Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people (Review)

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Lee Hooper[1], Asmaa Abdelhamid[1], Natalie J Attreed[1], Wayne W Campbell[2], Adam M Channell[1], Philippe Chassagne[3], Kennith R Culp[4], Stephen J Fletcher[5], Matthew B Fortes[6], Nigel Fuller[7], Phyllis M Gaspar[8], Daniel J Gilbert[9], Adam C Heathcote[10], Mohannad W Kafri[11], Fumiko Kajii[12], Gregor Lindner[13], Gary W Mack[14], Janet C Mentes[15], Paolo Merlani[16], Rowan A Needham[17], Marcel GM Olde Rikkert[18], Andreas Perren[19], James Powers[20], Sheila C Ranson[1], Patrick Ritz[21], Anne M Rowat[22], Fredrik Sjöstrand[23], Alexandra C Smith[9], Jodi JD Stookey[24], Nancy A Stotts[25], David R Thomas[26], Angela Vivanti[27], Bonnie J Wakefield[28], Nana Waldréus[29], Neil Peter Walsh[6], Sean Ward[9], John F Potter[30], Paul R. Hunter[31]

[1]Norwich Medical School, University of East Anglia, Norwich, UK. [2]Department of Nutrition Science, Purdue University, West Lafayette, IN, USA. [3]Geriatrics Department, Rouen University Hospital, Rouen Cedex, France. [4]College of Nursing, University of Iowa, Iowa City, IA, USA. [5]Department of Anaesthesia and Intensive Care Medicine, Bradford Teaching Hospitals NHSFT, Bradford, UK. [6]College of Health and Behavioural Sciences, Bangor University, Bangor, UK. [7]Master in Public Health Programme, Institute of Learning & Teaching, Faculty of Health & Life Sciences, The University of Liverpool, Liverpool, UK. [8]Colleges of Medicine and Nursing, University of Toledo, Toledo, OH, USA. [9]Norfolk and Norwich University Hospital NHS Trust, Norwich, UK. [10]Department of Medicine, James Paget University Foundation Hospital NHS Trust, Great Yarmouth, UK. [11]Nutrition and Dietetics, Birzeit University, Birzeit, Palestine. [12]Gerontological Nursing, St Luke's International University, Chuo-ku, Japan. [13]Department of General Internal Medicine and Department of Emergency Medicine, Inselspital, Bern, Switzerland. [14]Brigham Young University, Provo, UT, USA. [15]University of California Los Angeles, Los Angeles, CA, USA. [16]Department of Intensive Care Medicine EOC and Intensiva care Unit Lugano, Ente Ospedaliero Cantonale (EOC), Lugano, Switzerland. [17]Drayton and St Faiths Medical Practice, Norwich, UK. [18]Department of Geriatrics, Radboud University Nijmegen Medical Centre, Nijmegen, Netherlands. [19]Intensive Care Medicine, Ospedale Regionale Bellinzona e Valli, Bellinzona, Switzerland. [20]TVHS GRECC and, Vanderbilt University School of Medicine, Nashville, TN, USA. [21]Department of Endocrinology, Nutrition and Metabolic Diseases, Chu de Toulouse, Toulouse, France. [22]School of Nursing, Midwifery and Social Care, Edinburgh Napier University, Edinburgh, UK. [23]Gustavsberg, Sweden. [24]Childrens Hospital Oakland Research Institute (CHORI), Oakland, CA, USA. [25]Physiological Nursing, University of California San Francisco, San Francisco, CA, USA. [26]Department of Medicine, Saint Louis University, St Louis, MO, USA. [27]Department of Nutrition and Dietetics, Princess Alexandra Hospital, Woolloongabba, Australia. [28]Sinclair School of Nursing, University of Missouri, Columbia, MO, USA. [29]Department of Research, Södertälje Sjukhus, Södertälje, Sweden. [30]Ageing & Stroke Medicine, Norwich Medical School, University of East Anglia, Norwich, UK. [31]The Norwich School of Medicine, University of East Anglia, Norwich, UK

Contact address: Lee Hooper, Norwich Medical School, University of East Anglia, Norwich Research Park, Norwich, Norfolk, NR4 7TJ, UK. l.hooper@uea.ac.uk.

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ABSTRACT

Background

There is evidence that water-loss dehydration is common in older people and associated with many causes of morbidity and mortality. However, it is unclear what clinical symptoms, signs and tests may be used to identify early dehydration in older people, so that support can be mobilised to improve hydration before health and well-being are compromised.

Objectives

Our objectives were to determine the diagnostic accuracy of state (one time), minimally invasive clinical symptoms, signs and tests (collectively referred to as tests) to be used as screening tests for detecting water-loss dehydration (including impending and current water-loss dehydration) in older people by systematically reviewing studies that measured a reference standard and at least one index test in people aged 65 years and over.

Search methods

Structured search strategies were developed for MEDLINE (OvidSP), EMBASE (OvidSP), CINAHL, LILACS, DARE and HTA databases (*Cochrane Library*), and the International Clinical Trials Registry Platform (ICTRP). Reference lists of included studies and identified relevant reviews were checked. Authors of included studies were contacted for details of further studies.

Selection criteria

Titles and abstracts were scanned and all potentially relevant studies obtained in full text. Inclusion of full text studies was assessed independently in duplicate, and disagreements resolved by a third author. We wrote to authors of all studies that appeared to have collected data on at least one reference standard and at least one index test, and in at least 10 people aged ≥65 years, even where no comparative analysis has been published, requesting original data set so we could create 2 x 2 tables.

Data collection and analysis

Diagnostic accuracy of each test was assessed against the best available reference standard for water-loss dehydration (serum or plasma osmolality cut-off ≥295 mOsm/kg, serum osmolarity or weight change) within each study. For each index test study data were presented in forest plots of sensitivity and specificity. The primary target condition was water-loss dehydration (including either impending or current water-loss dehydration). Secondary target conditions were intended as current (>300 mOsm/kg) and impending (295 to 300 mOsm/kg) water-loss dehydration, but restricted to current dehydration in the final review.

We conducted bivariate random-effects meta-analyses (Stata/IC, StataCorp) for index tests where there were at least four studies and study data sets could be pooled to construct sensitivity and specificity summary estimates. We assigned the same approach for index tests with continuous outcome data for each of three pre-specified cut-off points investigated.

We planned that covariates would be incorporated into the bivariate model to examine the effects of factors that may have been responsible for heterogeneity. However, because the number of studies for each test was limited, this was judged inappropriate, having limited power.

Pre-set minimum sensitivity of a useful test was 60%, minimum specificity 75%. As pre-specifying three cut-offs for each continuous test may have led to missing a cut-off with useful sensitivity and specificity, we conducted post-hoc exploratory analyses to create receiver operating characteristic (ROC) curves where there appeared some possibility of a useful cut-off missed by the original three. These analyses enabled assessment of which tests may be worth assessing in further research. A further exploratory analysis assessed the value of combining the best two index tests where each had some individual predictive ability.

Main results

There were few published studies of the diagnostic accuracy of state (one time), minimally invasive clinical symptoms, signs or teststo be used as screening tests for detecting water-loss dehydration in older people. Therefore, to complete this review we sought, analysed and included raw data sets that included a reference standard and an index test in people aged ≥65 years.

We included three studies with published diagnostic accuracy data and a further 21 studies provided data sets that we analysed. We assessed 67 tests (at three cut-offs for each continuous outcome) for diagnostic accuracy of water-loss dehydration (primary target condition) and of current dehydration (secondary target condition).

Only three tests showed any ability to diagnose water-loss dehydration (including both impending and current water-loss dehydration) as stand-alone tests: **expressing fatigue** (sensitivity 0.71 [0.29, 0.96], specificity 0.75 [0.63, 0.85], in one study with 71 participants, but two additional studies had lower sensitivity), **missing drinks between meals** (sensitivity 1.00 [0.59, 1.00], specificity 0.77 [0.64,

0.86], in one study with 71 participants) and **bioelectrical impedance, BIA, resistance at 50 kHz** (sensitivities 1.00 [0.48, 1.00] and 0.71 [0.44, 0.90] and specificities of 1.00 [0.69, 1.00] and 0.80 [0.28, 0.99] in 15 and 22 people respectively for two studies, but with sensitivities of 0.54 [0.25, 0.81] and 0.69 [0.56, 0.79] and specificities of 0.50 [0.16, 0.84] and 0.19 [0.17, 0.21] in 21 and 1947 people respectively in two other studies). In post-hoc ROC plots drinks intake, urine osmolality and axillial moisture also showed limited diagnostic accuracy. No test was consistently useful in more than one study.

