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Total Water Intake and Beverage Variety Are Associated with Social Capital and Health-Related Quality of Life Among Older Adults

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Abstract

Older adults are vulnerable to dehydration. Thus, it is important to understand factors related to barriers/enablers to total water intake (TWI). We hypothesized that their ability to access, purchase, prepare and drink a variety of beverages towards optimal TWI is affected by their physical/mental health and social support. To test the hypothesis, we evaluated TWI, social capital, and Health-Related Quality Of Life, using the Water Balance Questionnaire, Social Capital questionnaire, and SF-36, respectively, in 890 free-living participants (49.6% male), aged>65 years recruited in Metropolitan Athens and Crete, Greece. TWI, 80% from beverages, was 2.6±0.7L in men and 2.4±0.8L in women and was associated with beverage variety (4.1±1.0 in men, 3.9±1.1 in women). Social capital, mental health and variety of beverages were significant predictors of TWI; for each increased unit of the aforementioned predictors, TWI increased to 9.1, 6.8 and 183.5mL, respectively. Spatial and gender differences were observed in social capital score and its components, and in Health-Related Quality Of Life and its components, thus reflecting differences in social support and in functional health, plausibly linked to barriers/enablers to TWI. This study highlights the special needs, as well as the social and health-related barriers, regarding hydration and beverage accessibility.

Keywords: hydration; aging; water; drinks; dehydration; social capital; health; social support; elderly

1. Introduction

Older adults are vulnerable to dehydration, attributed to age-related changes in physiology, psychology, physical and cognitive abilities, and lifestyle (Beck *et al.*, 2021; Li, Xiao and Zhang, 2023).

Dehydration is a prevalent and often under-recognized health concern among older adults, attributed to a combination of age-related physiological, cognitive, and lifestyle factors (Mantantzis *et al.*, 2020; Parkinson *et al.*, 2023). As individuals age, there is a natural decline in total body water content and a diminished sensation of thirst, which can impair fluid intake regulation (Masot *et al.*, 2020; Johnson, 2022). Additionally, renal function declines with age, reducing the kidneys' ability to concentrate urine and conserve water, thereby increasing the risk of dehydration (Guppy *et al.*, 2024; Muzaale *et al.*, 2024). Cognitive impairments, such as dementia, further exacerbate the risk, as they can hinder an individual's ability to recognize and respond to thirst cues (Mentes, 2006; Queirós *et al.*, 2023). Moreover, medications commonly prescribed to older adults, including diuretics and

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laxatives, can lead to increased fluid loss (van Poelgeest *et al.*, 2025). Lifestyle factors, such as reduced mobility and social isolation, may also limit access to fluids and contribute to inadequate hydration (Bunn *et al.*, 2015; Edmonds *et al.*, 2021).

The consequences of dehydration in the elderly are significant. Even mild dehydration can impair cognitive functions, particularly attention and executive function, which are critical for daily activities (Suhr *et al.*, 2004). Chronic dehydration has been associated with increased risks of urinary tract infections, kidney stones, constipation, and falls (Ferry, 2005; Stookey *et al.*, 2020; Nerbass, Pecoits-Filho and Calice-Silva, 2021). Furthermore, studies have linked inadequate hydration to accelerated cognitive decline and increased mortality rates (Hooper *et al.*, 2014a; Bunn *et al.*, 2015; Li, Xiao and Zhang, 2023).

Despite the clear risks, dehydration remains a common issue among older adults. A systematic review and meta-analysis estimated that approximately 20–30% of community-dwelling older individuals experience low-intake dehydration, with higher prevalence observed among those with multiple chronic conditions (Hooper *et al.*, 2014a; Parkinson *et al.*, 2023). This highlights the need for targeted interventions to promote adequate hydration in this population.

Understanding the multifaceted causes and consequences of dehydration in older adults is essential for developing effective prevention and management strategies(Beck *et al.*, 2021; Li, Xiao and Zhang, 2023). Barriers and facilitators to the process of daily hydration through the selection of beverages and foods must be identified and fully understood (Bruno *et al.*, 2021; Mellett, Leddy and Mullee, 2022; Rosin *et al.*, 2024). It appears that beyond individual physiological and cognitive factors, broader social determinants such as social capital may also influence hydration behaviors in older adults, shaping access to care, support for daily needs, and overall health practices through social networks and community engagement. We hypothesized that in older adults, the ability to access, purchase, prepare and drink a variety of beverages mainly depends on their a) health b) social interaction. This paper aims to explore the physiological, cognitive, and lifestyle factors contributing to dehydration in the elderly and thus, indirectly, to identify potential interventions to mitigate this pervasive health issue.

