Detecting dehydration in older people: useful tests

Dehydration is a common problem in older people, and can cause a range of complications that lead to increased morbidity and mortality. These include:

- Doubling the four-year risk of disability (Stooke et al, 2004);
- Increasing the risk of death over eight years by 40% (Stooke et al, 2004);
- Longer hospital stays (El-Sharkawy et al, 2014);
- Increased mortality after stroke and in older, hospitalised people (El-Sharkawy et al, 2014; Bhalla et al, 2000).

The most common type of dehydration in older people is water-loss dehydration, (WLD) caused by insufficient fluid intake (Thomas et al, 2008; Weinberg and Minaker, 1995). This article relates to WLD, which is characterised by raised serum osmolality – the concentration of serum, which can be measured directly from a venous blood sample (Cheuvront et al, 2013; Thomas et al, 2008; Institute of Medicine, 2004). Box 1 gives definitions of terms used.

Newborn babies comprise 70% water, children 60% and older people 50%; age therefore reduces the buffer against dehydration (Hooper et al, 2014). Water plays a central role in regulating cell volume, nutrient transport, waste removal and thermal regulation, and provides a medium for biological reactions. It means body water volume is tightly controlled; when we do not drink enough to replace fluid losses, the osmolality of body fluids rises as electrolytes, urea and glucose become more concentrated. This triggers the thirst response, which stimulates drinking to replenish diminished fluids and the release of antidiuretic hormone (ADH, or vasopressin), causing the kidneys to concentrate urine and reduce urinary fluid losses.

The sense of thirst and the ability to concentrate urine diminishes with age, so body water volume can drop. Other factors in older people include difficulties in remembering to drink, obtaining drinks, toileting or stating their needs (Hooper et al, 2014).

Studies consistently report high levels of dehydration in older people. We found that 19% of those in residential care in Norfolk and Suffolk were dehydrated and another 27% had impending dehydration (Siervo et al, 2008).
Detecting dehydration

Nurses must be able to identify those who may be becoming dehydrated so they can help them drink more, reducing the risk of dehydration and associated ill health. Two types of tests can determine this:

- Tests that diagnose dehydration;
- Tests that screen for dehydration.

Screening tests are not as exact as diagnostic tests but are cheaper and less invasive so can be used regularly and often.

Diagnostic tests

The diagnostic test for WLD is serum or plasma osmolality. There are no equivalent guidelines in the UK but the US Institute of Medicine (2004) recommends directly measured serum osmolality. Experts consider this the “gold standard” measure as it:

- Directly measures the concentration of serum or plasma;
- Can be measured at one assessment;
- Is associated with health outcomes;
- Is not affected by failing renal function (Hooper et al, 2014; Cheuvront et al, 2013).

The blood urea nitrogen/creatinine ratio is often recommended as a diagnostic test. However, this is also a measure of renal function and, as impaired renal function is prevalent in older people, a raised BUN/creatinine ratio cannot distinguish between poor renal function and dehydration. As such, it is not a reliable test for dehydration in this age group (American Medical Directors Association, 2009; Thomas et al, 2008).

Screening tests

Various clinical signs, tests and questions are commonly used to screen for dehydration as they are cheap and can be used in any setting (Shepherd, 2011). Some work well in children but there is doubt about their efficacy in older people (Thomas et al, 2008; 2004). Box 2 lists signs often used by health professionals to screen for dehydration.

We carried out a Cochrane systematic review to assess how well screening signs and tests identify dehydration in people aged ≥65 years (Hooper et al, 2015). These were considered clinically useful if they had sensitivity of >60% and a specificity of >75%. The review identified studies that assessed:

- Skin turgor (in several places) – nine studies in total, with one or two assessing any one site;
- Capillary refill (n = 2);
- Dry underarm (n = 2);
- Dry oral mucosa (n = 1);
- Tongue furrows (n = 1);
- Tongue dryness (n = 1).

No study suggested any measure was useful in dehydration screening. Thomas et al (2008) said a lack of utility of skin turgor in older people may be due to skin ageing and that control of fluid losses, including saliva flow and perspiration, may become less linked to hydration status.