Combining two tests so that an individual both missed some drinks between meals and expressed fatigue was sensitive at 0.71 [0.29, 0.96] and specific at 0.92 [0.83, 0.97].

There was sufficient evidence to suggest that several stand-alone tests often used to assess dehydration in older people (including fluid intake, urine specific gravity, urine colour, urine volume, heart rate, dry mouth, feeling thirsty and BIA assessment of intracellular water or extracellular water) are not useful, and should not be relied on individually as ways of assessing presence or absence of dehydration in older people.

No tests were found consistently useful in diagnosing current water-loss dehydration.

Authors' conclusions

There is limited evidence of the diagnostic utility of any individual clinical symptom, sign or test or combination of tests to indicate water-loss dehydration in older people. Individual tests should not be used in this population to indicate dehydration; they miss a high proportion of people with dehydration, and wrongly label those who are adequately hydrated.

Promising tests identified by this review need to be further assessed, as do new methods in development. Combining several tests may improve diagnostic accuracy.

PLAIN LANGUAGE SUMMARY

What simple tests can tell us whether older people are drinking enough fluid?

Water-loss dehydration results from drinking too little fluid. It is common in older people and associated with increased risk of many health problems. We wanted to find out whether simple tests (like skin turgor, dry mouth, urine colour and bioelectrical impedance or BIA) can usefully tell us whether an older person (aged at least 65 years) is drinking enough. Within the review we assessed 67 different tests, but no tests were consistently useful in telling us whether older people are drinking enough, or are dehydrated. Some tests did appear useful in some studies, and these promising tests should be re-checked to see whether they are useful in specific older populations. There was sufficient evidence to suggest that some tests should not be used to indicate dehydration. Tests that should not be used include dry mouth, feeling thirsty, heart rate, urine colour and urine volume.

BACKGROUND

Target condition being diagnosed

Dehydration is defined as "loss or removal of fluid" from the body and occurs when fluid intake fails to fully replace fluid losses in the body (Churchill Livingstone Medical Dictionary 2008). A more physiological definition of dehydration would be having a clinically relevant decline in total body water volume compared to the subject's euvolaemic volume state, which gives the person the best haemodynamic, renal and peripheral tissue-fluid homeostasis.

Causes of dehydration in older people may include diarrhoea, exudation (from burns or other raw areas), fever and increased sweating, polyuria (frequent urination), bleeding, vomiting and/or inadequate fluid intake. The resultant hypovolaemia (decrease in blood plasma volume) is accompanied by electrolyte balance disruption (Churchill Livingstone Medical Dictionary 2008). The most extreme manifestation of dehydration is hypovolaemic shock, which requires emergency medical treatment. Signs of hypovolaemic shock can include cool and clammy skin, reduced urine output, flattening of veins in the neck, altered mental state, low pulmonary wedge pressure, low cardiac index and high systemic vascular re-

sistance index (Goldman 2004). Milder dehydration is common in older people.

The Dehydration Council suggests that dehydration is a complex condition resulting in a reduction in total body water (TBW) (Thomas 2008). It can be classified as water-loss dehydration (due to water deficit, which can be hypernatraemic (high blood sodium levels) or hyponatraemic (low blood sodium levels) in the presence of hyperglycaemia (high blood glucose)); or salt-loss dehydration (due to salt and water deficit, generally hyponatraemic, rarely isotonic (the same concentration of solutes as blood)).

Serum osmolality is the osmolar concentration or osmotic pressure of serum, so reflects the number of dissolved particles (whether they are able to permeate cell membranes or not) per kilogram of serum. Serum osmolality of 275 to < 295 mOsmol/kg is considered normal; 295 to 300 mOsmol/kg suggests impending water-loss dehydration; and > 300 mOsmol/kg suggests current water-loss dehydration (Thomas 2008). In this review we have used the term "water-loss dehydration" to indicate people with serum osmolality of 295mOsm/kg or more (with either impending or current dehydration). The terms "impending dehydration" and "current dehydration" have been used, following the terminology of Thomas 2008, although these terms are not commonly used in some settings.

In water-loss dehydration either serum sodium or glucose levels are raised and hypotonic fluids must be given, diuretic medications changed and/or other causes of increased fluid losses treated. Impending (mild or pre-clinical) water-loss dehydration is an intermediate stage that may indicate long term chronic fluid deficiency, which may not progress, or an early stage of dehydration before onset of current dehydration. Impending dehydration may indicate a point at which an intervention to reverse dehydration, prevent medical emergency and reduce the risk of current dehydration, can be applied. Rapid medical intervention is needed for current (severe or clinical) water-loss dehydration because electrolyte disturbance and volume reduction is a significant health risk.

Dehydration in older people is associated with high risk of adverse health outcomes and death (Waikar 2009; Warren 1994). Dehydration contributes to many of the major causes of death and morbidity in older people. Adverse health outcomes associated with dehydration in older people include falls, fractures, heart disease, confusion, delirium, heat stress, constipation, kidney failure, pressure ulcers, poor wound healing, suboptimal rehabilitation outcomes, infections, seizures, drug toxicity, and reduced quality of life (Chan 2002; DoH and Nutrition Summit 2007; Mentes 2006a; Olde Rikkert 2009; Rolland 2006; Thomas 2008; Wakefield 2008).

There are consistent data from high quality prospective studies (appropriately adjusted for concurrent risk factors and disease) indicating that raised serum osmolality and tonicity (indicating water-loss dehydration) are associated with increased risk of mortality in a general elderly US population, UK stroke patients and US older people with diabetes (Bhalla 2000; Stookey 2004; Wachtel 1991), and with poorer functional status in US older people (Stookey 2004). In 2004, John Reid, UK Secretary of State for Health, stated that high numbers of unplanned hospital admissions among the at-risk elderly were for entirely preventable conditions such as dehydration (Reid 2004). The estimated avoidable cost to the 1999 US healthcare system of older people admitted to hospital with primary diagnoses of dehydration was US$1.1 to US$1.4 billion annually, and admission rates appeared to be rising (Xiao 2004). Early identification, prevention and treatment of dehydration in the community would benefit older people and reduce healthcare costs.

Dehydration becomes more common as people age for several reasons (Hooper 2014). As we get older our thirst response decreases (De Castro 1992), meaning that it is not appropriate for them to rely on thirst to ensure that they drink sufficient quantities of fluid. In addition, their ability to retain salt and fluid falls as kidney function decreases, kidney and urinary diseases increase in prevalence (Davies 1995; Lindeman 1985), and total body fluid reduces (Olde Rikkert 1997; Olde Rikkert 2009). Medications such as diuretics, laxatives, angiotensin-converting enzyme inhibitors, psychotropic medications and polypharmacy (Mentes 2006a), as well as increased dependence on carers to provide drinks, also increase dehydration risk. The prevalence of dehydration in frail older people varies by setting and level of care required, as well as how hydration status is assessed. It has been asserted that hydration is well maintained in older people living independently, maintaining normal patterns of eating and drinking, but dehydration can develop following illness, depression, surgery, trauma or other physically stressful situations (Luckey 2003). However, recent evidence suggests that the prevalence of dehydration in independent community-dwelling older people is higher than previously thought. Plasma osmolality, measured in a US population of 15,000 people aged from 20 to 90 years (from the NHANES III cohort), found that 40% of those aged 70 to 90 years had impending water-loss dehydration, and a further 28% had current dehydration (high plasma tonicity, >300 mmol/L, Stookey 2005a). Another large US survey found that 50% of older people had elevated plasma tonicity. Both findings may relate to a high prevalence of elevated glucose, rather than hypernatraemia (Stookey 2005b; Thomas 2008). Older people living in residential care represent an extremely frail population. In the UK, 4% of the growing number of older people live in care homes or long-stay hospitals; rising to 21% of those aged 85 years and over (National Care Homes R&D Forum 2007). Research in Norfolk (UK) care homes found that on a single assessment of 56 residents (from six institutions), 17 (30%) residents were dehydrated (with a furrowed tongue). A year later rates were lower (21%) and the risk of being dehydrated at the second visit did not relate to hydration status at first visit (Kenkmann 2010). More recently a cross-sectional study of 186 older people living in 56 Norfolk and Suffolk care homes measured dehydration using serum osmolality and found that 46% had water-loss dehy-

dration (including 19% with current dehydration, and a further 27% with impending dehydration, Siervo 2014). A Californian nursing home study found that 31% of residents were dehydrated (defined as follows: 11% of elderly residents were hospitalised for dehydration, 6% were given intravenous rehydration, and 14% were found to have blood urea nitrogen/creatinine ratio greater than 25:1) at some point over six months (Mentes 2006b). However, point prevalence dehydration was reported to be 1.4% in Missouri nursing homes (Thomas 2008). The prevalence of dehydration in studies depends not only on the population assessed, but also on what definition of dehydration is employed and methods used. A small study of US nursing home residents suggested that most participants did not drink enough fluid (39/40 drank less than 1.5 L/day), and drank little between meals (Chidester & Spangler 1997; Spangler & Chidester 1998), but dehydration was not assessed. Factors contributing to low fluid intake included clinical (dysphagia, functional impairment, dementia, and pain); social (lack of attention to drink preferences, inability of residents to communicate with staff, and lack of social support); and institutional factors (untrained and unsupervised staff).