The objective of the present study was a) define associations with variety in beverage intake, water intake from beverages and total water intake, as well as physical and mental health scores and b) to assess social capital among older adults living in different geographical settings (the island of Crete and metropolitan Athens).

2. Materials and Methods

2.1. Ethical Permission

The study protocol was designed in line to the Declaration of Helsinki and the principals of research on human subjects and was reviewed and approved by the Ethical Committee of the Agricultural University of Athens (181-14/02/2014). Before entering the study, all participants were informed on the aims and procedures of the study and were asked to provide informed consent. All data were collected via personal one-on-one interviews and were treated with confidentiality, according to the ethical clearance provided by the Ethics Committee.

2.2. Study Participants

Older adults (age >65 years) were recruited via invitation at Social Structures for the Elderly (KAPI) in an urban and a rural area in Greece, namely the area of metropolitan Athens (several municipalities) and the Municipality of Minoa in Crete. Exclusion criteria included inability to communicate, cognitive impairment and lack of knowledge of the Greek language. Out of 1,200 invited, 890 agreed to participate (male 49.6%), specifically 454 from Athens and 436 from Crete. Participation rate reached 70%, while 30 participants withdrew for personal reasons, despite having provided prior consent.

Trained personnel collected all information via interviews.

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2.3. Socio-Demographic Parameters

Collected demographics included sex, age, educational level, marital status, number of children, employment status, number of people cohabiting the same house, car ownership, annual income, smoking habits, and health problems (recorded as known diagnoses of medical conditions). Anthropometric data were self-reported and included weight and height. Body Mass Index (BMI) was calculated from these data for each participant.

The characteristics of the sample are presented in **Table 1**.

Table 1. Participant characteristics.

Participant characteristics	Value
Inhabitants of Athens/Crete (*n*)	454/436
Sex (men/women *n*)	441/449
Age (years)	75.6 ± 6.6
Marital status (married/widower/divorced/ never married) (%)	65.7/30.1/2.5/1.7
Educational tier (primary/secondary/tertiary/professional school) (%)	65.4/26.1/5.5/2.9
Profession (pensioner/farmer/private employee/housewife/other) (%)	92.7/0.9/0.1/0.1/6.1/0.1
Annual income (<10 k€/10–20 k€/20–40 k€/>40 k€) (%)	59.0/34.5/5.8/0.7
Home ownership (%)	85.4
BMI (male/female)	27.6±3.6/28.7±4.5

2.4. Water and Beverage Intake

For estimating TWI and water intake from beverages, the Water Balance Questionnaire (WBQ) was employed (Malisova *et al.*, 2012). The WBQ embeds a food and beverage frequency questionnaire and allows collecting information on the variety and number of beverages consumed. The WBQ has been previously used in older adults in Greece (Malisova *et al.*, 2018).

In order to score variety in beverage consumption, beverages were categorized into eight groups: water (tap or bottled), fruit juice, caloric soft drinks, diet soft drinks, milk, alcohol, tea/coffee, other beverages. The sum of tap and bottled water intake was used to calculate drinking water consumption. The variety score was calculated as the sum of all beverages consumed from the eight distinct categories, with a minimum value of "0" and a maximum value of "8" (Malisova *et al.*, 2013, 2018; Athanasatou *et al.*, 2016). TWI was calculated from the moisture content of the consumed foods and the total beverage intake.

2.6. Social Capital

For scoring individual social capital, the Social Capital Questionnaire (SCQ) (Onyx and Bullen, 2000) was employed. The social capital questionnaire has been translated and validated for the Greek population (SCQ-G) in the past (Kritsotakis et al., 2008). The SCQ-G comprises of 36 questions in total organized in six subscales: Participation in the Local Community, Feelings of Safety, Family/Friends Connections, Value of Life and Social Agency, Tolerance of Diversity, and Work Connections. In the present study, the four questions from the subscale Work Connections and one additional question from the subscale Value of Life and Social Agency related to employment status were excluded, given that almost half of the participants were not working during the time of the study (Kritsotakis *et al.*, 2008). Each question has a 4-point scale reflecting the frequency of occurrence (1, not at all, no, never; 2, rarely, sometimes; 3, probably yes, often, much; 4, very much, frequently). Higher scores in each question indicate higher social capital. A score for each separate subscale is derived by adding the scores of the questions of each subscale; a total score by adding all scores is also estimated (Kritsotakis *et al.*, 2008).

