characteristics of volunteers included in the study. A total of 22 volunteers were included in the study, with a follow-up of 4 months. The distribution between genders was 7 males and 15 females.

	Mean ± standard deviation	**95% CI of mean (lower-upper)**
Age (years)	86 ± 6	85–87
Nutritional status		
BMI (kg/m^2)	23.3 ± 5.8	22.1–24.5
Mid-upper arm circumference (cm)	25.1 ± 4.1	24.2–26.0
Triceps skinfold thickness (mm)	11.3 ± 5.0	10.2–12.4
Albumin	4.3 ± 0.7	4.1–4.4
Total proteins	6.0 ± 1.1	5.8–6.3
Hydration parameters		
Osmolality (mOsm/L)	300.5 ± 26.3	295.3–305.8
Sodium (mEq/L)	139.5 ± 11.8	137.1–141.8
Haematocrit (%)	40.2 ± 4.0	39.3–41.0
Vasopressin (pg/mL)	1.53 ± 1.32	1.16–1.90
Body's total water content (%)	37.4 ± 9.1	34.6–40.2
Bioimpedance (Ohms)	484 ± 115	448–520
ACE activity (U/L)	47.3 ± 13.8	44.6–50.1
Beverage intake (mL/day)	1554 ± 292	1496–1612
Water (mL/day)	285 ± 303	225–345
Gelatine (mL/day)	849 ± 530	744–953
Fruit juices (mL/day)	280 ± 254	231–331
Milk (mL/day)	69.1 ± 123.5	44–94
Liquid yogurt (mL/day)	10.3 ± 33.0	4–17
Stool deposition		
Number (month^{-1})	22.2 ± 12.3	20–25
Normal (%)	77.8 ± 20.1	73.7–81.8
Liquid (%)	8.1 ± 12.9	5.5–10.7

	Mean ± standard deviation	95% CI of mean (lower-upper)
Semi-liquid (%)	10.6 ± 12.1	8.1–13.0
Lumpy (%)	2.3 ± 4.4	1.4–3.2
Fecolith (%)	0.7 ± 3.2	0.09–1.39

Beverage and fluid intake

The average beverage consumption was 1554 mL/day. Taking into account the recommendation of a daily intake of 30 mL/kg of body weight [11], the percentage of the adequacy of the intake was calculated individually, where 50% of the volunteers showed an adequate fluid intake (> 90% of the intake recommendations). Gelatine was the preferred hydration drink, providing 54% of the water intake outside the diet. Water and fruit juices constituted approximately 18% of the intake each, while the rest of beverages such as milk, yogurt, and others the remaining 10%. However, the distribution of beverage intake was not uniform in all the volunteers. In other words, there was wide variability in the type of drinks consumed during the day by the volunteers.

To determine if the consumption of different types of beverages could be related to the hydration parameters, Pearson correlation analysis was performed between the volumes of intake of each beverage with biomarkers of hydration (Fig. 1). No correlation was observed between the total amounts of liquids taken during the day with any of the biomarkers of hydration analysed. Contrary, water intake inversely correlated with blood levels of sodium, vasopressin, and Angiotensin-Converting-Enzyme (ACE) activity; and directly correlated with the number of stools depositions. Respect to this last observation, it was observed an inverse correlation between the percentage of normal stool deposition and water intake ($p = 0.0240$, $r=-0.232$), while a direct correlation with the percentage of liquid type deposition ($p = 0.0340$, $r = 0.217$). Regarding gelatine intake, only a direct correlation was observed with haematocrit levels ($p = 0.046$, $r = 0.217$). Results from a univariate general lineal model analysis of the effect of the intake of the different types of beverage and the osmolality are described in Table 2. Calculated osmolality can be estimated mainly by the amount of plain water, milk, and yogurt intake.