In hypovolaemic shock or severe hypovolaemia, low blood pressure, low body temperature and a rapid pulse rate can be seen. In the review we checked whether these signs also indicate WLD. Pulse rate was measured in four studies, body temperature in one and orthostatic hypotension in one; none of the signs were usefully diagnostic of dehydration in any study. Table 1 lists the signs and tests found useful in detecting impending and/or current dehydration; Box 3 lists those not found useful in any studies.

Urinary tests

Urinary tests, including urine specific gravity, urinary osmolality and urinary colour, have long been advocated as tests for dehydration in a wide range of nursing literature (Lima Ribeiro and Morley, 2015; Dougherty and Lister, 2011; Begum and Johnson, 2010; Docherty, 2008; Wotton et al, 2008; Armstrong, 2007; Bryant, 2007; Woodward, 2007; Mentes, 2004; Grandjean et al, 2003; Kavouras, 2002; Armstrong et al, 1994). However, while urinary tests may be justified in younger adults (Perrier et al, 2013; Cheuvront and Sawka, 2005; Lapides et al, 1965) evidence supporting their use in older adults is limited (Thomas et al, 2008).

Our review found that urine-specific gravity, colour and volume were not useful indicators of dehydration, but the evidence came from a few very small studies (Hooper et al, 2015). The fact that these were not useful indicators may be because the ability to concentrate urine decreases with age, so good quantities of dilute urine is produced even when dehydration is developing (Davies and Shock, 1950).

Questions

The review assessed questions that may be useful in dehydration screening (Hooper et al, 2015). These asked older people if they:

- Felt tired (n = 3);
- Were thirsty (n = 5);
- Had a dry mouth (n = 8);
- Felt headache (n = 2);
- Felt sick (n = 2);
- Felt dizzy (n = 2);
- Had weak muscles (n = 2);
- Ever missed drinks between meals (n = 1).

In one of the three studies that asked if participants felt tired, answering “yes” did indicate dehydration (Table 1). In the study that asked if participants always had a drink between breakfast and lunch, and between

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**Box 1. Useful Definitions**

- Directly measured serum osmolality (DMSO): the osmotic concentration of blood serum, expressed as milliosmoles of solute per kilo of plasma water. DMSO is assessed by degree of freezing point depression as follows:
  - Well hydrated: 275-<295mOsm/kg
  - Impending dehydration: 295-300mOsm/kg
  - Current dehydration: >300mOsm/kg (Thomas et al, 2008)
- Calculated serum osmolality: a calculated value estimating the osmolar concentration of plasma proportional to the number of particles per litre of solution (mMOL/L).
- Plasma tonicity: a form of calculated osmolality estimating the concentration of plasma solutes that are impermeable to cell membranes. These influence cell volume via their osmotic force on cells and are measured by the effective solute per kilo of plasma.
- Urinary osmolality: the osmotic concentration of urine, expressed as milliosmoles of solute per kilo of plasma water. Assessment is by degree of freezing point depression. Normal values vary with the concentration of urine (higher in more concentrated urine).
- Urine specific gravity: a measure of the density of urine versus the density of water.

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**Box 2. Signs Used to Screen for Dehydration**

- Skin turgor: assessed by gently pinching the skin on the back of the hand, foot, arm, thigh or sternum, then timing how long it takes the skin to return to its pre-pinched position.
- Capillary refill: squeezing and blanching the fingernail, then timing how long it takes for colour to return.
- Dry underarm (axilla) tongue or mucous membrane: assessed through observation or by looking for tongue furrows.
but these sensations are not universal in dehydrated to feel thirsty (Mack et al, 1994). and older people need to be much more which confirms research evidence that the thirsty is not a useful test for dehydration, Asking older people whether they feel further assessed to confirm their value. meals could be helpful in screening for missed drinks tended to be dehydrated. None of the other questions were useful. Asking whether older people feel tired (all serum measures in mmol/L)