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3. Results

3.1. Water and Beverage Intake and Variety

TWI, and its components, namely water from beverages, from drinking water (tap and bottled) and from foods is reported in **Table 2,** presenting values in men and in women, and at the two sites of the study in order to observe gender and spatial differences. TWI was 2543 (2057–3058) in men and 2322 (1838–2813) in women. Approximately 80% of TWI was from beverages. Gender differences were apparent in TWI and its components ($p \leq 0.001$), with the exception of water from foods, no differences were observed. There were no differences in TWI in older adults living in Athens and in Crete; however, water from beverages and water from foods were lower in Crete while water from drinking water was higher ($p \leq 0.001$).

Beverage variety score was 4.1±1.0 in men and 3.9±1.1 in women; women in Athens and in Crete scored lower variety compared to men ($p \leq 0.001$) but there was no difference in beverage variety in Athens and in Crete.

Table 2. Total Water Intake, observed as water from beverages, from drinking water (tap and bottled) and from foods, and among older adult men and women, inhabitants of metropolitan Athens and Crete.

Water intake and beverage variety	Men (*n*=441)	Women (*n*=449)	Athens		Crete		Total	
			Men (*n*=190)	Women (*n*=264)	Men (*n*=251)	Women (*n*=185)	Athens (*n*=454)	Crete (*n*=436)
TWI (*mL*)	2543 (2057–3058)	2322 (1838–2813)***	2661±800	2389 (1974–2851)*	2551±697	2298±828***	2466 (2006–2981)	2444±765
Water from beverages and drinking water (*mL*)‡	2025 (1597–2593)	1865 (1408–2365)***	1943 (1528–2471)	1889 (1482–2362)	2145±705	1850±799***	1911 (1514–2403)	1958 (1481–2521)
Water from beverages (*mL*)†	595 (411–805)	514 (361–745)***	669 (476–882)	554 (411–810)**	559 (402–724)	466 (297–658)***	622 (430–830)	514 (361–695)$^{\#\#\#}$
Drinking water (tap + bottled) (*mL*)	1440 (960–1920)	1200 (840–1680)***	1200 (960–1680)	1200 (960–1680)	1440 (960–2160)	1200 (720–1680)***	1200 (960–1680)	1400 (960–1920)$^{\#\#\#}$
Water from foods (*mL*)	435 (360–574)	470 (375–567)	560 (438–718)	491 (403–599)***	383 (338–453)	424 (339–533)***	516 (421–665)	395 (338–491)$^{\#\#\#}$
Beverage variety (*n*)	4 (4–5)	4 (3–5)***	5 (4–5)	4 (3–5)***	4 (4–5)	4 (3–4)***	4 (3–5)	4 (3–5)
	4,4±1,0	3,9±1,1	4,5±1,1	4,0±1,1	4,3±0,9	3,8±1,0	4,2±1,1	4,1±1,0

Results are presented as median with the respective IQR for skewed variables, or as mean ± standard deviation for normally distributed variables. Significance was tested with the Mann–Whitney U-test for skewed variables, or the t-test for normally distributed variables; *IQR*: interquartile range; *TWI*: Total water intake; † Excluding drinking water; ‡ Including drinking water; * Significantly different compared to men (*** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$); $^{\#}$ Significantly different compared to inhabitants of Athens metropolitan area ($^{\#\#\#}$ $p \leq 0.001$).

3.1. Social Capital

Social capital scores per gender and per area of residence are presented in **Table 3**. Men exhibited higher feeling of safety, and family and friend bonds compared to women in total sample ($p \leq 0.001$ for all), and at each site. The total social capital score was higher among men inhabiting Athens compared to women, whereas the sense of local community was higher among women living in Crete compared to men. Between areas, the sense of local community and tolerance diversity was higher in Athens compared to Crete ($p \leq 0.001$ and $p \leq 0.05$ respectively), whereas in the latter, the feeling of safety was higher ($p \leq 0.001$).

Table 3. Frequencies of social capital scores and score components among older adult men and women, inhabitants of metropolitan Athens and Crete.