Table 2
Results from univariate general linear model analysis predicting blood osmolality from different beverage intake ($F = 2.847$, $p = 0.020$)

Variable	Estimate (β)	Standard error	t	p-value
Intercept	300.95	4.76	63.18	0.000
Water	-5.37	2.33	-2.26	0.026
Gelatine	-0.03	0.26	-0.13	0.896
Fruit juices	4.58	2.83	1.62	0.109
Milk	11.63	5.64	2.06	0.042
Yogurt	-47.2	20.3	-2.32	0.022

As mentioned previously, there was wide variability in the beverage consumption by the volunteers. To determine if a specific pattern of intake may induce changes in hydration parameters, a cluster analysis was performed to identify the patterns of beverage type intake (Fig. 2). Three patterns were identified (PLS-DA cross-validation accuracy 0.89867; $R2 = 0.87346$; $Q2 = 0.86252$, Random Forrest Out-of-bag error = 0.0761) (Fig. 2A and 2B), where Cluster 1 was characterized by a higher variability of beverage type intake (without a preferred beverage intake), Cluster 2 was characterized by high consumption of gelatine, and Cluster 3 by a high intake of plain water. Differences in biomarkers of hydration were observed between clusters (Fig. 2C to 2E), where it was observed that the Cluster 3, with a higher intake of water, presented the lowest levels of plasmatic sodium ($p = 0.0347$ and $p = 0.0459$ compared to Cluster 1 and 2 respectively) and was the cluster that presented the highest intake of fluids ($p = 0.0427$ and $p = 0.0004$ compared to Cluster 1 and 2 respectively). These suggest better hydration parameters are observed in Cluster 3 where the intake of plain water was higher. Although no differences in plasma osmolality between the three clusters were observed.

Finally, appropriate diet intake was observed within the volunteers. The percentage of breakfast, lunch, and dinner taken was 92.6 (88.2–97.1); 91.7 (87.2–96.1); and 89.1 (84.6–83.6) respectively (mean (95% CI of the mean lower-upper). Based on the percentage of diet intake it was calculated that the texture-modified diet contributed with an average of 881 mL of water intake per day; from which can be estimated a mean daily water intake of 2435 mL (diet + beverages).

Medical complications and hydration characteristics

During the 4 months of follow-up, 31 cases of medical complications were observed, which included urinary (10 cases) and respiratory tract infections (21 cases). Based on the presence of medical complications, the main differences in hydration parameters (described in Table 3) are the higher levels of osmolality and lower dinner intake observed in the group with medical complications (Cohen's d effect size: 0.55 and 0.09 for osmolality and dinner intake respectively); although similar fluid intake was observed between groups. Similarly, it was not observed differences in the incidence of medical complications between the described clusters (Chi-square $p = 0.7486$), and during the 4 months of follow-up (Chi-square $p = 0.6198$). Nevertheless, there was a significant increase in the levels of plasma osmolality during October and November (Fig. 3). The increase in plasma osmolality during the last two months was not accompanied by a decrease in beverage intake or changes in beverage type intake, suggesting that other factors besides dietetic factors may influence this finding.

Table 3

Characteristics of volunteers that presented medical complications during the 4 months of follow-up. Medical complications included urinary (10) and respiratory tract infections (21). Values are presented as mean (lower-upper 95% CI of the mean). Differences in parameters between both groups are highlighted in bold and * denotes p-values below 0.05.