**Physical signs**
- Skin turgor, various sites (9/7)
- Capillary refill time (2/1)
- Dry underarm (2/0)
- Dry oral mucosa, cheek (1/1)
- Tongue furrows (7/7)
- Dry tongue (1/1)

**Bioelectrical impedance measures**
- BIA resistance 100kHz (1/1)
- BIA resistance 200kHz (1/1)
- BIA TBW% (5/4)
- BIA ICW% (4/3)
- BIA ECW% (4/3)


Weight change
Rapid weight change in babies, children and young athletes signal change in hydration as fluid is the body component that can alter most quickly (Cheuvront et al, 2010; Shirreffs, 2003). For this reason, losing >3% of body weight within seven days may be considered a sign of dehydration; this relies on regular, accurate weighing that accounts for issues such as constipation or oedema (Cheuvront et al, 2010). However, research suggests that body weight can alter by >3% in well-hydrated older people (Vivanti et al, 2013) and dehydration may occur slowly over several weeks, so weight change is unlikely to be a good indicator in this group.

**Blood tests**
Calculated serum osmolality is an estimation of directly measured osmolality – confusingly, these are two different tests with similar names. Osmolarity equations combine serum concentrations of (some or all of) sodium, potassium, urea and glucose.

A wide range of osmolarity equations are used but it is not clear which best estimate osmolality in older people. These equations were tested on data from the Dehydration Recognition In our Elders (DRIE) study (Siervo et al, 2014). In 186 care home residents (mean age: 86 years), one equation (out of 36 investigated) had high sensitivity and high specificity in detecting dehydration (Siervo et al, 2014):

\[
\text{Osmolarity} = 1.86 \times (\text{Na}^+ + \text{K}^+) + 1.15 \times \text{glucose} + 0.018 \times \text{urea} + 14 \text{ (all serum measures in mmol/L)}
\]

We are now testing osmolarity equations in other populations of older people, such as those living in the community and those admitted to hospital. If an equation works across different groups, hospital laboratory computers could report calculated serum osmolality every time an older person has a routine blood test that includes glucose, urea and electrolytes. A positive result would alert nursing and medical staff to dehydration.

**Novel measures**
Bioelectrical impedance analysis (BIA) is a measure of electrical impedance through the body, which can estimate total body water (TBW). The test, used routinely in US care homes, is non-invasive and has been promoted to assess hydration status.

Our review found that BIA resistance at a frequency of 50kHz was assessed in four studies and at 100kHz and 200kHz in one study each (Hooper et al, 2015). TBW was estimated in five studies, and intracellular water (ICW) and extracellular water (ECW) in four each. In two studies BIA resistance at 50kHz was useful in identifying impending dehydration, but not in the other two (Table 1). BIA resistance at 50kHz was usefully diagnostic of current dehydration in one of the four studies; none of the other BIA measures appeared useful (Box 3). BIA at 50kHz needs to be checked in further populations to understand its utility before being used to screen for dehydration in practice (Hooper et al, 2015; Kafri et al, 2013; Kyle et al, 2004; Olde Rikkert et al, 1998).

Saliva osmolality was recently investigated by Fortes et al (2015) as a screening test for dehydration in 130 older people admitted to hospital; they found it was able to identify dehydration, with a sensitivity of 70% and specificity of 68%. This result needs to be duplicated and the test made available for everyday use but appears to be promising.

It may be possible to record fluid intake to predict hydration status in older people, but fluid and drinks record charts can be inaccurate. Some tools enable older people to record their own drinks intake easily; these appear to be more accurate than records completed by carers (Jimoh et al, 2015; the Drinks Diary can be downloaded free of charge at Bit.ly/UEADrinksDiary). At present, however, the fluid intake needs of