Social capital questionnaire (SCQ) scores and components		Men (*n*=441)		Women (*n*=449)		Athens				Crete				Total			
						Men (*n*=190)		Women (*n*=264)		Men (*n*=251)		Women (*n*=185)		Athens (*n*=454)		Crete (*n*=436)	
		%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Total SCQ score (%, *n*)	Low	7.9	35	13.6	61	6.3	12	15.9	42	9.2	23	10.3	19	11.9	54	9.6	42
	Average	81.0	357	76.4	343	80.0	152	73.9	195	81.7	205	80.0	148	76.4	347	81.0	353
	High	11.1	49	10.0	45	13.7	26	10.2	27	9.2	23	9.7	18	11.7	53	9.4	41
SCQ Value of life score (%, *n*)	Low	80.7	356	71.3	320	76.8	146	65.9	174	83.7	210	78.9	146	70.5	320	81.7	356
	Average	8.8	39	14.3	64	11.1	21	16.7	44	7.2	18	10.8	20	14.3	65	8.7	38
	High	7.9	35	13.6	61	6.3	12	15.9	42	92	23	10.3	19	11.9	54	9.6	42
Total score (31–124)†		74 (68–80)		73 (67–79)		74 (69–80)		72.0±9.5*		74 (68–80)		75 (69–79.5)		73 (67–79)		75 (68–79.8)	
SCQ scores components	Local community (12–48)†	21 (18–23)		21 (19–24)		21 (-19–25)		21 (19–24)		20 (18–22)		21 (19–23)**		21 (29–24)		20 (18–23)###	
	Safety (2–8)†	6 (4–7)		4 (3–6)***		5 (4–6)		4 (3–5)***		6 (5–7)		6 (4–7)***		4 (3–6)		6 (5–7)###	
	Family and friends bonds (2–8)†	4 (4–5)		4 (3–5)***		5 (4–5)		4 (3–5)**		4 (3–5)		4 (3–5)***		4 (3–5)		4 (3–5)	
	Tolerance diversity (2–8)†	4 (3–5)		4 (3–5)		4 (3–6)		4 (3–5)		4 (3–4)		4 (3–5)		4 (3–5)		4 (3–4)#	
	Value of life (11–44)†	32 (30–35)		33 (30–36)		32 (30–35)		33 (30–36)		32 (30–35)		33 (30–36)		33 (30–36)		33 (30–35)	

* Significantly different compared to men (*** $p \leq 0.001$; ** $p \leq 0.01$); # Significantly different compared to inhabitants of Athens metropolitan area (### $p \leq 0.001$; # $p \leq 0.05$); †.

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3.3. Health-Related Quality of Life

The distinct SF-36 components per gender and per area of residence are presented in **Table 4**. Higher scores for reported for components of SF-36 physical functioning, bodily pain, social functioning and mental health were observed among men in the total sample, compared to the women ($p \leq 0.001$). Vitality, as well as physical and mental health summaries were also higher among men participants compared to women ($p \leq 0.02$, $p \leq 0.008$ and $p \leq 0.002$, respectively). In Crete, men demonstrated increased social functioning and physical health compared to women ($p \leq 0.001$ for all), whereas in Athens, men also scored higher in role emotional compared to women ($p \leq 0.05$). In both sites, female participants reported reduced bodily pain, vitality, mental health and mental health summary, compared to the men. When pooled gender samples were compared from each site, components of SF-36 role physical, role emotional, general health, vitality, physical and mental health summaries ($p \leq 0.001$ for all), as well as mental health ($p \leq 0.05$) were greater in Athens compared to Crete.

Table 4. Health-Related Quality Of Life in older adult men and women, living in the metropolitan Athens and in Crete, evaluated with the SF 36 questionnaire and reported per components of SF-36.