	Without complications	**With at least one complication**	**p-value**
Age (years)	86.0 (84.5–87.6)	87.9 (85.7–90.0)	0.2459
Nutritional status			
Body mass index (kg/m^2)	23.4 (22.0-24.7)	22.8 (20.2–25.5)	0.7394
Mid-upper arm circumference (cm)	25.3 (24.4–26.2)	24.4 (22.4–26.4)	0.3984
z-score	-1.50 (-1.88 – (-1,13))	-1.77 (-2.53 – (-1.00))	0.5472
Triceps skinfold thickness (mm)	11.1 (10.0–12.2)	12.1 (9.3–14.9)	0.4619
z-score	0.99 (0.71–1.28)	0.87 (0.91–1.57)	0.7321
Blood albumin (mg/dL)	4.24 (4.05–4.42)	4.32 (4.06–4.58)	0.6548
Blood total proteins (mg/dL)	5.91 (5.71–6.11)	6.08 (5.50–6.66)	0.4961
Creatine kinase (U/L)	30.8 (26.1–35.6)	37.4 (25.8–49.1)	0.3013
Hydration status			
Osmolality (mOsm/L)	**297.8 (291.5–305.8)**	**312.3 (302.6–321.9)***	**0.0327**
Sodium (mEq/L)	138.3 (135.4–141.2)	143.9 (140.1 -147.8)	0.0650
Chloride (mEq/L)	98.8 (97,6–100.1)	100.7 (97.9–103.4)	0.2144
Haematocrit (%)	40.4 (39.5–41.3)	39.2 (37.3–41.1)	0.2633
Blood urea nitrogen (mg/dL)	43.1 (38.0–48.2)	52.4 (39.6–65.1)	0.1232
Vasopressin (pg/mL)	1.60 (1.14–2.05)	1.48 (0.39–2.57)	0.8261
ACE activity (U/L)	48.0 (44.6–51.4)	46.1 (41.7–50.5)	0.5884
Diet intake (% of plate)			
Breakfast (%)	98.8 (98.0–99.5)	98.6 (97.5–99.8)	0.8180
Lunch (%)	98.1 (97.0–99.1)	96.8 (94.6–99.1)	0.2928
Dinner (%)	**96.4 (95.3–97.5)**	**93.4 (89.5–97.3)***	**0.0455**
Beverage intake			
Total (mL/day)	1529 (1444–1614)	1527 (1451–1602)	0.9754

	Without complications	With at least one complication	p-value
Water (mL/day)	309 (235–383)	249 (125–373)	0.4617
Gelatine (mL/day)	841 (728–953)	928 (704–1151)	0.4988
Fruit juices (mL/day)	306 (242–368)	270 (180–360)	0.5985
Milk (mL/day)	56 (32–79)	54 (10–99)	0.9451
Liquid yogurt (mL/day)	11 (3–20)	9 (1–17)	0.8025

Discussion

Few studies have evaluated the effectiveness of beverage type intake on hydration parameters in older people living in long-term care residences. The main objective of this study was to determine if specific types and patterns of beverage intake are related to better outcomes of hydration parameters in older people that follow a texture-modified diet. The importance of this study lies in the fact that this population group presents a higher risk of dehydration and is associated with several consequent medical complications [16]. Our findings confirm that more than 50% of the analysis performed in the volunteers showed parameters of dehydration or risk of dehydration. Although there is no clear consent to the extent of this problem due to differences in the diagnosis methodology and cut-offs to determine dehydration in this population [17, 18]; other studies have reported that 75% of individuals in long-term care have been reported to be dehydrated when relying on thickened liquids for oral hydration [19]. Similarly, results consistently demonstrate that individuals who require thickened liquids consume less than if they were to consume unthickened liquids [20, 21]. This study observed that most volunteers reported an adequate intake of fluid based on the 1500 mL/day recommendation. Nevertheless, based on the 30 mL/kg fluid intake recommendation; only 50% of the volunteers met the recommendation.

To counteract this situation, several strategies have been raised to improve fluid intake that includes frequent encouragement to drink, by offering a wide variety of beverages, by advising to drink often rather than large amounts, and by adaptation of the environment and medications as necessary [22]. Other authors have focused on greater variability in options of beverage intake as a strategy to increase fluid intake [7, 23], although the improvement in the hydration status in these studies was inconclusive. Similarly, in this study, no correlation was observed between the total fluid intake and any of hydration biomarkers analysed. Nevertheless, it was observed that the preference of intake certain types of beverage is correlated with several biomarkers of hydration status. In this sense, three different patterns of consumption were observed: mixed beverage intake, rich in gelatine, and rich in plain water. Higher plain water intake observed in Cluster 3 was associated with lower levels of plasmatic sodium and higher fluid intake. Similar findings were observed in the correlation analysis between the type of beverage and hydration biomarkers, where the increase in plain water intake was correlated with lower levels of plasmatic sodium and ACE activity. In this sense, the adequate selection of beverage seems to have influences in some biomarkers of the hydration.