<table>
<thead>
<tr>
<th>BOX 3. SIGNS AND TESTS NOT FOUND TO BE OF USE</th>
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</thead>
<tbody>
<tr>
<td><strong>Tests</strong>, <strong>signs</strong> and <strong>questions</strong> found useful in studies, with studies assessed – studies where test was useful/studies assessed, n</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Test, sign or question</strong></th>
<th><strong>Impending dehydration (&gt;295mosm/kg)</strong></th>
<th><strong>Current dehydration (&gt;300mosm/kg)</strong></th>
</tr>
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<tbody>
<tr>
<td><strong>Urinary tests</strong></td>
<td></td>
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<tr>
<td>Urine osmolality</td>
<td>1/6</td>
<td>0/6</td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you feel tired?</td>
<td>1/3</td>
<td>1/3</td>
</tr>
<tr>
<td>Do you ever miss drinks between meals?</td>
<td>1/1</td>
<td>1/1</td>
</tr>
<tr>
<td><strong>Bioelectrical impedance measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIA resistance, 50kHz</td>
<td>2/4</td>
<td>1/4</td>
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<thead>
<tr>
<th><strong>Physical signs</strong></th>
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<tbody>
<tr>
<td>Skin turgor, various sites</td>
<td>9/7</td>
<td></td>
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<tr>
<td>Capillary refill time</td>
<td>2/1</td>
<td></td>
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<tr>
<td>Dry underarm</td>
<td>2/0</td>
<td></td>
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<tr>
<td>Dry oral mucosa, cheek</td>
<td>1/1</td>
<td></td>
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<tr>
<td>Tongue furrows</td>
<td>7/7</td>
<td></td>
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<tr>
<td>Dry tongue</td>
<td>1/1</td>
<td></td>
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<thead>
<tr>
<th><strong>Questions</strong></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Do you feel thirsty?</td>
<td>5/4</td>
<td></td>
</tr>
<tr>
<td>Does your mouth feel dry?</td>
<td>8/6</td>
<td></td>
</tr>
<tr>
<td>Do you feel dizzy?</td>
<td>2/2</td>
<td></td>
</tr>
<tr>
<td>Do you feel sick?</td>
<td>2/2</td>
<td></td>
</tr>
<tr>
<td>Do your muscles feel weak?</td>
<td>2/2</td>
<td></td>
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<tr>
<td>Do you feel headache?</td>
<td>2/2</td>
<td></td>
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<thead>
<tr>
<th><strong>Bioelectrical impedance measures</strong></th>
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<tbody>
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<td>BIA TBW%</td>
<td>5/4</td>
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<td>BIA ICW%</td>
<td>4/3</td>
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<tr>
<td>BIA ECW%</td>
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older people are not well defined so it is not easy to tell when they are drinking enough to stay hydrated (Hooper et al, 2014).

**Risk factors**

All older people are at greater risk of dehydration but some factors confer greater risk:

- Increasing age (Stookey, 2005; Warren et al, 1994);
- Gender – women are more at risk than men (Stookey, 2005; Stookey et al, 2005; Warren et al, 1994);
- Ethnicity – Afro-Caribbean Americans are at greater risk than white Americans (Stookey, 2005; Lancaster et al, 2003; Warren et al, 1994).

Long-term conditions are associated with dehydration, particularly:

- Diabetes (Stookey et al, 2005);
- Hypertension (Stookey et al, 2005);
- Obesity (Stookey et al, 2005);
- Oral problems (Dyck, 2004);
- Functional limitations (Stookey et al, 2005);
- Dementia (Albert et al, 1989).

Table 2 gives a more detailed overview of these factors. Use of diuretics (Lancaster et al, 2003), acute infection (Dyck, 2004) and increased environmental temperature (Josseran et al, 2009) may also increase risk.

Reliable studies assessing risk factors have classified dehydration using serum osmolality, tonicity or the International Classification of Diseases codes.

While dehydration can be prevented by drinking more, ensuring older people drink enough is not easy (Bunn et al, 2015). Older people in long-term care settings in the UK were at greater risk of low fluid intake if they were incontinent, physically dependent or cognitively impaired (Armstrong-Esther et al, 1996). In a small US care home study, the association of poor fluid intake with greater independence in physical ability, speaking ability and help with feeding was weak but statistically significant – residents most dependent on staff seemed to receive adequate fluids but those who were more independent struggled to drink enough (Gaspar, 1999; Gaspar, 1988). However this relationship needs to be assessed in further groups of older people.