SF-36 components	Men (*n*=441)	Women (*n*=449)	Athens		Crete		Total	
			Men (*n*=190)	Women (*n*=264)	Men (*n*=251)	Women (*n*=185)	Athens (*n*=454)	Crete (*n*=436)
Physical Functioning	70 (50–90)	60 (40–80)^{***a}	70 (45–85)	65 (45–80)^{d}	75 (50–95)	50 (35–75)***	65 (45–80)^{e}	65 (40–85)
Role-Physical	69 (44–94)	69 (44–94)	75 (50–100)	81 (50–100)	63 (38–88)	63 (44–82)	75 (50–100)	63 (39–81)$^{\#\#\#}$
Bodily Pain	72 (51–100)	61 (41–74)***	74 (51–100)	61 (41–84)***	64 (51–84)	61 (41–72)***	62 (41–100)	62 (42–74)
General Health	57 (42–72)	57 (40–72)	62 (47–75)	65 (48–77)	52 (40–67)	4±22**	62 (47–76)	50 (35–67)$^{\#\#\#}$
Vitality	63 (50–75)	63 (44–75)*	69 (50–88)	69 (50–81)*	63 (50–75)	56 (44–69)**	69 (50–81)	56 (50–69)$^{\#\#\#}$
Social Functioning	88 (63–100)	75 (50–100)***	88 (63–100)^{c}	88 (-50–100)	88 (75–100)	75 (50–100)***	88 (50–100)^{f}	75 (63–100)
Role-Emotional	75 (42–100)	75 (42–100)	92 (65–100)	83 (50–100)*	58 (33–100)	58 (25–92)	92 (58–100)	58 (33–92)$^{\#\#\#}$
Mental Health	75 (60–85)	65 (45–80)***	70 (59–85)	65 (45–80)***	75 (65–85)	65 (50–80)***	70 (50–80)	70 (55–85)$^{\#}$
Physical Health Summary	47 (40–53^{b})	45 (38–52)^{**a}	48 (42–53)^{c}	46±9^{d}	47 (39–53)	42±9***	48 (40–53)^{g}	45 (37–52)$^{\#\#\#}$
Mental Health Summary	50 (43–56^{b})	48 (38–56)^{**a}	54 (45–57)^{c}	50 (39–57)^{**d}	48 (42–54)	45±11**	52 (42–57)^{g}	47 (40–54)$^{\#\#\#}$

Results are presented as median with the respective 1st and 3rd interquartile ranges for skewed variables, or as mean ± standard deviation for normally distributed variables (in italics). Significance was tested with the Mann–Whitney U-test for skewed variables, or the t-test for normally distributed variables; IQR: interquartile range; SF-36: Short form 36 questionnaire (MChorney, Ware and Raczek, 1993).

3.4. Correlations Between Study Variables

In the total sample, social capital was positively correlated with physical and mental health (rho=0.195, rho=0.240, $p \leq 0.001$ for both). Weak positive correlations were observed between beverage variety and water intake from beverages (rho=0.234, $p \leq 0.001$) and TWI (rho=0.260, $p \leq 0.001$). In addition, water from beverages demonstrated a strong positive correlation with TWI (rho=0.972, $p \leq 0.001$).

A multiple linear regression model was used to predict TWI based on the social capital score, physical health, mental health, beverage variety, age, gender, BMI, car and income. The final model used was significant [$F_{(9,\ n=874)}=11.226$, $p \leq 0.001$], with an R^2 of 0.094. Social capital, mental health and variety of beverages were significant predictors of TWI, and for each increased unit of the aforementioned predictors, TWI increased to 9.1, 6.8 and 183.5 mL, respectively (**Table 5**).

Regarding the consumption of water from beverages, including drinking water, a regression equation was calculated [$F_{(9,\ n=874)}=8.890$, $p \leq 0.001$], with an R^2 of 0.074. Social capital, mental health, beverage variety and gender were predictors; for each unit increase of those predictors, water intake from beverages increased to 7.4, 6.6, 149.6 and 127.4 mL, respectively.

When participants' sex was accounted for, among women, beverage variety was predicted by age and car ownership ($\beta=0.037$, $p \leq 0.001$ and $\beta=0.254$, $p \leq 0.044$), a finding lacking from the men's

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sample (data not shown). As per area, in the Athenian population, social capital, physical health and gender were significant predictors, while in the Cretan sample, age and gender were demonstrated to be as significant predictors.

Table 5. Multiple linear regression analyses of social capital and Health-Related Quality Of Life components on TWI and beverage variety.

