Hydration in the aging

A review of current knowledge

The H4H Hydration for Health Initiative

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For healthcare professionals, scientists and academic researchers

Developed by DANONE RESEARCH for the Hydration for Health Initiative

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Hydration in the Aging

Introduction

Because it has numerous functions in the human body, water is one of the most important nutrients and is essential in every life stage. However, with aging, the body's mechanisms of water balance are disturbed, increasing the risk of dehydration among the elderly. Dehydration is indeed the most common fluid disorder among older persons, and it can have considerable clinical impact (Hodgkinson et al. 2003; Faes 2007). Existing evidence suggests high rates of dehydration in the elderly population (Begum and Johnson 2010; Himmelstein et al. 1983; Warren et al. 1994; Snyder et al. 1987; Bennett et al. 2004; Mentes et al. 2006a; O'Neill et al. 1990; Bourdel-Marchasson et al. 2004; Forsyth et al. 2008; Stookey et al. 2005a; Stookey 2005b), and dehydration is one of the ten most frequent diagnoses reported for hospitalisations of persons over 65 in the United States (Sheehy et al. 1999). More and more studies demonstrate the importance of preventing and managing dehydration to reduce its side-effects in this population (Faes 2007).

This document summarises the current scientific evidence on hydration in the aging population with a specific focus on the causes, consequences and management of dehydration.

I. The elderly: a population at risk of dehydration

Although there is no absolute definition, dehydration is typically defined as depletion in total body water content due to fluid losses, diminished fluid intake, or a combination of both (Begum and Johnson 2010). Depending on the ratio between sodium and water losses, dehydration can be classified as isotonic (equal loss in sodium and water – example: diarrhoea), hypertonic (excess loss of water compared to sodium – example: fever) or hypotonic (excess loss of sodium compared to water – example: overuse of diuretics) (EFSA 2010).

In the elderly, several parameters can increase the risk of dehydration, the most important ones being the age-related physiological changes.

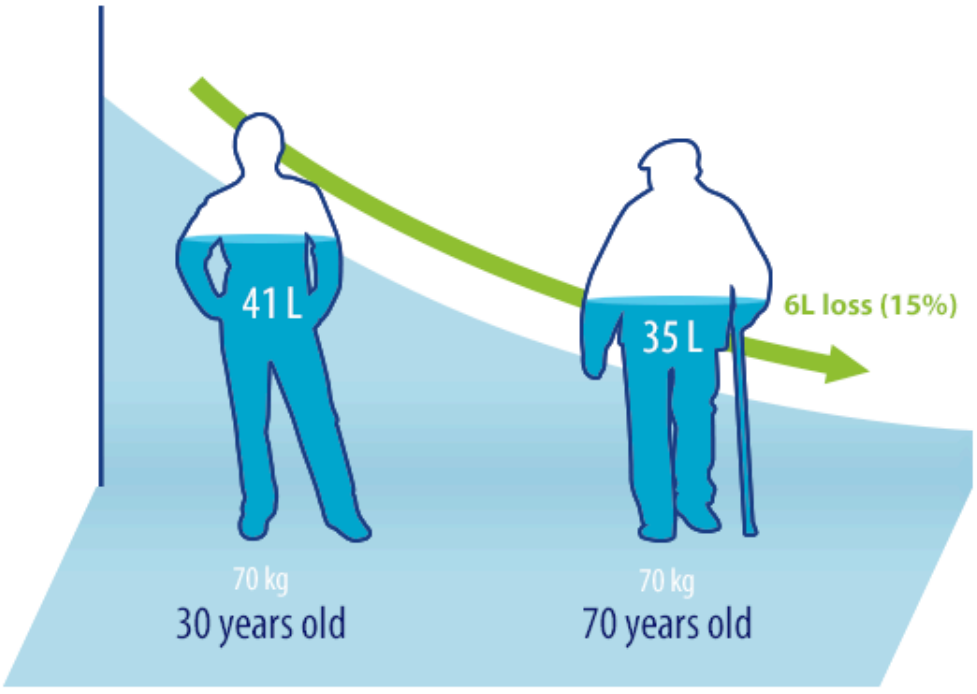
I.1. Age-related physiological changes influencing water balance

During aging a number of physiological changes take place, putting the elderly at greater risk of dehydration (Benelam and Wyness 2010). Decrease in fluid consumption and increase in fluid losses, as well as a reduced body water content, can disrupt water balance in the elderly (Schols et al. 2009; Hébuterne et al. 2009).