Older people in hospital are also at risk of dehydration. El-Sharkawy 2014 found that of 103 people aged at least 65 years recruited on admission to hospital, 40% were dehydrated on admission and 44% were dehydrated 48 hours later. Dehydration was assessed using serum osmolality measurements.

Suggested interventions to help prevent dehydration in older adults living in care homes include education and involvement of staff, use of social times, drinks carts and water jugs to support drinking habits, encouraging relatives to offer residents drinks, monitoring urine colour, drinking more in hot weather, being aware of medications and health conditions that increase fluid requirements, and providing specific support for those with swallowing problems (Mentes 2006a; Water UK 2006). However, many interventions have not been tested or were tested using methodology with moderate risk of bias such as before-after studies (Robinson 2002) or provided equivocal results (Culp 2003; Mentes 2003). A systematic review that aimed to "identify the factors that increase the risk of dehydration in older adults, how best to assess the risk and manage oral fluid intake" concluded that few data were available to answer these questions (Hodgkinson 2003). A systematic review assessing the effectiveness of factors to reduce the risk of dehydration in older people living in residential care is about to be published and a further review, assessing the effectiveness of interventions to support eating and drinking in those with dementia is in process (Bunn 2012; Bunn 2014; Abdelhamid 2014). Perhaps the first stage in prevention of dehydration in older people is recognising the condition when it occurs, so that is it clear whether it is an institutional problem and if measures to reduce dehydration have been successful. In particular, recognising early dehydration (impending dehydration) would enable early intervention of preventive measures.

This systematic review focussed on simple tests that may identify water-loss dehydration as distinct from salt-loss dehydration or volume depletion due to blood loss because it is likely that with underlying differences in physiology and impact, there will be differences in clinical symptoms, signs and tests..

Reference standard for dehydration

In the absence of a consensus definition or gold standard test of dehydration, we used several reference standards for water-loss dehydration. There are several approaches in situations where a reference standard is imperfect, but generally involve creation of a feasible reference standard (Reitsma 2009b). For dehydration due to reduced fluid intake, feasible reference standards for initial assessment of dehydration include raised serum or plasma osmolality, serum osmolarity or a large and rapid change in body mass (McGee 1999).

Serum and plasma osmolality are often used as interchangeable terms, but serum is missing fibrinogen which constitutes 4% of the total protein, so will have a very slightly different osmolality. Serum and plasma osmolality have the clinical advantage in that they can be assessed as a state or single measure (does not require prior knowledge or measurements), and because osmolality is highly controlled by the body, any change suggests problems in body biochemistry. Disadvantages are that if body fluids are lost along with electrolytes (through loss of blood or diarrhoea) then fluid may be lost without alteration of osmolality. However, this review is concerned with reductions in body fluid relating to conscious or unconscious reductions in fluid intake with or without increased losses due to variables such as use of diuretics, fever, diabetes insipidus, dysregulated diabetes mellitus, increased perspiration, or hot dry surroundings. In such situations where body fluids are lost overall, the response is likely to be increased osmolality (Thomas 2008). Serum and plasma osmolality appear to be useful markers of water-loss dehydration in the absence of tracking over time (Cheuvront 2010), and so constitute the most commonly used reference standard (Panel on Dietary Reference Intakes 2004; Thomas 2008; Cheuvront 2013).

During the review process it was agreed that serum osmolarity (which approximates serum osmolality but instead of being directly measured is calculated from the components of osmolality, including serum sodium, potassium, urea and glucose) would be used where serum or plasma osmolality (directly measured) was not available.

Total body mass, or weight, is the sum of body fluid, fat, muscle, organs and bone, and the weight of body fluid is difficult to disentangle from total weight. However, fluid is the body component with the ability to alter most quickly, so that a substantial change in body weight over a short period of time will relate most directly to fluid status (Cheuvront 2010; Shirreffs 2003). For this reason, a reduction of $\geq$ 3% of body weight within seven days may be considered to be a clear indication of dehydration, as would an increase of $\geq$ 3% of body weight on rehydration within seven days.

This relies on more than one assessment, and the assessments need to be accurate (for example, with weight measured nude and at the same time each day) and account for issues such as constipation or oedema (Cheuvront 2010).

Total body water can be estimated by deuterium oxide dilution and therefore change in total body water can be assessed over time (Schloerb 1950). A fall in body water of 2% or more could be considered to constitute dehydration, however due to the variance in assessment of total body water (1% to 2%), this will not be used as a reference standard. A single measure of total body water has not been correlated with hydration status in older people, so cannot be used as a reference standard on its own.

In summary, we accepted the use of the following reference standards for dehydration:

1. serum or plasma osmolality
2. serum or plasma osmolarity
3. change in body weight over seven days

Where more than one of these was available in any one study we always used osmolality for preference, followed by osmolarity.

The target condition of primary interest was water-loss dehydration, including impending or current water-loss dehydration (serum osmolality ≥295 mOsm/kg).

Index test(s)

Protecting the health of older people, and preventing emergency hospital admissions due to dehydration, requires early detection and treatment in the community. Carers, residential home staff and primary health care workers are in the position to facilitate this early detection and treatment. While a biochemical assessment may be the best state (one time) indicator of dehydration in a clinical setting (Thomas 2008) these tests are not generally available in community, primary or residential care settings (Leibovitz 2007).

A systematic review of the diagnostic accuracy of physical signs of hypovolaemia, which included studies published to late 1997, found that in the few relevant studies there was limited evidence that in older people with vomiting, diarrhoea or reduced fluid intake that dry armpits (axilla) supported the diagnosis of hypovolaemia (positive likelihood ratio 2.8, 95% CI 1.4 to 5.4), and moist mucous membranes or a tongue without furrows supported lack of hypovolaemia (negative likelihood ratio for each 0.3, 95% CI 0.1 to 0.6). Capillary refill time and poor skin turgor (elasticity) were not diagnostic (McGee 1999). A recent Australian cohort study found that systolic blood pressure drop on standing, sternal skin turgor, tongue dryness and body mass index were good indicators of early dehydration on hospital admission. However, these factors were compared with physician assessment of hydration status that may have included some or all of these clinical signs (Vivanti 2008). A recent retrospective case series of patients admitted to an emergency department in Switzerland found that the most common symptoms of patients with hypernatraemia (in over 50% of those presenting) were disorientation, somnolence and recent falls (Arampatzis 2012).

Other state (one time) methods proposed to diagnose dehydration include assessment of urine colour, urine specific gravity, saliva osmolality, tear osmolarity, urine volume, sunken eyes, rapid pulse, postural pulse increment, severe postural dizziness, fluid balance charts, upper body weakness, bioelectrical impedance (BIA), and checklists of risk factors (Cheuvront 2010; Eaton 1994; Fortes 2011; Gross 1992; Mentes 2006a; Mentes 2006b; Schut 2005; Thomas 2008; Vivanti 2008; Walsh 2004A; Walsh 2004B). A systematic review that searched literature to 1995 found that early diagnosis of dehydration in older adults can be difficult because "the classical physical signs of dehydration may be absent or misleading in an older patient" suggesting that even index tests established in younger people cannot be assumed to be useful in older people (Weinberg 1995). Although some tests are probably not useful in older people, others may indicate dehydration risk, early stages of dehydration, or current dehydration. It is likely that a portfolio of assessments would be needed to usefully assess stage and type of dehydration among people in residential care without indicating that all residents are at high risk (Wotton 2008).

Alternative test(s)

There are a variety of recommendations for tests used in clinical practice to assess dehydration, and many of those used in assessing dehydration in older people appear to be based on those used and validated in children or healthy young athletes, without further assessment. There are no existing validated simple assessments of dehydration in older people.

Despite this, on informal enquiry health and social care workers often report using simple clinical symptoms, signs and tests (often tongue furrows, dry mouth, urine colour, capillary refill or skin turgor) or non-invasive tests requiring some technology (such as urine specific gravity, change in blood pressure on standing or bioelectrical impedance) to screen older people for dehydration. Articles and websites teach or exhort health and social care professionals and the public to use and rely on these tests (Rushing 2009; MedicineNet 2014; NHS 2013; WebMD 2014; Allison 2005). As these tests appear to be commonly used it is important to check that they are providing accurate information.