	TWI		**Water intake from beverages‡**		**Beverage variety** (total sample)		**Beverage variety** (Athenians)		**Beverage variety** (Cretans)	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
SCQ total score	9.1**	3.2 to 15.0	7.4*	1.6 to 13.1	0.01*	0.0 to 0.02	0.02***	0.01 to 0.03	-0.002	-0.014 to 0.01
Physical Health Summary	-1.9	-7.9 to 3.9	-1.0	-6.7 to 4.6	-0.002	-0.01 to 0.006	-0.02**	-0.03 to -0.004	0.006	-0.005 to 0.017
Mental Health Summary	6.8**	1.9 to 11.7	6.6**	1.8 to 11.3	-0.001	-0.01 to 0.01	-0.01	-0.02 to 0.001	0.004	-0.006 to 0.014
Beverage variety	183.5***	136.1 to 230.9	149.6***	104 to 195.2	-		-		-	
Age	0.4	-8.1 to 9.0	-1.4	-9.6 to 6.8	0.02***	0.01 to 0.03	0.02	0.00 to 0.04	0.019*	0.002 to 0.035
Gender	110	-4.7 to 224.6	127.4*	17.1 to 237.6	0.4***	0.3 to 0.6	0.4***	0.2 to 0.7	0.455***	0.245 to 0.665
BMI	2.9	-9.3 to 15.2	1.5	-10.2 to 13.3	-0.006	-0.02 to 0.01	-0.01	-0.04 to 0.012	0.001	-0.021 to 0.023
Car ownership	-109.3	-226.3 to 7.6	-71.7	-184.2 to 40.7	0.11	-0.06 to 0.3	-0.02	-0.26 to 0.22	0.213	-0.011 to 0.437
Income	12.3	-69.6 to 94.1	-56.5	-135.1 to 22.2	0.1	-0.06 to 0.17	-0.006	-0.17 to 0.16	0.052	-0.118 to 0.222

BMI, Body Mass Index; *CI*, confidence interval; *SCQ*, Social Capital Questionnaire (Onyx and Bullen, 2000); *TWI*, total water intake; *β*, beta coefficient; ‡ Including drinking water; * Statistically significant (*** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$).

4. Discussion

The present study highlights that among older adults, total water intake (TWI) is significantly influenced by social capital, mental health, and beverage variety. Beverage variety itself was associated with age, gender, and social capital, suggesting interconnected pathways that affect hydration behaviors. Notably, spatial and gender disparities were evident, with differences observed between older adults residing in metropolitan Athens and those living on the island of Crete. These differences were reflected not only in levels of social capital but also in the types and quantities of beverages consumed, underscoring the importance of environmental and socio-demographic factors in shaping hydration-related behaviors in aging populations.

With regard to the volume of water consumed by the older adults inhabiting Athens and Crete, it appears that both sexes reached the adequate intake values suggested by the European Food Safety Authority (EFSA) (EFSA Panel on Dietetic Products Nutrition and Allergies (NDA), 2010) for men and women (2.5 and 2.0 L, respectively). Similar levels of intake were observed among older adults inhabiting Athens and Crete. However, other studies suggest that older adults are at risk for insufficient fluid intake and are encouraged to drink more (Volkert *et al.*, 2019); research from countries like Sweden, the Netherlands, Czech Republic, Slovenia, Spain, and the UK, recorded water intakes below the adequate intake threshold (Ocké *et al.*, 2013; Hendriksen *et al.*, 2014; Engelheart and Akner, 2015; Aparicio-Ugarriza *et al.*, 2016; Nissensohn *et al.*, 2016; Lešnik *et al.*, 2017; Klimešová, Wittmannová and Kováčová, 2018; Jimoh *et al.*, 2019). According to O'Connor *et al.* (O'Connor, Walton and Flynn, 2014), older men in Ireland failed to meet the EFSA's adequate volume intakes compared to women. These low fluid intakes are the epiphenomenon of aging-related altered

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physiology, including thirst perception (Hooper *et al.*, 2016), physical limitations (i.e., reduced mobility) (Białecka-Dębek and Pietruszka, 2019), social isolation, depression, or other illnesses (Hooper *et al.*, 2014b). In parallel, with older adults demonstrating significant deficiencies in hydration health literacy (Picetti *et al.*, 2017), the reduced water intakes reported in these studies might also be attributed to the low hydration knowledge of participants. On the other hand, in Poland, 70% of older adults met the reference values (Białecka-Dębek and Pietruszka, 2019), older data from the UK suggest a nearly similar TWI to the EFSA reference values (Gibson, Gunn and Maughan, 2012), whereas in Germany, the majority of independently living elderly consumed adequate amounts of fluids (Volkert, Kreuel and Stehle, 2005). More recently, adequate mean daily intake was reported among a sample of Greek-born Australians (Tsindos, Itsiopoulos and Kouris-Blazos, 2015). Based on the present findings corroborated by previous research on the Greek population (Malisova *et al.*, 2013, 2016; Athanasatou *et al.*, 2016), it appears that in Greece, inhabitants tend to consume greater fluid intakes compared to other countries (Rodríguez Alonso *et al.*, 2015; Nissensohn *et al.*, 2016). According to Muñoz and Wininger (Muñoz and Wininger, 2020), models explaining hydration should account for the environment. Thus, the aforementioned finding might be the result of climate, acculturation to increased drinking volumes from a younger age, and the abundance of free drinking water available in most parts of the country.