I.1.1. Total body water content

As one ages, the total body water content declines, due to a decrease in lean body mass and an increase in percentage of body fat (a tissue poor in water) (Sheehy et al. 1999). Four to six litres of total body water can be lost from the age 20 to the age of 80 (Gille 2010) **(Figure 1)**.
This loss of total body water content results in the availability of even small losses of body water to cause signs and symptoms of dehydration (Rikkert et al. 2009).

Figure 1. Age-related decrease in water body content



Data from Hébuterne et al. 2009

I.1.2. Thirst sensation

The elderly often experience reduced thirst sensation which leads to decreased fluid consumption, especially following water deprivation (Schols et al. 2009; Kenney and Chiu 2001). Several hypotheses have been proposed, such as alteration in osmo- and baroreceptor function and changes in hormones and neurotransmitters (depletion of dopamine levels – a neurotransmitter involved in thirst induction –, increased level of plasma Atrial Natriuretic Peptide – ANP, a well-recognised thirst inhibitor – etc.) (Silver 1990; Wilson 1999). Due to this impaired regulation of thirst, older individuals often do not drink enough to properly rehydrate themselves after fluid deprivation (Sheehy et al. 1999; Kenney and Chiu 2001).

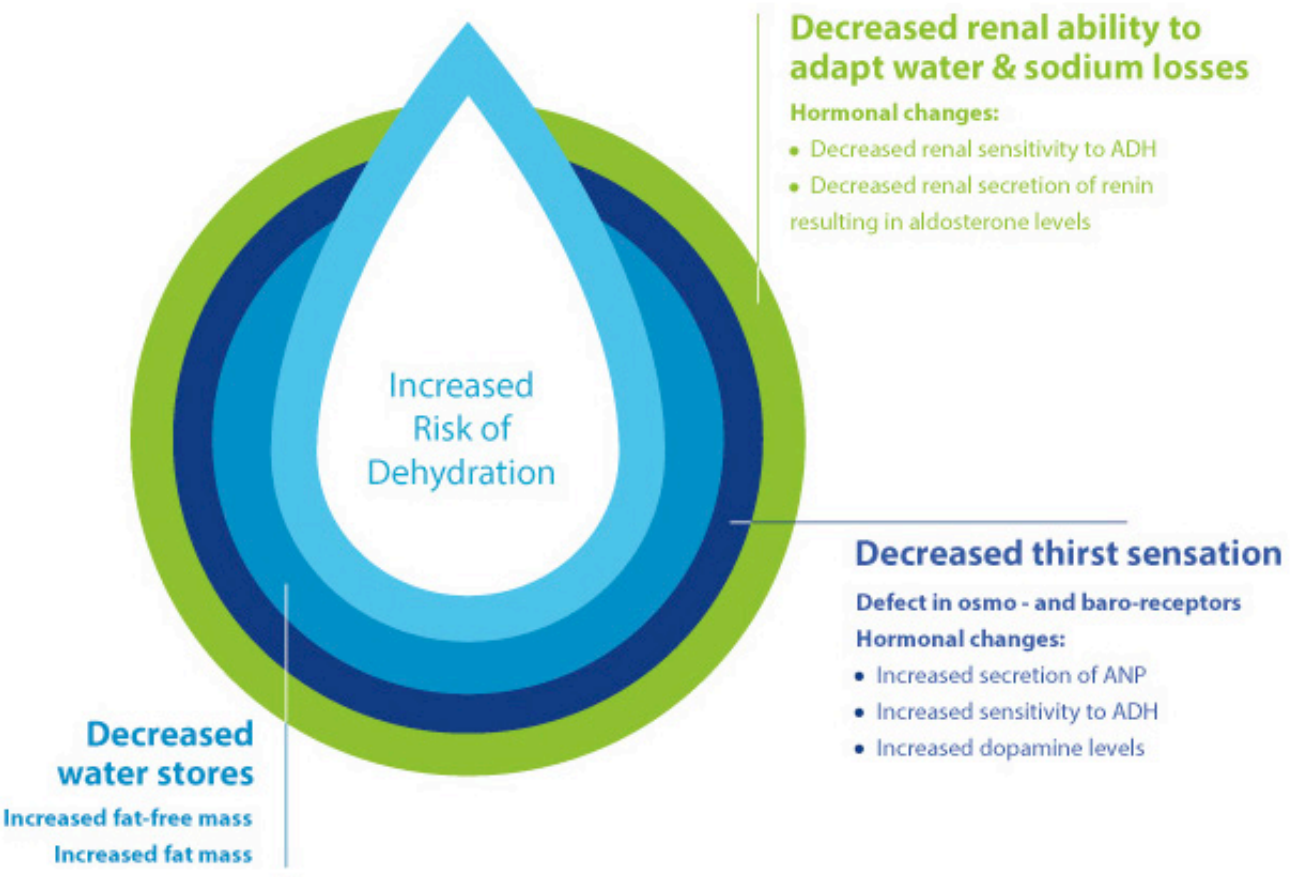
I.1.3. Kidney function

Also as a consequence of aging, renal water conservation is impaired. Aged kidneys are less able to concentrate urine, and thereby to retain water during water deprivation (Bennett 2000). Age-related lower responsiveness of the kidney to the Anti-Diuretic Hormone (ADH), is thought to play an important role in this loss of renal function (Sheehy et al. 1999).

In addition, aging kidneys have a lower ability to adequately regulate sodium excretion (Silver 1990).

Thus, in older individuals, aged-related physiological changes occur and these make the body less able to maintain water homeostasis (Schols et al. 2009) **(Figure 2)**.