Rationale

Currently available evidence on water-loss dehydration in older people is inconsistent. It is vital both for the health and well-being of older people and to reduce unplanned emergency hospital admissions, that the risk of water-loss dehydration is reduced, methods of assessing dehydration risk are developed, impending dehydration in older people in the community and residential care are recognised, and early referral for diagnosis and treatment is car-

ried out where appropriate. The US report on Dietary Reference Values for water intake states that development of "simple non- or minimally invasive indexes of body dehydration status" is a key research need (Panel on Dietary Reference Intakes 2004). A valid, simple and non-invasive screening test for dehydration for older adults in the community would better enable:

- identification of older adults with impending water-loss dehydration so that measures can be taken to improve fluid status;
- monitoring progress of such older people;
- identification of older adults with likely current water-loss dehydration so that further testing or rapid medical support or both can be provided;
- identification of settings/populations where there is a high risk of dehydration so that public health measures to improve hydration may be taken; and
- assessment of effects of interventions to improve hydration in individuals and populations.

OBJECTIVES

To determine the diagnostic accuracy of state (one time), minimally invasive clinical symptoms, signs and tests to be used as screening tests for detecting water-loss dehydrationin older people by systematically reviewing studies that have measured a reference standard and at least one index test in people aged 65 years and over. Water-loss dehydration was defined primarily as including everyone with either impending or current water-loss dehydration (including all those with serum osmolality ≥295mOsm/kg as being dehydrated).

Secondary objectives

1. To assess the effect of different cut-offs of index test results assessed using continuous data on sensitivity and specificity in diagnosis of water-loss dehydration.
2. To identify clinical symptoms, signs and tests that may be used in screening for water-loss dehydration in older people.
3. To identify clinical symptoms, signs and tests that are not useful in screening for water-loss dehydration in older people.
4. To assess clinical symptoms, signs and tests of current dehydration (including all those with serum osmolality >300mOsm/kg).
5. To assess clinical symptoms, signs and tests of impending dehydration (including all those with serum osmolality 295 to 300mOsm/kg).
6. To directly compare promising index tests (sensitivity ≥ 0.60 and specificity ≥ 0.75) where two or more are measured in a single study (direct comparison).
7. To carry out an exploratory analysis to assess the value of combining the best three index tests where the three tests each have some predictive ability of their own, and individual studies include participants who had all three tests.

Investigation of sources of heterogeneity

We planned to explore sources of heterogeneity in the diagnostic accuracy of those individual clinical symptoms, signs and tests that showed some evidence of discrimination. Heterogeneity was to be explored according to the reference standard used, cut-off value for tests providing continuous data, type of participants (community-dwelling older people, those in residential care, and those in hospital), sex, and baseline prevalence of dehydration (Leeflang 2013).

METHODS

Criteria for considering studies for this review

Types of studies

Diagnostic studies that compared an index test with a reference standard for water-loss dehydration in older people were included. We also considered cohort and cross-sectional studies that had not analysed diagnostic accuracy, but where at least one reference standard and at least one index test were measured in at least 10 participants aged 65 years or over and with at least two participants with water-loss dehydration and at least two participants without water-loss dehydration. These studies were included where the authors were able to provide a relevant 2 x 2 table comparing a reference with an index test, or a data set from which relevant 2 x 2 tables could be calculated. Where we had access to the full study data set we excluded any participants who did not receive both the index test and the reference standard. We attempted to access the full data sets (such as Excel spreadsheets or SPSS files) of all included studies.

Participants

People aged 65 years and over who were hospitalised, living in the community, or in institutions, in a developed country were included. Participants could not have kidney failure, heart failure, had not recently been prepared for surgery or undergone surgery, but may have had other chronic or acute illnesses, such as stroke, fracture, diabetes or infection. For mixed populations of older people that included participants aged under 65 years, we excluded participants aged less than 65 years where we had access to the full

data set; but, where only summary data were available, the study was only included where the proportion of those under 65 years was less than 10%. In the same way, when using published data we excluded studies with more than 10% of participants having one or more of the following: kidney failure, heart failure or a recent operation; and when using full study data sets, participants diagnosed with any of these conditions (according to individual study criteria) were excluded from analysis.

Index tests

Single clinical symptoms, signs and tests or a portfolio of symptoms, signs and/or tests and/or a checklist. Prespecified potential index tests for dehydration included dry axilla and other markers of transepidermal water loss; dry mucous membranes; dry or furrowed tongue; extended capillary refill time and measures of skin blood flow; poor sternal skin turgor; systolic blood pressure drop on standing; urine colour; urine specific gravity; saliva osmolality; urine volume; sunken eyes; rapid pulse; postural pulse increment; postural dizziness; fluid balance charts; thirst; bad taste in the mouth; upper body weakness; measures of thermoregulation; bioelectrical impedance analysis (BIA); and checklists of risk factors. Index tests that appeared appropriate and so were included during the review process included drink and fluid intake; number of urine voids; urine osmolality; tear osmolality; tear volume or symptoms of dry eyes; saliva volume; cognitive and consciousness levels; feelings of tiredness or dullness; enjoyment of food and appetite; need for iv or thickened fluids and presence of blue lips. These index tests were included regardless of the definition of test positivity or cut-off chosen (and these sometimes did vary between studies).

BIA assesses electrical impedance through the body (commonly from the fingers to the toes) and is often used to estimate body fat. Equipment is portable and fairly easy to use, and some types of BIA are theoretically able to assess total body water. BIA is in use in some areas in assessing hydration status of older people (especially those living in residential care). Different measurements can be made, including resistance (the resistance of the extracellular path through the body) and multi-frequency machines use take measurements at several different electrical frequencies. BIA machines may produce raw data on resistance and impedance, or use internal functions (incorporating information such as participant height, weight and age) to automatically calculate total body water (TBW) and the extracellular water (ECW) and intracellular water (ICW) components.

Comparator tests

There is no existing comparator test.

Target conditions

Water-loss dehydration (including people with either impending or current water-loss dehydration, anyone with a serum osmolality of $\geq$295 mOsm/kg) was the primary target condition. Impending water-loss dehydration (serum osmolality 295 to 300 mOsm/kg) and current water-loss dehydration (>300 mOsm/kg), treated as two separate conditions, were planned as secondary target conditions.

Reference standards

Studies that used one of our reference standards for water-loss dehydration, ordered in terms of their importance to make best use of the reference standard better able to represent water-loss dehydration in frail older people, were included. The primary standard was raised plasma or serum osmolality, followed by serum osmolarity, then body mass (weight) change.

We have referred to those with either impending (serum osmolality 295 to 300 mOsm/kg) or current (serum osmolality >300mOsm/kg) dehydration as having water-loss dehydration. Having water loss dehydration (having either impending or current dehydration, serum osmolality $\geq$295 mOsm/kg) has been contrasted with being euhydrated (serum osmolality 275 to <295 mOsm/kg) as our primary target condition.

The secondary target condition was current dehydration (serum osmolality >300 mOsm/kg) compared with euhydration or impending dehydration (serum osmolality 275 to 300 mOsm/kg). We intended to assess another secondary target condition, impending dehydration alone (serum osmolality 295-300) compared to euhydration (serum osmolality 275 to <295 mOsm/kg), but these analyses were not carried out.

Serum or plasma osmolality

- The primary target condition, water-loss dehydration, included all those with serum or plasma osmolality of 295mOsm/kg or greater (people with either impending or current dehydration)
- Serum or plasma osmolality of 295 to 300 mOsmol/kg suggested impending water-loss dehydration.
- Serum or plasma osmolality >300 mOsmol/kg suggested current dehydration.

Serum osmolarity

We planned to use serum and plasma osmolality in the protocol, but during the review process it was decided to include serum osmolarity as a reference standard as it is an estimate of serum osmolality. Serum osmolarity is calculated from serum sodium, potassium, glucose and urea, rather than being directly measured. The exact formula used to calculate serum osmolarity has been noted for each study, and the cut-offs used are the same as the cut-offs for serum osmolality.

Body mass (weight) change

Weight change could be naturally occurring or follow encouragement to limit fluid intake for a period, but could not result from unusual levels of exercise or saunas (because these may result in dehydration that is metabolically distinct from naturally occurring dehydration). Weight change was included where a baseline weight was measured and re-weighing occurred within seven days (and no surgery had occurred within that period).