In lieu of the aforementioned assumption, differences in the source of water intake were observed among older adults inhabiting metropolitan Athens compared to those living on the island of Crete. The first consumed more beverages and bottled water, whereas the latter reported a greater tap and drinking water intake. The quality of drinking water is easily influenced by natural and anthropogenic factors, including the industry. This issue may explain spatial differences in the source of water intake observed among older adults inhabiting metropolitan Athens compared to those living on the island of Crete. Moreover, in Crete, the availability of water of tap better quality might also be the driving force behind the observed increased intake.

In the present study, water from beverages, including drinking water, contributed to the TWI at approximately 80%, a finding in agreement with the consumption reported by the NHANES 2005–2010 (Drewnowski, Rehm and Constant, 2013) and the estimated adequate intakes suggested by the EFSA (EFSA Panel on Dietetic Products Nutrition and Allergies (NDA), 2010). Similar observations were recorded for men and women living either in Athens or Crete. In other populations, water intake from beverages may be different; for example, in Irish elder individuals, water intake from beverages contributed to the TWI at approximately 63% (O'Connor, Walton and Flynn, 2014).

In our sample, TWI and water from beverages, including drinking water, were predicted from beverage variety and social capital. Beverage variety is an important factor associated with water intake (Nissensohn *et al.*, 2016). Herein, we adopted a system for scoring variety, which takes into consideration 8 different categories of hot and cold beverages, including drinking water. Adopting a similar scoring system from studies in adults living in the UK showed that greater variety scores were linked with increased water intake (Gibson and Shirreffs, 2013). Furthermore, a scoring system analogous to the one used herein has been applied to determine the pattern of beverage variety of French older adults and was associated with increased TWI (Szabo de Edelenyi *et al.*, 2016). Gibson and associates (Gibson, Gunn and Maughan, 2012) stated that the results from the secondary analysis of the NDNS 2000/2001 indicate a positive correlation between beverage variety and TWI. We observed that older adults' beverage variety was positively correlated with TWI and water intake from beverages for all participants as well as in the samples from Athens and Crete. The same association between beverage variety and TWI has also been observed among older adults in Spain (Nissensohn *et al.*, 2016). Given that an inverse age-related gradient is reported to exist in total beverage and water intake (Zizza, Ellison and Wernette, 2009), assuring a social support network for older adults appears to be another means of ameliorating fluid intake and avoiding dehydration in this population.

Although older adults tend to be involved to a greater degree in their communities compared to younger ones (Arezzo and Giudici, 2017), social interactions and connections demonstrate a decline

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through the course of life, being influenced by work careers and labor market particularities, memberships and family ties (McDonald and Mair, 2010). Globally, gender differences exist in the components of social capital (Kavanagh *et al.*, 2006; Tobiasz-Adamczyk *et al.*, 2017; Lu *et al.*, 2018), given the different life trajectories of both sexes and the different gender perceptions regarding individual social capital components, including safety, value of life, social and family interactions, etc. In the present sample, women in both sites reported a lower feeling of safety as compared to the men, indicating that gender characteristics might augment the feeling of safety among men. Moreover, women reported fewer family and friends bonds, as a possible result of a lack of career, or having to stay at home and raise their children during earlier years (McDonald and Mair, 2010). According to McDonald, individuals with greater work experience demonstrate expanded social networks accumulated during their careers (McDonald and Mair, 2010). In parallel, these social capital components are also influenced by the place of residence, with the Cretan sample reporting greater safety as compared to the Athenian one. It is also of interest to highlight that men achieved a greater social capital score compared to women, although, between study sites, a similar total social capital score was observed.

Regarding the social capital it was shown that as the level of socialization increased, i.e., the social capital score was elevated, older individuals had better chances to achieve the recommended intake of water and increase beverage variety. According to Durkheim's classic social integration theory (Berkman and Glass, 2000; Moren-Cross and Lin, 2006), the conceptual model ties social capital to health outcomes first at a macro level (political state, culture, socioeconomic status (SES), etc.) and secondly at a micro level (social support and engagement etc.), both influencing health through physiological, psychological and behavioral pathways (Tobiasz-Adamczyk *et al.*, 2017). Moreover, social capital reflects the quality of life (Prachuntasen, Laohasiriwong and Luenam, 2018) and collective efficacy (Cagney and Wen, 2008) and, by inference, the potential aid that older adults might employ to improve accessibility to purchasing foods and drinks.