Figure 2. Age-related physiological changes increasing risk of dehydration

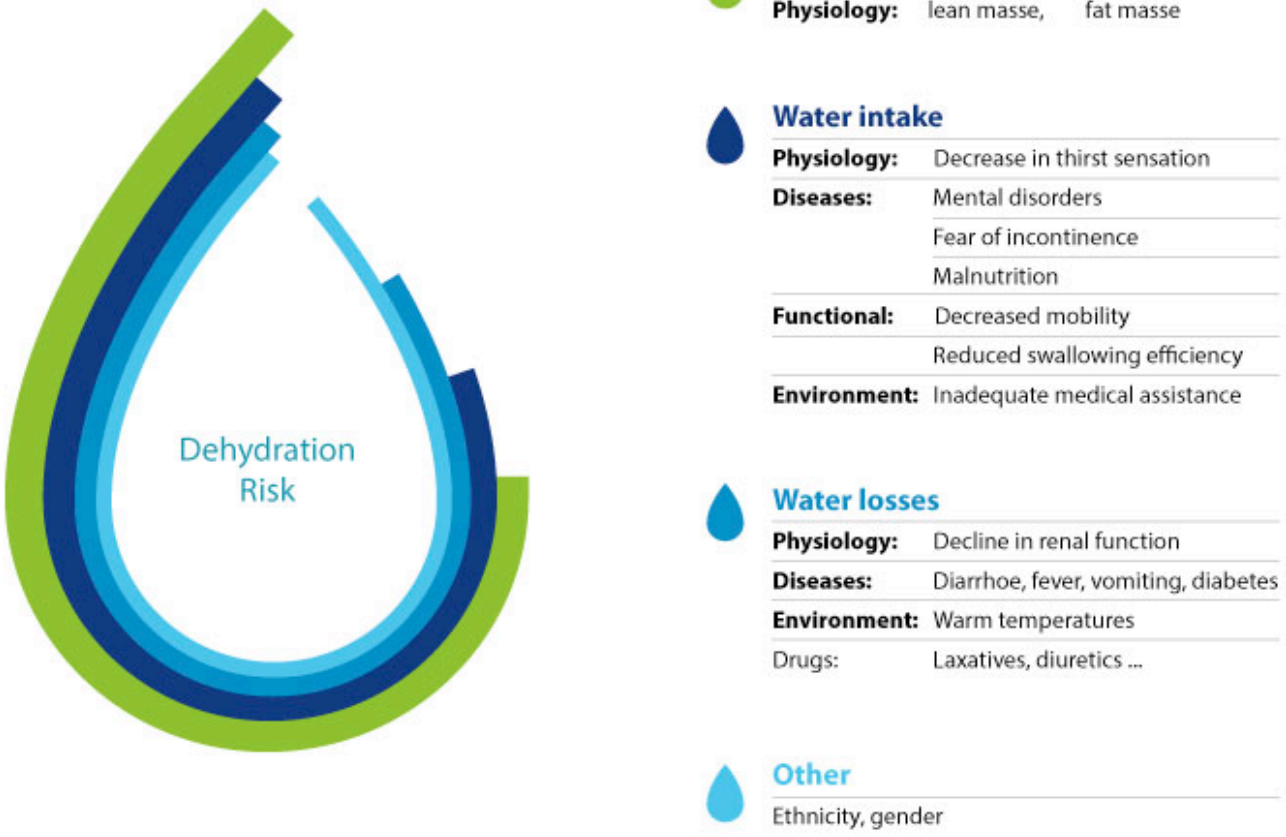


ADH= Anti-Diuretic Hormone; **ANP**= Atrial Natriuretic Peptide

I.2. Additional factors

In addition to age-related physiological changes in the body, numerous other factors can put the elderly at increased risk of dehydration **(Figure 3)**. The more risk factors, the greater the likelihood for dehydration (Wotton et al. 2008).
Aging is associated with limitations such as reduced swallowing capacity, reduced mobility, or comprehension and communication disorders, which can lead to insufficient fluid intake. Disease-related factors, such as fever, diabetes, or incontinence can increase water losses (Mentes 2006b; Weinberg et al. 1994; Feinsod et al. 2002). Dehydration may also be caused by environmental factors (warm temperature, inadequate knowledge or the lack of time of care workers in institutions contributing to inadequate fluid intake…) or iatrogenic factors (medications including laxatives, diuretics or angiotensinconverting enzyme inhibitors, and medical procedures such as those requiring fasting) (Faes 2007; Mentes 2006b; Amella 2004; Dyck 2007).

Figure 3. Risk factors of dehydration in the elderly



The hydration status of older people is the result of a fragile balance, and should therefore be carefully monitored. A constant attention is needed, as dehydration can have a considerable clinical impact.

II. Dehydration: an actual concern in the elderly population

II.1. Dehydration prevalence in the elderly

Despite its high relevance in public health, prevalence of dehydration has been poorly investigated, especially in healthy community-dwelling elderly (not in assisted living or nursing home) (Stookey et al. 2005a). Nevertheless, existing evidence is strongly suggestive of high rates of dehydration in the elderly within hospitals and other healthcare institutions (Begum and Johnson 2010; Himmelstein et al. 1983; Warren et al. 1994; Snyder et al. 1987; Bennett et al. 2004; Mentes et al. 2006a; O'Neill et al. 1990; Bourdel-Marchasson et al. 2004; Forsyth et al. 2008). In fact, dehydration is a frequent cause of hospitalisation of older adults and one of the ten most frequent diagnoses responsible for hospitalisation in the United States (Sheehy et al. 