- We defined impending dehydration as a reduction of 3% to 5% of body weight within seven days or less, or an increase of 3% to 5% of body weight within seven days as an indication that a person was dehydrated before rehydration.
- Current dehydration corresponded to changes of more than 5% of body weight.
- Weight change over a period less than seven days was not multiplied up to the seven day equivalent.

Search methods for identification of studies

Search methods used were based on guidelines for Cochrane diagnostic test accuracy reviews (de Vet 2008).

Electronic searches

Searches were run in MEDLINE (OvidSP), EMBASE (OvidSP) and CINAHL from inception until November 2010, with update searches in March 2011 and November 2011. The most recent update search was conducted 29 April 2013. The Database of Reviews of Effectiveness (DARE) and Health Technology Assessment (HTA) databases were searched via *The Cochrane Library* for any relevant non-Cochrane reviews using a strategy adapted from the MEDLINE strategy. The International Clinical Trials Registry Platform (ICTRP) was searched for ongoing studies using keywords derived from this search strategy. We sought assistance from the Cochrane Renal Group's Trials Search Co-ordinator to search the *Cochrane Register of Diagnostic Test Accuracy Studies* for further relevant studies. Searches for these databases were run in April 2013. No limits as to language or publication type were applied, and no diagnostic methodology search filters were employed as these appear unhelpful in reducing sensitivity (de Vet 2008; Whiting 2011).

Searching other resources

Reference lists of included studies and identified relevant reviews were checked. Authors of included studies were contacted for details of further relevant studies.

Data collection and analysis

Selection of studies

Titles and abstracts were scanned and all potentially relevant studies obtained in full text. Full text articles in languages other than English were translated. Study inclusion eligibility was assessed independently in duplicate, and disagreements resolved by a third author. We wrote to authors of all studies that appeared to have collected data on at least one reference standard and at least one index test, and in at least 10 people aged 65 years and over, even where no comparative analysis has been published, requesting either that the original authors supply the relevant 2 x 2 table or the original data set so that we could create 2 x 2 tables. The latter was preferable because it enabled the review authors to remove data relating to any participants aged under 65 years, or with heart failure or kidney disease, and provided the potential to explore effects of different cut points for index tests that provided continuous data. We also wrote to authors who had published data in relevant participants including either index or reference standard data, to ask whether relevant reference standard or index data had been collected.

Data extraction and management

A data extraction form, including validity criteria, was developed for the review and tested by all data extractors (LH, AA, NA, AC, DG, AH, SR, AS, SW) on two or three included studies. We collected age, gender, health, functional status, and level of independence data for participants, as well as how each test was performed and assessed, timing of each test including how far apart in time the different tests were taken, and at what time of day. The data extraction form was refined (with definitions and explanations added as required by the team), then data extraction was carried out in duplicate for each included study. Authors who extracted data conferred to agree on a final data extraction and validity assessment for the review. Where items required for data extraction or validity assessment were designated as unclear, original study investigators were contacted to obtain further details.

Where complete data sets for included studies were sought from original investigators, we requested data on sex, age, and presence or absence of diseases such as kidney and heart failure as well as results of our index tests and reference standards. In processing the study data sets, we ensured that details of each component of the data set was understood (the timing of tests, units, serum or urinary measures and so forth) by analysing the publication and from contact with original investigators. The data set was then cleaned by removing data of participants aged less than 65 years; those with kidney disease, heart failure, or oedema; or who were perioperative or postoperative; and participants who had no reference standard data or with serum osmolality <275 mOsm/kg. The process, including losses of participants, was logged. This final data set for each included study was used to complete tables of characteristics and validity.

We constructed 2 x 2 tables (no dehydration versus water-loss dehydration) for each index test, one table for each dichotomous index test for each study, and three tables per continuous index test (one table for each of three cut-off points). The three pre-specified cut-off points for continuous index tests were consistent for all studies measuring that index test, and based on recommended cut-offs in the literature (ideally), reference ranges (where recommended cut-offs are not available) or were data driven (Table 1). Data driven cut points were set as the median in the data set, plus a value higher than the median and lower than the median. The higher cut point was chosen as the point midway between the median and highest value present in the data set, and the lower cut point as the point midway between the median and the lowest value present. Before analyses were finalised the proposed cut-offs for each included index test were circulated around the review authors for comments (without the results of any of the analyses) and the cut-offs for several index tests were adjusted according to suggested references and accepted levels (details for each cut off found in Table 1).

Once the cut-offs were finalised we calculated sensitivity, specificity, positive and negative predictive values (PPV and NPV), positive and negative likelihood ratios (PLR and NLR) and diagnostic odds ratio (DOR) for each 2 x 2 table.

Assessment of methodological quality

Assessment of methodological quality was carried out independently in duplicate as part of data extraction. It was based on the characteristics suggested by QUADAS (the first version), and reflected in the RevMan 5.2 program (Reitsma 2009a; Whiting 2006). Additionally, we recorded whether the study was free of commercial funding. The qualities assessed are described in further detail in Appendix 2.

Statistical analysis and data synthesis

Analyses were performed according to descriptions in the *Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy* (Macaskill 2010). Diagnostic accuracy of each clinical symptom, sign and test was assessed against the best available reference standard for water-loss dehydration (ideally assessed using serum osmolality, but serum osmolarity or weight change where osmolality was not available) within each study.

The main analysis for each index test assessed ability to diagnose water-loss dehydration (no dehydration versus impending or current dehydration, serum osmolality ≥295 mOsm/kg). For each index test we also assessed ability to diagnose current dehydration (no or impending dehydration versus current dehydration, serum osmolality >300 mOsm/kg), a secondary target condition. It was planned that we would also analyse no dehydration versus impending dehydration alone (serum osmolality 295-300 mOsm/kg, omitting data for those with current dehydration), but as the number of analyses in the review was so high, and the data in each study already limited, this was abandoned.

Individual study data for each index test were presented in forest plots of sensitivity and specificity and in receiver operating characteristic (ROC) space, subgrouped by cut-off for continuous index tests.

We conducted bivariate random-effects meta-analyses in Stata/IC (StataCorp) using metandi for index tests where there were at least four studies or data sets on a single index test and the studies all shared a cut-off for test positivity, so that data sets could be pooled (Reitsma 2005) to construct sensitivity and specificity summary estimates, and summary ROC curves. We assigned the same approach for index tests with continuous outcome data for each of the three cut-off points investigated. Where meta-analyses would not run in STATA we increased the number of integration points, until the meta-analysis would run (Table 2). We planned that covariates would be incorporated into the bivariate model to examine the effects of factors that may have been responsible for heterogeneity, however as the number of studies for each test was limited (eight studies were available for one test, dry mouth, but most tests included in the meta-analyses had only four useful data sets) this was felt to be inappropriate, having limited power.

The principal aim of this review was to identify the potential usefulness of index tests to identify or rule out water-loss dehydration (impending or current dehydration). Because the index tests may be used to screen for dehydration in populations with little or no current screening, but among whom there are likely to be high levels of dehydration, initial tools needed to be quite specific. This will help to limit numbers of false positive results that may discredit future time spent in responding to positive results. Any level of sensitivity would be an improvement on the current lack of ability to detect most episodes of dehydration in the community, but clearly, the higher the sensitivity the better, while maintaining high specificity. We suggested in the protocol that minimum specificity of a useful test would be 75%, and minimum sensitivity would be 60% for either impending or current dehydration. These levels were used as standards against which the utility of minimally invasive clinical symptoms, signs and tests were assessed.

We directly compared index tests that fulfilled the minimum criteria of sensitivity ≥60% and specificity ≥75% where two or more were measured in a single study (direct comparison). We planned that the tests would be compared at their best cut-off point, that is, the point that provided the best discrimination, its threshold nearest to the upper left quadrant of the ROC curve. We also planned bivariate meta-regression to explore including a binary covariate for index test to understand whether the expected sensitivity and specificity or both differed between index tests (Macaskill 2010).

For the review we had to pre-specify three cut-offs for each test with a continuous measure (as above). As this is an area where there is little previously published research the danger was that we chose unhelpful cut-offs and missed a cut-off with useful sensitivity and specificity. For this reason we carried out post-hoc analyses to cre-

ate more detailed ROC curves where there appeared some possibility from the completed analyses that a cut-point with sensitivity ≥60% and specificity ≥75% may exist (between two pre-specified cut-offs or below or above the cut-offs tested). These analyses were presented so that we could assess which tests may be worth testing in further research (as the cut-offs were not pre-specified we cannot derive conclusions from them, but they may be useful in driving future primary research). Interpretation of ROC plots involves assessment of how close to the top left-hand corner the curve runs (the closer to this corner, the higher the sensitivity and specificity). A straight line running from the bottom left to top right corners is the line of no effect (indicating an absence of any diagnostic accuracy). Useful diagnostic accuracy (pre-specified as sensitivity of ≥60% and specificity of ≥75%) is indicated by the curve entering the rectangle outlined in grey in the top left hand corner of the plot.