To our knowledge, few studies have specifically investigated the bioavailability of water when mixed with thickening agents. Beverages in texture-modified diets are offered as thicken liquids normally by the addition of starches and gums. Starch is generally broken down through enzymatic digestion and water-binding capacity is expected to be reduced throughout the gastrointestinal tract. Gums on the other hand are resistant to enzyme digestion in humans, and some concerns have been raised about the water-release capacity of gums. Acute hydration studies with healthy and younger volunteers have demonstrated that water bioavailability was unaffected by several types of thickeners [24, 25]. However, no study has been performed in older people following a texture-modified diet with its associated characteristics and medical complications, and in a longer period. In this study, two main types of beverages were employed: 1) based on the thickening of the usual beverage with modified-starch and gums, and 2) the use of flavoured gelatine as a source of water. Several nutritional and functional differences can be pointed out between both approaches. Starch and gums provide a considerable amount of fibre to the thickened beverage. For example, a range between 1 to 2.4 g of fibre is added for each 250 mL beverage for honey and pudding consistency respectively. For a total beverage intake of 1500 mL/day, an extra fibre intake of 14.4 g/day is expected. This fact is in agreement with the observations in this study since the use of thickened plain water showed a direct correlation with the increase in stool depositions (Fig. 1). In this sense, increased water losses could be expected due to fibre water-binding effect and increased intestinal motility, which was associated with a higher number of liquid type stools depositions. On the other side, flavoured gelatine is not a liquid state *per se*; and it breaks down when chewing, as well as melting when it is in contact with the mouth or at temperatures above 25 ºC. These characteristics can bring functional problems since some authors suggest that flavoured gelatines might increase oropharyngeal residue; although, in vitro swallowing behaviour of jellies and yogurt showed comparable characteristics to thickened fluids [26].

Another important factor that should be taken into consideration is the osmolality of the beverages to be thickened. For example, high osmolality has been reported for flavoured gelatine (735 mOsm/kg) and fruit juices (orange 601, apple 772, and pineapple 705 mOsm/kg) [27]. In this context, the higher osmolality reported in this type of beverage may induce a reduction in water absorption in the studied population. To point out this observation, in younger adults, beverages with osmolality ranging from 440 to 631 mOsm/kg have demonstrated to induce an increase in fluid secretion into the intestinal lumen [28], compromising water absorption. Few studies have determined the optimal beverage osmolality for water absorption in older persons, which may be difficult to delimitate due to the higher incidence of gastrointestinal complications in older people. Welch et al [29], improved hydration parameters after a 5 days treatment with a beverage that contained higher amounts of carbohydrates and lower amounts of chloride, potassium, and sodium than the recommended for oral rehydration formulas [30]. Suggesting that lower amounts of electrolytes are suitable to induce a proper hydration capacity in the older population. The second factor of importance is that higher osmolality beverages may provide higher amounts of sodium, which may interfere with the capacity to regulate water homeostasis. Moreover, high glycemic beverages may induce hyperinsulinemia that may cause vascular and kidney injury and may exacerbate dehydration [31]. Whereas, acute effects of high glucose/fructose beverage intake in mild dehydration has also been described, which may activate vasopressin release and the aldolase reductase and worsen dehydration-associated renal injury [32]. Altogether, these findings raise the importance of the research and design of adequate beverage products for the older population, which few clear statements and protocols have been developed.

This population also has a significantly greater risk of medical complications induced due to dehydration [33]. The results of this study suggest that the incidence of medical complications (respiratory and urinary) were associated with higher levels of blood osmolality. Nevertheless, no differences were observed regarding total fluid intake or between the different beverage types taken. Regarding other factors that deserve attention in this aspect, thermoregulation capacity is not well regulated in the older population, while the sleep/wake and rest/activity rhythms are likely to be weak and fragmented [34]. Few studies have evaluated the effects of indoor climate changes in hydration status. For example, it was observed that the lower indoor's humidity in the winter was associated with lower skin surface hydration of the residents compared to other seasons [35]. Similarly, adequate fluid intake should be done during the dinner to counteract water losses during sleeping due to respiration or night sweats. In this sense, this study observed that a lower dinner intake was associated with the presence of medical complications.