1999). Studies in nursing homes also reveal high rates of dehydration in this population. For instance, one study indicates that the prevalence of dehydration in older residents of continuing care facilities was as high as 88% when assessed by plasma osmolality (O'Neill et al. 1990). Another study is also suggestive of a high prevalence, by showing that 31% of nursing home residents encountered dehydration defined as high blood urea nitrogen to creatinine ratio, hospitalisation and administration of intravenous fluids for rehydration (Mentes 2006c). This is in line with studies indicating that between 50% to 92% of nursing home residents have inadequate fluid intakes (Mentes and Kulp 2003). In contrast, data are more conflicting in the community-dwelling elderly (Stookey 2005b). While some studies found no evidence of dehydration (Morgan et al. 2003; Bossingham et al. 2005), one found that the prevalence of hypertonicity, a measure of dehydration, may be as high as 60% (Stookey 2005b). It is likely that actual prevalence of dehydration among community-dwelling elderly adults varies depending on the indicator used to define hydration (Stookey et al. 2005a).

II.2. The elderly show inadequate fluid intake

II.2.1. What are the fluid intake recommendations for the aging?

As daily water needs strongly depend on various factors like fluid losses and dietary composition, the estimation of water requirement is highly variable and quite complex. This is particularly true for the elderly for whom health conditions such as congestive heart failure and kidney diseases or medication use (diuretics or laxatives) highly influence fluid needs (Volkert et al. 2005).

Only a few countries have established national recommendations for fluid intakes (Popkin et al. 2010) and existing recommendations vary between countries (EFSA 2010; IoM 2004). For instance, the Institute of Medicine of the National Academies of Science in the United States defined in 2005 a recommendation for total fluid intake (water provided from beverages and foods) of 3.7L and 2.5L for the elderly men and women respectively (IoM 2004). In Europe, the European Food Safety Authority has recently set a reference value for total fluid intake (water provided from beverages and foods) of 2.5L for elderly men and 2L for elderly women (EFSA 2010).