An exploratory analysis assessed the value of combining the best three index tests where each had some individual predictive ability, as combining several slightly useful tests may result in a more useful test. As these are simple tests it would be realistic to carry out two or three of them as a screening test for dehydration in the clinical or social care context. We were only able to assess the diagnostic accuracy of combined tests where an individual study included participants who had all of the best index tests. As we had access to individual participant data for the study that included two potentially useful tests (expressing fatigue and missing drinks between meals, Kajii 2006), we were able to assess diagnostic accuracy where individuals had positive results from both tests, and where individuals had positive results from either test.

Investigations of heterogeneity

Heterogeneity was examined by considering study characteristics, visual inspection of forest plots of sensitivities and specificities, and examining ROC curves of raw data. Heterogeneity due to different cut-off values for each index test were examined by comparing results of the bivariate random-effects meta-analyses at each cut-off point. It was planned that we would assess the effects of reference standard type (serum osmolality, serum osmolarity or weight change), participant type (community-dwelling older people, those in residential care or in hospital), sex, and baseline prevalence of dehydration were assessed (Leeflang 2009). However, given the small number of studies that assessed each test, this was not considered appropriate. Most were study-level variables, but for mixed sex studies where we had the full study data set, we planned to produced separate 2 x 2 tables for men and women to enable more complete analysis - this was not carried out because most studies included few participants and further subdivision would lead to little gain in information.

Sensitivity analyses

We planned to assess the effect of four quality items: acceptable delay between tests; incorporation avoided; partial verification avoided; and withdrawals explained; on the results by using each quality assessment item as a covariate in bivariate regression. These four items were chosen for sensitivity analyses because they were not explored within the investigations of heterogeneity and were potentially troublesome even though we had access to full data sets for most included studies. However, given the small number of included studies for each test this bivariate regression was considered inappropriate.

Assessment of reporting bias

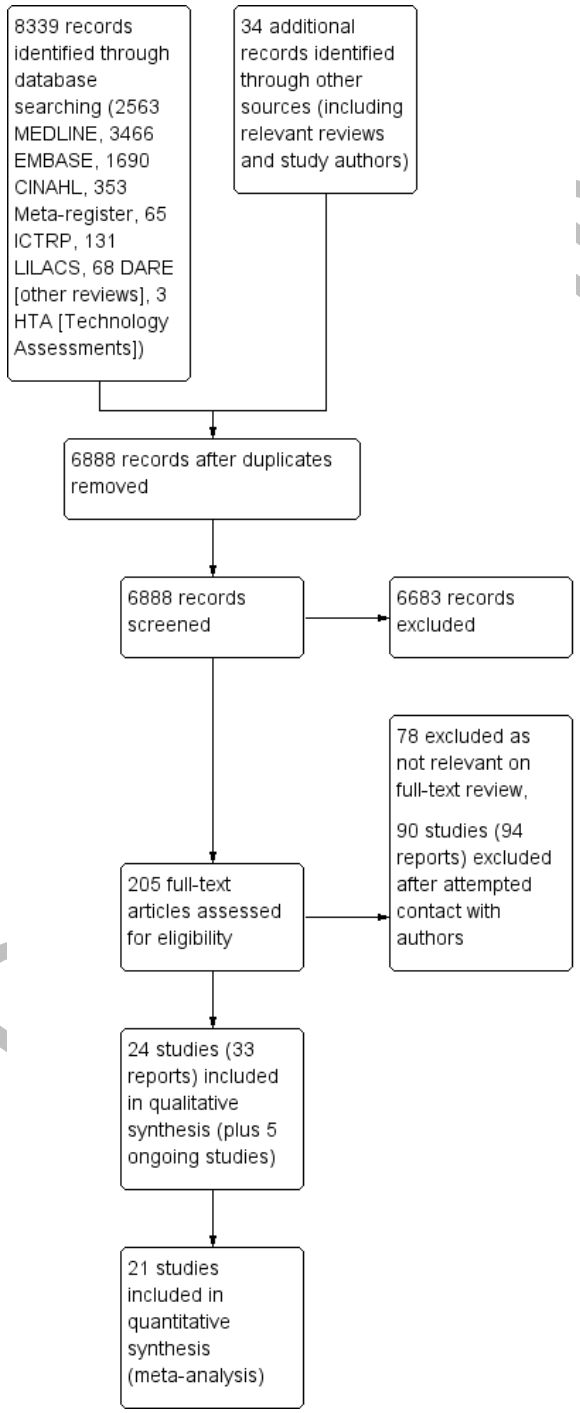
As there were so few studies reporting any single index test it was not possible to formally assess the extent of reporting bias in the included studies.

RESULTS

Results of the search

The final searches were run in April 2013 (for MEDLINE, EMBASE and CINAHL) (Figure 1). After duplicates were removed from the 6888 records retrieved, 205 records were identified as possibly being relevant, and the full texts of these articles were assessed. Of these, 78 were found not to be relevant to this review. The remaining 127 articles related to 114 studies. We attempted to contact study authors to obtain further information, including whether relevant reference test or index test data were available, and if so, seeking data sets for inclusion in this review. As a result of this process we excluded 90 studies, leaving 24 studies for inclusion in the review. We also identified two ongoing studies through database searching, and three other ongoing studies through contact with authors. Two further potentially relevant studies were identified in a non-systematic way after submission of this review for publication, and have not yet been formally assessed for inclusion, but will be assessed for inclusion at the first update of this review (Studies awaiting classification).

Figure 1. Study flow diagram



Three studies were included using only data from study publications (Allison 2005; Eaton 1994; Shimizu 2012), and although we tried to contact authors for further details and the full data set, no additional data were received. We obtained 21 full data sets from study authors for inclusion in the review (Bossingham 2005; Chassagne 2006; Culp 2003; Fletcher 1999; Gaspar Acute & LTC 2011; Johnson 2003; Kafri 2012; Kajii 2006; Lindner 2009; Mack 1994; McGarvey 2010; Monahan 2006; Powers 2012; Rowat 2011; Source Study 2001; Stookey 2005; Stotts 2009; Walsh 2012; Perren 2011; Sjöstrand ED 2013; Sjöstrand Healthy 2013). None of these studies could have been included without obtaining these additional data.

We included 24 studies (3412 participants) that ranged in size from 10 to 1947 participants (see Characteristics of included studies). Participants were living in the community (7 studies, 2116 people), residential care (5 studies, 850 people), hospital (11 studies, 418 people) and mixed settings (1 study, 28 people from residential care and hospital settings). Among the included studies, 13 used serum osmolality (measured directly) as the reference standard; seven used serum osmolarity (calculated); three used weight change and one used a combination of serum osmolality and raised serum urea/creatinine ratio.

There was a wide variety of index tests among the included included studies. Of these index tests, at least four studies (making meta-analysis realistic) provided data on: fluid intake, urine volume, fluid balance, urine specific gravity, urine colour, urine osmolality, heart rate, bioelectrical impedance analysis (BIA) resistance at 50 kHz, BIA total body water, extracellular water (ECW) and intracellular water (ICW) as percentages of body weight, dry mouth and feeling thirsty. The 21 studies that contributed data for these endpoints are included in the meta-analyses (Allison 2005; Bossingham 2005; Chassagne 2006; Culp 2003; Fletcher 1999; Gaspar Acute & LTC 2011; Johnson 2003; Kafri 2012; Kajii 2006; Lindner 2009; Mack 1994; McGarvey 2010; Perren 2011; Powers 2012; Rowat 2011; Sjöstrand ED 2013; Sjöstrand Healthy 2013; Source Study 2001; Stookey 2005; Stotts 2009; Shimizu 2012).

Methodological quality of included studies

The methodological quality of included studies is set out in Characteristics of included studies, and summarised in Figure 2. Representative spectrum assessed whether participants were older people living in the community independently or in care, and whether there was consecutive or random recruitment. We assessed six studies at low risk of bias (included older people living in the community and recruitment was consecutive or random), 13 were at high risk of bias (so participants were not living in the community or recruitment was neither consecutive or random), and risk of bias was unclear in five studies.

Figure 2. Methodological quality summary: review authors' judgements about each methodological quality item for each included study.