This study presents some limitations that should be taken into consideration for further studies. The risk and definition of dehydration were based on the calculated serum osmolality. Although other blood and anthropometric hydration parameters were determined, the analysis of skin hydration, urine osmolality, between others, could have improved the description of the hydration status of the volunteers. Similarly, the presence of medical complications could not be attributed solely to the dehydration of the volunteers. In this sense, a detailed monitoring analysis should be performed to determine if the dehydration is a cause or a consequence of the medical complications reported. Furthermore, it will be interesting to determine the effect of the hydration status in the recovery time of the presented medical complications.

Conclusions

Besides the focus on the increase in total fluid intake, an appropriate selection of beverages is an important parameter that may influence hydration parameters in the older population. Unfortunately, there is little evidence of the ideal beverage osmolality that may favour good hydration avoiding gastrointestinal complications and unbalances in electrolyte levels. In this sense, further studies should focus on the determination and design of appropriate beverage characteristics for hydration purposes in the older population.

Abbreviations

ACE
Angiotensin-Converting-Enzyme

Declarations

Ethics approval and consent to participate

The recruitment of the volunteers was carried out through group and individual sessions with the families responsible for the residents; and signed the informed consent to participate in the study. Ethics Committee of the Hospital Universitari Arnau de Vilanova, in Lleida, Spain (CEIC-1768, June 29, 2017) approved the study, and it was conducted according to the ethical guidelines of the Helsinki Declaration.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interest

The authors declare no conflict of interest.

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Author Contributions

Conceptualization, J. CE. S.; methodology, J. CE. S.; investigation, M.M.; J.M; A.C.; M.B.; and A.G-S.; resources, J. CE. S.; data curation, M.M; A. G-S; and J. CE. S.; writing—original draft preparation, J. CE. S. and A. G-S.; writing—review and editing, all authors; funding acquisition, J. CE. S. All authors have read and agreed to the published version of the manuscript.