**Discussion**

There is limited evidence that any individual test, sign or question tested to date is useful in screening for dehydration in older people. Some tests may be useful but need to be assessed in greater detail. These assess:

- Fatigue;
- Whether drinks are missed between meals;
- BIA resistance at 50kHz;
- Laboratory reports using an osmolarity equation to screen for dehydration in routine blood tests;
- Saliva osmolality.

These need repeating in larger studies to determine their efficacy the screening of older people (Hooper et al, 2015).

Our systematic review and a further study published after the review searches were completed suggested that some tests

**Table 2. Risk factors for dehydration**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Study</th>
<th>Finding</th>
<th>Study design and population</th>
<th>Sample (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Stookey (2005)</td>
<td>&gt;65yrs increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>14,855</td>
</tr>
<tr>
<td></td>
<td>Stookey (2005), Warren et al (1994)</td>
<td>&gt;85yrs increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>14,855</td>
</tr>
<tr>
<td></td>
<td>Stookey (2005), Warren et al (1994)</td>
<td>Females increased risk*</td>
<td>Cross-sectional, community dwelling</td>
<td>14,855</td>
</tr>
<tr>
<td>Diuretic use</td>
<td>Lancaster et al (2003)</td>
<td>Increased risk</td>
<td>Case-control, hospital admissions</td>
<td>46,185</td>
</tr>
<tr>
<td>Obesity (BMI&gt;30kg/m²)</td>
<td>Stookey et al (2005)</td>
<td>Increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>1,737</td>
</tr>
<tr>
<td>Dementia diagnosis</td>
<td>Albert et al (1989)</td>
<td>Increased risk</td>
<td>Controlled trial, hospital based</td>
<td>18</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Stookey et al (2005)</td>
<td>Increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>1,737</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Stookey et al (2005)</td>
<td>Increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>1,737</td>
</tr>
<tr>
<td>Chronic disease comorbidity</td>
<td>Stookey et al (2005)</td>
<td>Increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>1,737</td>
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<tr>
<td>Functional limitations</td>
<td>Stookey et al (2005)</td>
<td>Increased risk</td>
<td>Cross-sectional, community dwelling</td>
<td>1,737</td>
</tr>
<tr>
<td>Raised environmental temperature</td>
<td>Josseran et al (2009)</td>
<td>Increased risk</td>
<td>Retrospective analysis of hospital admission and outpatient data</td>
<td>415,862</td>
</tr>
</tbody>
</table>

BMI = body mass index. *Warren et al found an increased risk for white females 65-79yrs only. Males were at higher risk at other ages and ethnicities.
should not be used to screen for dehydration in older people (Fortes et al, 2015; Hooper et al, 2015). However, for all of these – urinary colour, specific gravity and volume; physical signs such as dry mouth and feeling thirsty; heart rate – the evidence came from only a few small studies.

Further developments

We are undertaking DRIE, a diagnostic accuracy study including 186 frail older people aged 65-105 years (mean: 85.8 years) living in homes for people with dementia, nursing homes and residential care homes in the UK. The study will provide further evidence for the ability of screening signs, tests and questions to identify dehydration in older people (Sierwo et al, 2014; Bit.ly UEDARIE). It is also investigating whether combining three tests is more useful than performing single tests alone.

Concluding

There is limited evidence that any clinical sign, test or question is useful in screening for dehydration in older people. Although all older people are at increased risk of dehydration, knowledge of risk factors may be helpful in targeting more vulnerable groups to ensure they receive adequate fluid intake; further research is needed to assess promising tests, signs and questions in screening for dehydration.

Part 2 of this series, to be published on 19 August, will report on how one care home took a whole-staff approach to improving residents’ hydration. NT

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American Medical Directors Association (2009) Dehydration and Fluid Maintenance in the Long-Term Care Setting. Columbia, MD: AMDA.

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Recognising and preventing dehydration among patients

Bit.ly/NTPreventDehydration