We assessed that 13 of the 24 included studies had a low risk reference standard (serum or plasma osmolality directly observed). Delay between index and reference standard tests is of particular importance in dehydration; hydration status can alter over the course of a few hours. For this reason our standard for good practice was that the delay between the index and reference standard tests would be two hours or less. We found that 11 studies were at low risk from delay between tests (less than two hours between at least 90% of index and reference standard tests); five were at high risk, and risk was unclear in eight studies.

We found that 17 studies were at low risk from partial verification (prospective studies where all participants received both index and reference standard tests); five were at high risk; and two were unclear risk. To be considered at low risk of bias from partial verification a study had to be prospective (so that the reference standard test was planned, and not delivered on the basis of other findings, that may include the results of the index tests) (de Groot 2011).

Our assessment found that 23 studies were at low risk from differential verification (studies at low risk used the same reference standard in all participants); one was unclear. Furthermore, 22 studies were at low risk of incorporation of index tests into the reference standard, and two were at high risk. There were 20 studies that had reference standard results interpreted blind to index test results, so were at low risk of reference standard results being interpreted according to the index test results; one was at high risk and three at unclear risk. There were 18 studies at low risk from index test results being interpreted according to reference standard test results; six were unclear. We found that 22 studies (including all of those where a data set was provided) were at low risk of interpreting index or reference tests with reference to other relevant clinical data; two were unclear. We identified that 19 studies were at low risk of uninterpretable test results being a problem; five were at unclear risk. There were 18 studies at low risk of unexplained withdrawals, three at high risk and three at unclear risk. Lastly, 16 studies were at low risk of commercial funding biasing reporting of the study, five were at high risk and three at unclear risk.

Findings

Adequate sensitivity and specificity for water-loss dehydration (including people with impending or current dehydration, serum osmolality ≥295 mOsm/kg)

Sensitivity was defined as the percentage of dehydrated people who are correctly identified as having the condition by the index test, and specificity the percentage of euhydrated people who were correctly identified by the index test as not being dehydrated. The positive predictive value is the probability that with a positive index test result, the person is truly dehydrated, and the negative predictive value is the probability that with a negative index test result, the person is truly euhydrated.

A receiver operating characteristic (ROC) curve is a graph that shows how well a continuous index test predicts dehydration (as measured by the reference standard) as the cut-off of the index test varies. For a clear introduction to the concepts of sensitivity, specificity, likelihood ratios and other measures, and interpretation of ROC plots see Linnet 2012.

The sensitivity and specificity of each index test for each included study at each pre-specified cut-off are presented in forest plots of sensitivity and specificity in the data tables. Furthermore, data on positive predictive value, negative predictive value, positive and negative likelihood ratios (PLR and NLR), diagnostic odds ratio (DOR), pre- and post-test probabilities are presented in Table 3. Of the 152 cut-offs tested for 68 possible index tests only three showed sensitivity of at least 60% and specificity of at least 75%. These potentially useful index tests were **missing drinks between meals** (sensitivity 1.00 [95% CI 0.59, 1.00], specificity 0.77 [0.64, 0.86] in 71 people) and **expressing fatigue** (sensitivity 0.71 [0.29, 0.96], specificity 0.75 [0.63, 0.85], in 71 people, each assessed in Kajii 2006) and **BIA resistance at 50 kHz** with a cut-off of ≥ 450 Ω. Two other studies (Sjöstrand ED 2013; Sjöstrand Healthy 2013) also assessed fatigue but did not show this level of diagnostic accuracy (with sensitivities of 0.42 [0.23, 0.63] and 0.30 [0.07, 0.65] and specificities of 0.80 [0.28, 0.99] and 1.00 [0.29, 1.00] in 31 and 13 people respectively). BIA resistance at 50 kHz was assessed in four studies but showed the appropriate specificity and sensitivity in only two (sensitivities 1.00 [0.48, 1.00] and 0.71 [0.44, 0.90] and specificities of 1.00 [0.69, 1.00] and 0.80 [0.28, 0.99] in 15 and 22 people respectively for Allison 2005; Powers 2012, but with sensitivities of 0.54 [0.25, 0.81] and 0.69 [0.56, 0.79] and specificities of 0.50 [0.16, 0.84] and 0.19 [0.17, 0.21] in 21 and 1947 people respectively in Kafri 2012 and Stookey 2005).

Kajii 2006 included 71 frail elderly Japanese people living at home, mean age 76 years, 63% women. The reference standard used was serum osmolality (directly measured) and all other methodological quality indicators where high (indicating low risk of bias) except that it was unclear whether recruitment (which took place from a community centre) was consecutive or random. This study provides high quality evidence of the diagnostic utility of missing drinks between meals and of expressing fatigue; however, missing drinks between meals has not been tested in any other studies.

Missing drinks between meals was assessed by participants being asked how much water they drank between breakfast and lunch, between lunch and dinner, and between dinner and next breakfast, they were scored as missing drinks between meals if they answered "none" to any of these questions. Fatigue was assessed in the answer to the question "do you feel fatigue?" (yes or no were allowed as answers).

Expressing fatigue was tested in two further studies (Sjöstrand

ED 2013; Sjöstrand Healthy 2013). Sjöstrand Healthy 2013 recruited 13 elderly volunteers from Sweden, mean age 81 years, 54% women. Sjöstrand ED 2013 included 40 elderly people attending the emergency department of a tertiary care centre in Sweden, mean age 84 years, 58% women. The reference standard for both studies was serum osmolality (directly measured), and again, all other methodological quality indicators were met (indicating low risk of bias) except for representative spectrum. This was because it was unclear whether consecutive or random recruitment took place in either study, and the emergency department-based study did not recruit from the community.

We identified four studies that assessed BIA resistance at 50 kHz; their validity was more variable. The reference standard was serum osmolality (directly measured) for Kafri 2012 and Stookey 2005, serum osmolarity (calculated) for Allison 2005 and Powers 2012. Validity concerns for the Allison 2005 study included that only 22 of 1225 care home residents discussed (age and gender balance not reported) were represented in the data (without explanation), partial verification appeared to be a problem (in that not everyone receiving the index tests also received the reference standard, de Groot 2011), there appeared to be a delay of up to three months between the reference standard and index tests (a problem in a condition as fast-changing as dehydration), and that it did not appear free of commercial funding.

Powers 2012 (which also suggested appropriate sensitivity and specificity for BIA resistance at 50 kHz) included 22 US geriatric facility inpatients and outpatients, mean age 79 years, 64% women. For this study all reference and index tests were conducted on the same day, partial verification was not dealt with, withdrawals were explained, and the study appeared free of commercial funding.

Kafri 2012 included 21 people hospitalised following a stroke in the UK, mean age 78 years, 35% women. All reference and index tests were conducted on the same day, although not always within two hours, partial verification was not a problem, withdrawals were explained, and the study was partly funded by the European Hydration Institute.

Stookey 2005 included 1947 older people as part of a nationally representative US sample (National Health and Nutrition Examination Survey or NHANES, http://www.cdc.gov/nchs/nhanes.htm), mean age 75 years, 51% women. The index and reference standard were carried out at a single interview, partial verification was not a problem, withdrawals were explained and the study was free of commercial funding.

While there is an indication of some level of diagnostic accuracy for BIA resistance at 50 kHz this was not confirmed by the largest and highest validity study, Stookey 2005. Potential sources of heterogeneity among studies, aside from validity, included differing baseline prevalence of dehydration (varying from 4% in Stookey 2005 to 77% in Powers 2012, effect of prevalence discussed in Leeflang 2013) and general health (the studies included the general public, care home residents, geriatric unit inpatients and outpatients and people in hospital following a stroke).

We planned to explore sources of heterogeneity of diagnostic accuracy of individual clinical symptoms, signs and tests that show some evidence of discrimination by the reference standard used, cut-off value for tests providing continuous data, type of participants (community-dwelling older people, those in residential care, and those in hospital), sex, and baseline prevalence of dehydration, however there were no groups of studies with appropriate levels of accuracy within which to explore any heterogeneity.

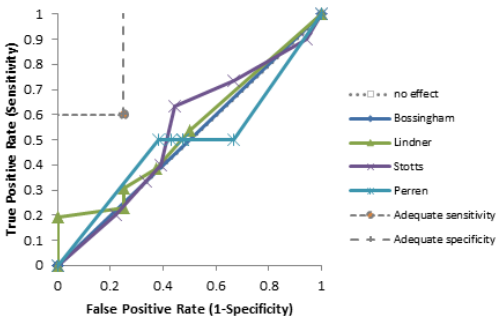
Because a study was published during the conduct of this review that suggested body weight fluctuations of over 3% in well hydrated hospitalised elderly patients (Vivanti 2013) we questioned the validity of weight change as a reference standard. For this reason we examined the diagnostic accuracy of the tests reported by the three studies that used weight change as a reference standard (McGarvey 2010; Monahan 2006; Perren 2011). Where these clinical symptoms, signs and tests were assessed by more than one study in no case did the study using weight change as the reference standard stand out in suggesting dramatically better or worse diagnostic accuracy. Being unable to spit was the only test examined only in a study using weight change as the reference standard - this did not suggest any useful diagnostic accuracy, but should be re-checked against serum osmolality.