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Figures

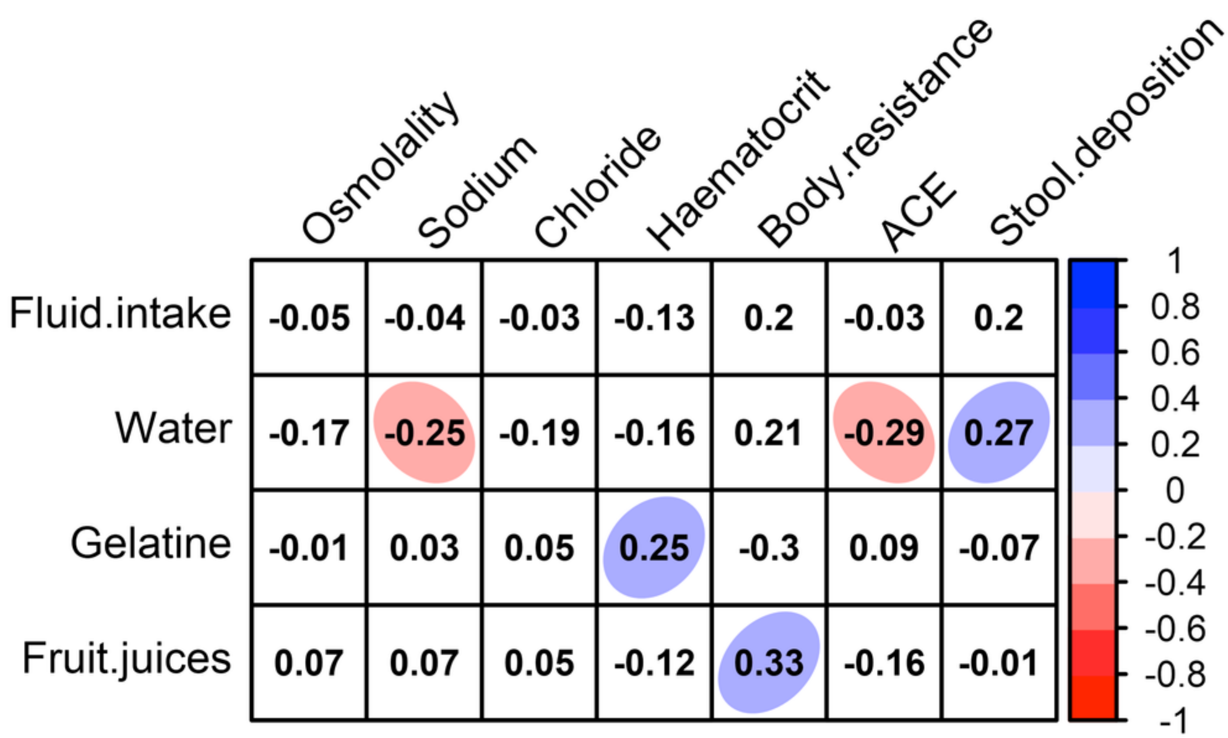

Figure 1

Correlations between hydration parameters and beverage intake of plain water, gelatine and fruit juices. Significant correlations (p<0.05) are shown by a coloured ellipse indicating the magnitude of correlation determined by Pearson's analysis, with R-value superimposed on the ellipse. Positive correlations are shown in blue, negative correlations in red, and non-significant correlations appear in white. ACE: Angiotensin-converting enzyme activity.