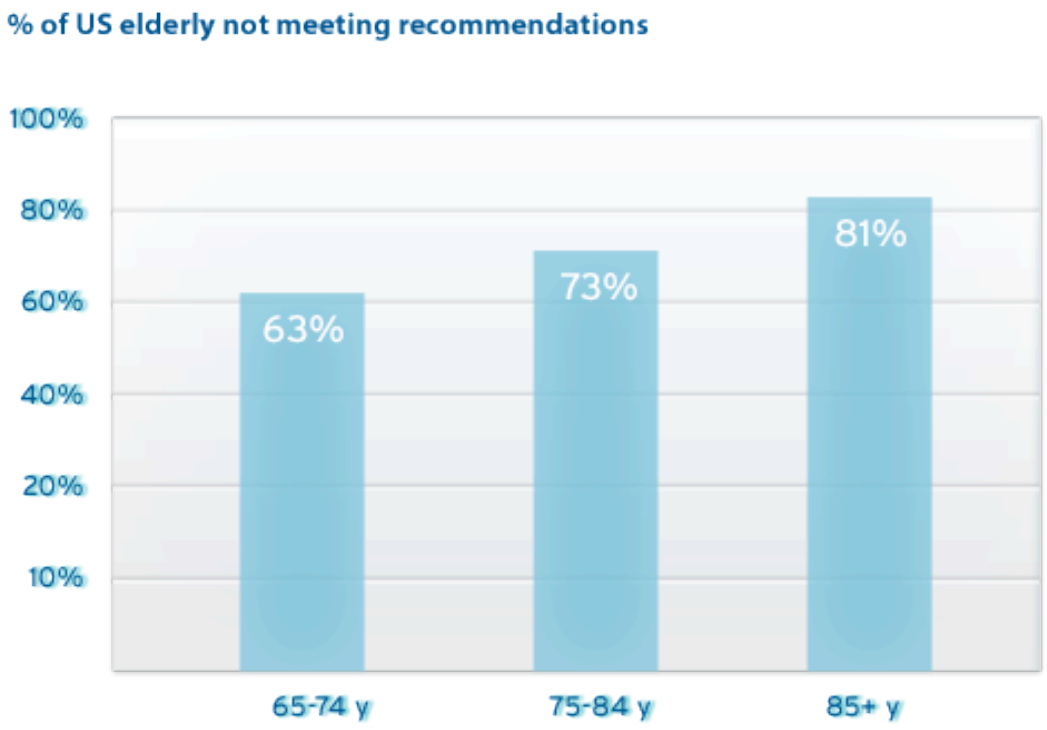
II.2.2. How much water do elderly people drink?

Despite the general consensus that an appropriate level of fluid intake is essential for health, little work has been done to date to measure total fluid intake, especially in the older population (Popkin et al. 2010; Bellisle et al. 2010). The few studies, including nationally-representative studies, addressing the measurement of fluid intakein the elderly (Volkert et al. 2005; Bellisle et al. 2010; Haveman-Nies et al. 1997; Raman et al. 2004;

Zizza et al. 2009; Kant et al. 2009) reveal that total fluid intake steadily decreases with age within the elderly population and that this decrease is mainly driven by a decrease in water intake from beverages (including drinking water) (Volkert et al. 2005; Raman et al. 2004). Comparisons between observed fluid intakes and local or regional recommendations indicate that a substantial proportion of the elderly population may be at risk for insufficient fluid intake and thereby of dehydration, especially among seniors over age 85 (Volkert et al. 2005; Haveman-Nies et al. 1997; Zizza et al. 2009; INVS and CNAM 2006).

For example, a German study conducted in independently living elderly found that one-third of this population did not meet the German reference value for total fluid intake. This poor total fluid intake was reflected by a low level of fluid intake from beverages (Volkert et al. 2005). Similarly, an American study indicated that about two-thirds (63%) of the young elderly (65-74 y) and the vast majority (81%) of the oldest elderly (85+ y) have inadequate total fluid intake based on recommendations from the Institute of Medicine (IoM 2004) **(Figure 4)**.

Figure 4. Proportion of the US elderly not meeting recommendations for fluid intake from beverages and food (Kant et al. 2009)



Cut-off used: 3700 ml (men) or 2700 ml (women) /day (US recommendations)

The hydration status of older people is the result of a fragile balance, and should therefore be carefully monitored. A constant attention is needed, as dehydration can have a considerable clinical impact.

III. Health consequences and economic burden

III.1. Health consequences of dehydration

Maintaining an adequate level of hydration is important for proper function of the whole human body (Benelam and Wyness 2010). Its impairment can have deleterious health consequences (EFSA 2010), especially in the older person, for whom dehydration is frequent and can be fatal if undiagnosed (Gille 2010).