In different subgroups of the sample, social capital, age, and car ownership were predictors of the beverage variety score, indicating the complex mechanisms driving beverage variety among older adults. Car ownership, in particular, was an important factor affecting beverage variety among Cretan women. In rural and semi-rural areas like Crete, owning a car is important for transportation, socializing and purchasing food commodities. Thus, in the Cretan sample car ownership appears to be an asset aiding social capital among older women, which, in turn, might explain its effect on beverage variety. In parallel, social capital and SES have both been linked to the health and health-related behaviors of older adults (Han *et al.*, 2018). Given that nearly half (45.4%) of the women participants herein were widowers, owning a car is a SES indicator that may undoubtedly increase social interactions and ameliorate quality of life.

With regard to the physical and mental health domains, the sample's mean perceived scores were suboptimal (close to the average), with similarly average scores being also observed in either sites (Ware and Sherbourne, 1992). However, based on the findings, mental health appears to be a greater determinant of beverage variety and TWI as compared to the physical health. This corroborates the plethora of research suggesting that adequate hydration consists of an important component of mental health among older adults, as depressed individuals tend to be dehydrated (Mentes, Chang and Morris, 2006).

Moreover, social capital is also intertwined with mental health. The effect of the environment and social capital is so strong, that twins' studies indicate that cognitive social capital can even suppress a genetic predisposition for developing depression (Cohen-Cline *et al.*, 2018). Among older adults, weak social capital has been associated with depression (Han *et al.*, 2018), which, in turn, has been shown to reduce water intake (Haghighatdoost *et al.*, 2018). Poor mental health consists an important challenge in older age, and herein it is shown that mental health can predict both water intake and beverage variety. The combination of low fluid intake and compromised mental health appears to perpetuate a vicious cycle of dehydration among older adults (Liska *et al.*, 2019). Research on cohort and randomized controlled trials indicate that suboptimal fluids intake affects cognition

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and mental health, and in turn, poor mental health also deteriorates the level of hydration and the stimulus of thirst (Benton, 2011). To battle this vicious cycle, Lindeman (Lindeman *et al.*, 2000) suggested encouraging older adults to increase their fluid intake. In parallel, data from the Czech Republic reported lower hydration levels among non-exercising older adults (Klimešová, Wittmannová and Kováčová, 2018), identifying exercise as an additional means to stimulate thirst and water intake in this age group.

The present study has several limitations that should be acknowledged. First, its cross-sectional design limits the ability to draw causal inferences. While associations between beverage variety, health indicators, and total water intake (TWI) were identified, the study cannot determine the directionality or causality of these relationships. Longitudinal or intervention-based research is needed to establish whether beverage variety or social capital directly influences hydration status and related health outcomes.

Second, the reliance on self-reported data and structured questionnaires, rather than objective measurements (e.g., biomarkers of hydration, direct fluid intake tracking), may introduce recall bias or social desirability bias, potentially affecting the accuracy of the findings. Future studies should incorporate objective methods to validate self-reported intake and health status.

Additionally, the study did not explore the detailed composition of consumed beverages, such as the intake of sugary drinks, caffeinated beverages, or alcohol, nor did it assess their caloric contribution or potential health implications. Given the growing public health concern over sugar-sweetened beverages and alcohol consumption in older populations, this remains a critical area for further investigation.

Regarding the study population, although the sample size was adequate and included participants from both metropolitan and rural settings, the use of a convenience sampling method may limit the generalizability of the findings. Participants may not be fully representative of the broader elderly population in Greece or in similar cultural settings. Therefore, caution is advised when extrapolating the results to other populations. Future research should aim to recruit larger, randomized, and more diverse samples to enhance representativeness and external validity.

5. Conclusions

Among older adults, beverage variety is linked to greater water intake. Social capital and mental health are also linked to both fluid intake and beverage variety. In our hypothesis, functional health and social capital may be viewed as an asset for achieving better hydration. It may be expected that older adults may overcome some of the barriers and increase their access to beverages, if they have high individual social capital allowing them the make full use of personal and community structures. This finding is imperative for the prioritization of future interventions to increase variety in beverage consumption among older adults, and evaluate health indicators in relation to social capital and to determine their effect on beverage consumption.

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