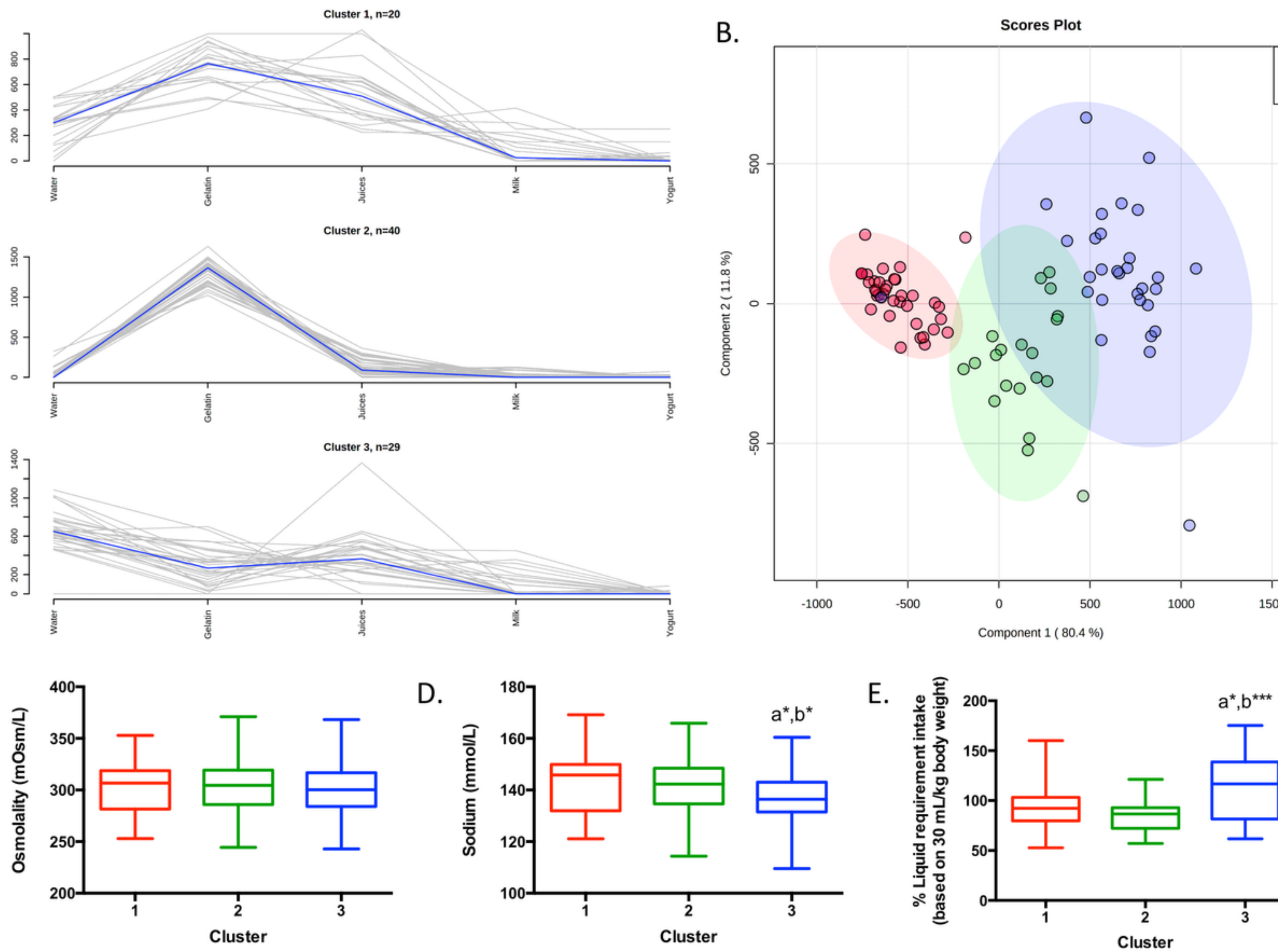

Figure 2

Cluster analysis of beverage intake and its relation with hydration biomarkers. A. K-means cluster analysis of beverage intake during the 4 months of study follow-up. Three clusters were obtained, which can identify the volunteers by its beverage pattern with an estimated out-of-bag error of 0.0761. B. PLS-DA analysis that validates the belonging of each data to a specific cluster (accuracy: 0.8987, R2: 0.8735 and Q2: 0.8625). C., D. and E., plasma osmolality, sodium levels, and percentage of liquid requirement intake of the volunteers in the three different clusters. Statistical differences were determined by one-way ANOVA and multiple comparisons were performed by Fisher's LSD test, p<0.05 and p <0.001 are marked with * and *** respectively; (a) and (b) denotes difference to the observed parameters with Cluster 1 and 2 respectively. Cluster 1, 2 and 3 are characterized by a mixed, high gelatine and high plain water intake respectively.

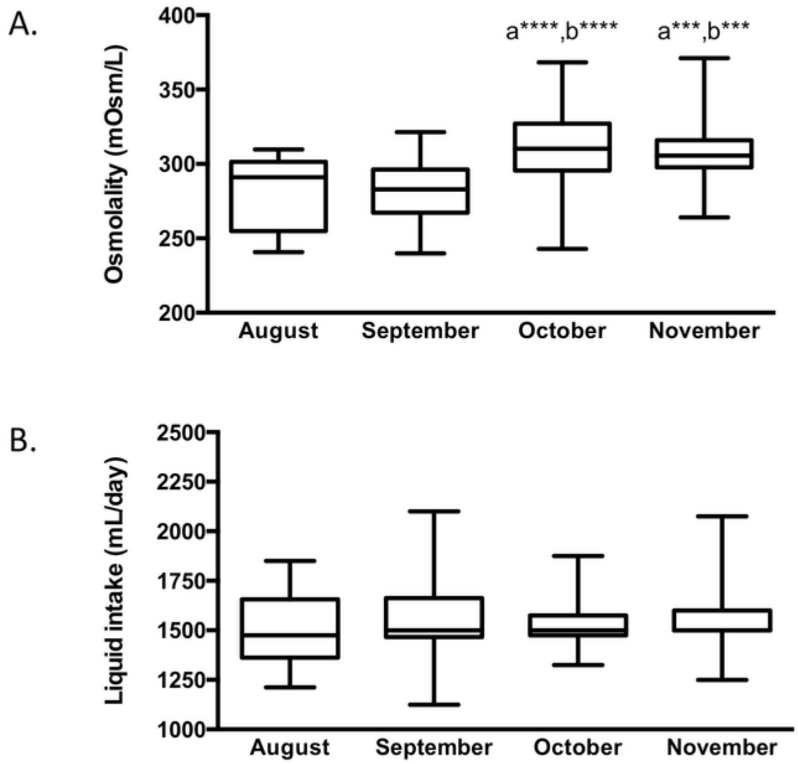

Figure 3

Osmolality, liquid intake and environmental parameters during the 4 months of study follow-up. A. Blood calculated osmolality. An increase in osmolality was observed during October and November. Statistical differences were determined by one-way ANOVA and multiple comparisons were performed by Fisher's LSD test, p<0.001 and p <0.0001 are marked with *** and **** respectively; (a) and (b) denotes difference to the observed parameters in August and September respectively. B. Changes in fluid intake (mL/day) during the study follow-up.