Several studies support that dehydration is associated with increased mortality rates among hospitalised older adults (Mentes 2006b). In a study of American seniors hospitalised with a primary diagnosis of dehydration, the mortality rate in the following year was nearly 50%. This study also found that even when dehydration was not the primary diagnosis, concomitant dehydration increased patients' relative 12-month mortality risk by 16 to 78%, compared to patients with the same diagnosis but without dehydration (Warren et al. 1994).
In older adults with many comorbidities, dehydration can precipitate emergency hospitalisation and increase the risk of repeated hospitalisations (Begum and Johnson 2010; Mentes 2006b; Anti et al. 1998; Robinson and Rosher 2002; Suhr et al. 2004; Ship and Fischer 1997; Shannon et al. 2002; Burge et al. 2001).

Moreover, there is increasing evidence that dehydration, even its mild form, plays a role in the development of various morbidities (Manz 2007). Current evidence suggests that dehydration can cause constipation, impaired cognitive function, falling, orthostatic hypotension, salivary dysfunction, poor control of hyperglycaemia in diabetes or hyperthermia (Manz 2007; Anti et al. 1998; Robinson and Rosher 2002; Suhr et al. 2004). The potential consequences of dehydration on the development of different morbidities, and the associated level of evidence in the elderly population are summarised in Table 1.

Table 1. Health consequences of dehydration on the development of associated morbidities and associated level of evidence in the elderly population

Disease / health conditions	Level of evidence il the elderly population	Type of evidence in the ederly population	References
Constipation	Strong	Evidence from observational and one interventional studies Homogeneity in results	Anti, 1998 Manz, 2007 Robinson, 2002
Impaired cognition/ Acute confusion	Medium	Evidence from observational studies Heterogeneity in results from intervention studies	Kleiner, 1999 Suhr, 2004 Suhr, 2010 Popkin, 2010
Falling	Medium	Evidence from observational and one interventional studies Some heterogeneity in results	Costello, 2008 Water UK, 2005 Robinson, 2002
Hyperthermia	Medium	Limited evidence from interventional studies Plausible underlying mechanisms and evidence on population other than elderly	Begum, 2010
Glycaemic control (for diabetes or hyperglycaemia)	Medium	Limited evidence from interventional studies	Burge, 2001

Disease / health conditions	Level of evidence il the elderly population	Type of evidence in the ederly population	References
Orthostatic hypotension	Medium	Limited evidence from interventional studies Plausible underlying mechanisms and evidence on population other than elderly	Lu, 2003 Shannon, 2002
Salivary dysfunction (xerostomia)	Medium	Limited evidence from interventional studies Plausible underlying mechanisms and evidence on population other than elderly	Ship, 1997
Urinary tract infection	Weak	Limited observational data based essentially on extrapolation from mechanisms and on evidence on population other than elderly	Manz, 2007 Beetz, 2003
kidney stones	Weak	Based essentially on extrapolation from evidence on population other than elderly	Zanni 2009 Water UK, 2005
Coronary heart disease	Weak	Limited evidence from observational studies Some heterogeneity in results	Chan, 2002 Rodriguez, 2009 Leurs, 2010
Pressure ulcers	Weak	Limited evidence from observational and interventional studies Some heterogeneity in results	Casimiro, 2002 Stotts, 2003 Stotts, 2009
Medication toxicity	Weak	Based essentially on extrapolation from mechanisms	Begum, 2010

Of interest, it has been shown that provision of water to individuals with a water deficit, i.e rehydration, has shown a beneficial effect on some of these conditions (Anti et al. 1998; Robinson and Rosher 2002). One study found that improving hydration status by promoting the additional consumption of 2 glasses per day in nursing home residents increased hydration level, improved constipation and reduced the number of falls (Robinson and Rosher 2002).

III.2. The economic burden of dehydration

Although data on the economic burden of elderly dehydration are scarce, analyses of hospital expenditures in the United States show that cost associated to dehydration is substantial. Some key figures are summarised in the table below **(Table 2)**.

Table 2. Economic burden of dehydration in the elderly population

Dehydration in hospitalised patients (patients above 65)		
% of hospitalised elderly diagnosed as dehydrated (1991)	6.7%	Warren et al. 1994
Dehydration as primary diagnosis (patients above 65)		
% of hospitalised elderly (1991)	1.4%	Warren et al. 1994
Average cost per hospitalisation (1999)	$ 7,442	Xia et al. 2004
Average length of stay (1999)	4.6 days	Xia et al. 2004
Total cost for preventable hospitalisations = potential savings (1999)	$ 1.14 billion	Xia et al. 2004

The financial burden is also considerable in nursing homes as suggested by an American study which found that dehydration was 1 of the 5 most expensive health conditions, with a treatment cost reaching approximately $1,000 per episode (Alessi et al. 2003).

In addition to its individual clinical impact, dehydration also represents an important public health issue by imposing a significant economic burden.

IV. Maintaining a correct hydration status: the importance of dehydration prevention in the elderly

IV.1. Hydration status: a complex assessment

While various indices exist to assess hydration status, there is no universally accepted method to evaluate dehydration in the elderly (Vivanti et al. 2008; Kavouras 2002). Dehydration diagnosis in the elderly is complicated since classical signs and symptoms of dehydration, especially those resulting from mild dehydration are often more difficult to recognise in the elderly than in adults or children (including dryness of the mouth, muscle weaknesses or poor skin turgor/elasticity); moreover, some symptoms may even be absent (increased thirst for instance) (Schols et al. 2009; Sheehy et al. 1999).

As there is no single diagnostic parameter, it is generally recommended to recognise a pattern consisting of several indicators indicative of dehydration (Schols et al. 2009). Guidelines on dehydration advise to evaluate the medical history of the patients, assess physical parameters, perform laboratory tests and address fluid intake behaviour (American Medical Director Association 2009; Mentes 2008). Laboratory tests are generally used to confirm the presence of dehydration and guide healthcare providers in choosing the best course of treatment (Schols et al. 2009). Examples of signs or symptoms that can be used to diagnose dehydration are summarised in Table 3.

Table 3. Diagnostic clues for dehydration in the elderly (Schols et al. 2009)

SIGN OR SYMPTOM	WATER LOSS ONLY	WATER AND SODIUM LOSS
HISTORY :		
	Recent weight loss of >3%	Recent weight loss of >3%
	Decreased water intake	Vomiting, diarrhoea, use of diuretics, bleeding
	Increased water loss (fever, tachypnea, heat)	
PHYSICAL EXAMINATION:		
Dry tongue	+	+
Lengthwise groove in tongue	+	+
Dry mucous membranes in mouth	+	+
Decreased muscle strength in upper body	+	+

SIGN OR SYMPTOM	WATER LOSS ONLY	WATER AND SODIUM LOSS
PHYSICAL EXAMINATION:		
Dry tongue	+	+
Lengthwise groove in tongue	+	+
Dry mucous membranes in mouth	+	+
Decreased muscle strength in upper body	+	+
Confusion	+	+
Speaking difficulties / dysarthria	+	+
Sunken eyes	+	+
Blood pressure	Normal or decreased	Significantly decreased
Pulse rate / heart rate	Normal or decreased	Significantly decreased
Weight loss	>1 kg/day	>1 kg/day
PHYSICAL EXAMINATION:		
Serum creatinine	Increased	Increased
Serum urea	Increased	Significantly increased
Serum sodium	Increased	Normal or decreased
Urine production	Decreased	Increased, normal or decreased

IV.2. Dehydration treatment strategies

Four main therapeutic strategies for rehydration can be identified, based on the route of fluid administration: oral, enteral, subcutaneous or intravenous administration (Schols et al. 2009). The choice of the rehydration methods depends on the severity and type of dehydration (isotonic, hypotonic, or hypertonic), the patient's clinical condition, including complications that influence urgency of rehydration efforts, and the availability of facilities such as intravenous or subcutaneous procedures (Faes 2007). In terms of fluid to administer, the choice depends on the type of dehydration (saline solution for hypotonic dehydration and solution with low osmolality for hypertonic dehydration) (Hébuterne et al. 2009).

Whenever possible, oral fluid repletion is preferred (Hébuterne et al. 2007; Pershad 2010). This type of therapy is appropriate in the absence of severe symptoms and when the situation allows for it, i.e. if fluids can be restored gradually over time (Faes 2007; Schols et al. 2009). When oral fluid intake is insufficient or when the patient is not consuming sufficient nutrients, fluid administration via a nasogastric feeding tube is advisable. It allows an early and rapid rehydration, without risk of overload (Hébuterne et al. 2007). Intravenous therapy is effective when the dehydration is severe and when the clinical state of the patient demands an acute intervention (Faes

Because they can require qualified staff and specific facilities, treatment strategies for dehydration are generally serious and not easy to administer. Dehydration prevention, which is based on simple and effective measures aimed at ensuring an adequate level of fluid intake, is thus of paramount importance.

2007; Schols et al. 2009). In addition to its potential risk and its expensive cost, a major drawback to this option is that it requires qualified staff, and generally, hospitalisation (Schols et al. 2009; Pershad 2010). Despite these disadvantages and recommendations for oral therapies, intravenous strategies are favoured by caregivers in practice (Pershad 2010). An interesting alternative with a low risk of complication is the subcutaneous infusion of fluids, also called hypodermoclysis (Faes 2007; Schols et al. 2009). Because hypodermoclysis is easy to administer, it can be effectively used in elderly people living in nursing homes or in the community (Schols et al. 2009), so that hospital admission may be avoided (Faes 2007). However, this strategy is often underused (Schols et al. 2009).

IV.3 Dehydration prevention strategies

IV.3.1. What strategies should be implemented?

Prevention of dehydration in the elderly is primarily based on ensuring adequate fluid intake. Raising awareness among the elderly, their famililies and caregivers of the importance of dehydration and its risk factors is fundamental for dehydration prevention (Faes 2007; Mentes 2006b). In an American study, 89% of healthcare providers considered that educating and making the elderly aware is a key strategy (Abdallah et al. 2009). The elderly should be encouraged to consume fluids (Faes 2007; Abdallah et al. 2009). Numerous strategies have been proposed for this purpose, especially in geriatric institutions where nurses and caregivers play a major role in this task (Faes 2007; Bennett 2000; American Medical Directors Association 2009; Wick 1999). Examples are detailed in the following box.

Some strategies for encouraging fluids consumption (Faes 2007; Bennett 2000)

+ Offer fluids regularly during the day
+ Provide liquids readily available all day (at bedside or chairside in geriatric institutions)
+ by placing containers such as small bottles of water or sippy cups
+ Encourage consumption of fluids with medication
+ Provide preferred beverages
+ Prescribe and ensure a minimum intake of 1.5 litres, in periods of increasing risk for dehydration

To the possible extent, individual and environmental risk factors should be taken into account in preventive strategies for adequate hydration (Schols et al. 2009; Hébuterne et al. 2009; Weinberg and Minaker 1995). For instance, urinary incontinence should be managed properly so that patients will be less likely to avoid fluid (American Medical Directors Association 2009).

Monitoring fluid status of the elderly by healthcare providers (for the community-dwelling elderly: visiting nurse associations, home nutrition companies, and home health aides for example) is also of importance (Weinberg and Minaker 1995).

IV.3.2. What type of fluid should be recommended?

Attention should be paid to the quality of fluids as well as on modalities of consumption (Schols et al. 2009; Hébuterne et al. 2009). Water is obviously the first recommended fluid and should constitute the bulk of daily intake (Bennett 2000). Milk, fruit juices and non-salty soups are nutritious and can be useful in providing variety, to help ensure sufficient fluid intakes. Coffee and tea can have a diuretic effect and should therefore be consumed in reasonable amounts. Alcoholic beverages are not recommended (Bennett 2000; Schols et al. 2009; Hébuterne et al. 2009).

IV.3.3. Are prevention strategies effective in the elderly?

Several intervention programmes aimed at encouraging fluid consumption have been conducted and have been shown to be effective and cost-saving in geriatric institutions (Spangler et al. 1984; Simmons et al. 2001; Robinson and Rosher 2002; Mentes and Kulp 2003).

Actions as simple as verbal prompting to drink have been shown to be sufficient to increase fluid intake in 78% of incontinent nursing home residents, leading to a significant reduction in the proportion of residents having laboratory values indicative of dehydration (Simmons et al. 2001).

Another study, testing an approach based on providing assistance for hydration and materials to make hydration more attractive, showed improvement in hydration status while permitting to save on average $103 per resident per week on subsequent medical costs (Robinson and Rosher 2002).

Regular monitoring of hydration status and simple measures aimed at ensuring adequate fluid intakes are key to avoid dehydration and its deleterious consequences in the elderly population.

Conclusion

+ With aging, body water stores decrease, thirst sensation is disturbed and kidneys are less able to concentrate urine, putting the elderly at increased risk of dehydration.

+ It is widely recognised that an appropriate fluid intake is of paramount importance…

+ …however the estimation of water requirements is highly variable and quite complex.

+ A large proportion of the elderly, especially those who are very old, may be at risk for insufficient fluid intake.

+ Dehydration is a common condition with serious detrimental effects accounting for substantial healthcare expenditures.

+ Dehydration and its consequences can be largely avoided and reversed, if detected early.

+ Diagnosed dehydration generally requires a serious treatment, while its prevention can be ensured by simple and effective measures, such as encouraging adequate fluid intake.

+ Several strategies are available for treating dehydration. However, whenever possible oral fluid repletion should be preferred.

+ Increasing awareness among the elderly of the importance of a good hydration, as well as encouraging fluid consumption, are essential for preventing dehydration.
Beverages are not equally effective in maintaining water balance.

+ Water is the first choice for hydration and should represent the bulk of daily intake.

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