Meta-analyses were conducted for tests with at least four studies contributing data. These tests were fluid intake, urine volume, fluid balance, urine specific gravity, urine colour, urine osmolality, heart rate, BIA resistance at 50 kHz, total body water, intracellular water and extracellular water as percentages of body weight, dry mouth and thirst (Table 2). For no meta-analyses and no cut-offs were the point estimates of the sensitivity ≥60% and specificity ≥75%. The most encouraging was a meta-analysis run for BIA resistance at 50 kHz with a cut-off of ≥450 Ω, suggesting a sensitivity of 73% (57 to 84%) and specificity of 70% (18 to 96%). As with all the meta-analysis results the confidence intervals were very wide reflecting small studies and heterogeneity in results.

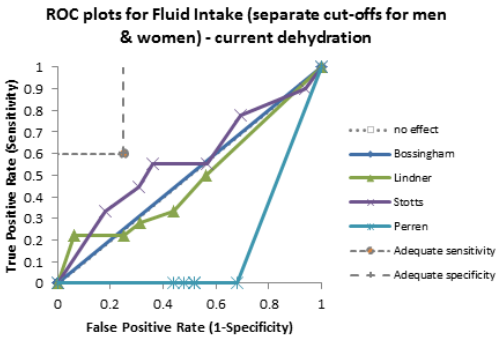
ROC plots for water-loss dehydration (serum osmolality ≥295mOsm/kg or equivalent) - post-hoc analyses

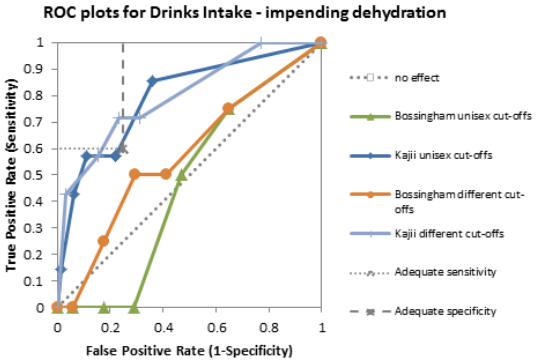
Data for several index tests suggested that there was a potential cut-off with sufficient sensitivity and specificity if we used higher, lower or intermediate cut-offs, so these post-hoc analyses were carried out, and ROC plots shown, for drinks and fluid intake (Figure 3), urine specific gravity and colour (Figure 4), urine osmolality and output volume (Figure 5), signs including axillial moisture, body temperature and skin turgor, and BIA resistance at 50 kHz (Figure 6), and BIA assessments of total body water, extracellular water and intracellular water as percentages of body weight (Figure 7). Most of these are shown for both impending and current dehydration, but to limit the number of figures the ROC plot for current dehydration was not shown for extracellular water or intracellular water (no point on either ROC curve fulfilled our criteria

Figure 3. ROC plots for drinks intake and fluid intake, for impending and for current dehydration. Better diagnostic accuracy (with sensitivity of at least 60% and specificity of at least 85%) is represented by a line falling within the grey-outlined oblong in the top left hand corner of each plot. For a clear introduction to the concepts of sensitivity, specificity, likelihood ratios and other measures, and interpretation of ROC plots see Linnet 2012 (downloadable from http://www.clinchem.org/content/early/2012/07/13/clinchem.2012.182543.full.pdf).



Secondary analyses: ROC plots for Fluid Intake, original cut-offs at men 1.70 & women 1.30 L/d, men 2.70 & women 2.00 L/d, men 3.70 & women 2.70L/d, added cut-offs men 1.95 & women 1.48 L/d, men 2.20 & women 1.65 L/d, men 2.45 & women 1.83 L/d.





Secondary analyses: ROC plots for Drinks Intake, **Unisex** original cut-off at 1.5L/d, added cut-offs at 1.0, 1.2, 1.4, 1.6 and 1.8 L/d. **Different** for men/women original cut-offs at men 1.4 & women 1.0 L/d, men 2.2 & women 1.6 L/d, men 3.0 & women 2.2 L/d, additional cut-offs men 1.6 & women 1.15 L/d, men 1.8 & women 1.3 L/d, men 2.0 & women 1.45 L/d.

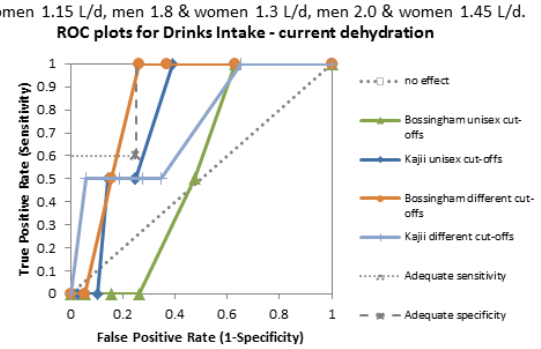
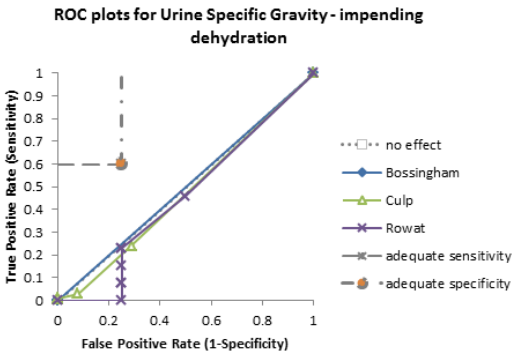
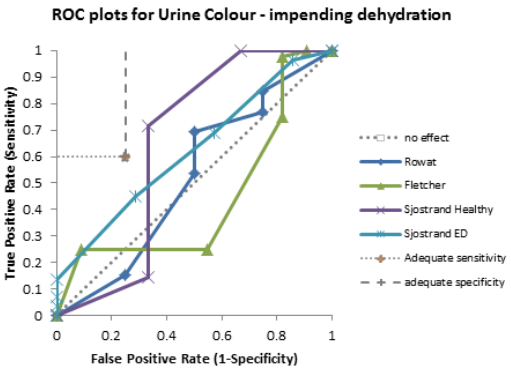


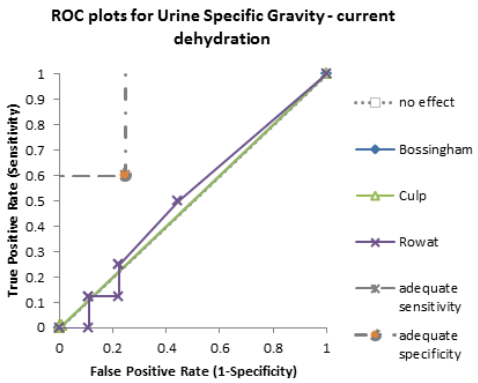
Figure 4. ROC plots for urine specific gravity and urine colour, for impending and for current dehydration. Better diagnostic accuracy (with sensitivity of at least 60% and specificity of at least 85%) is represented by a line falling within the grey-outlined oblong in the top left hand corner of each plot. For a clear introduction to the concepts of sensitivity, specificity, likelihood ratios and other measures, and interpretation of ROC plots see Linnet 2012 (downloadable from http://www.clinchem.org/content/early/2012/07/13/clinchem.2012.182543.full.pdf).



Secondary analyses: ROC plots for Urine Specific Gravity, original cut-offs at 1.035, 1.028 & 1.020, added cut-offs 1.050, 1.045, 1.040, and 1.030.



Secondary analyses: ROC plots for Urine Colour, original cut-offs at 6, 4 & 2, added cut-offs at 5, 3 & 1.



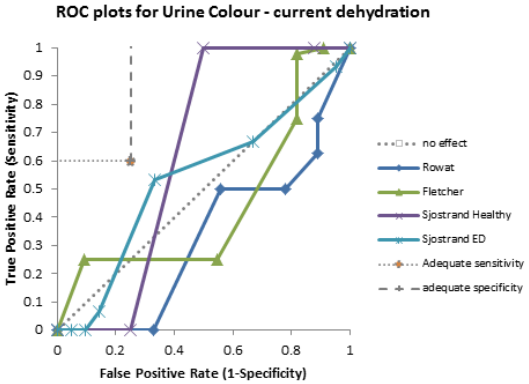
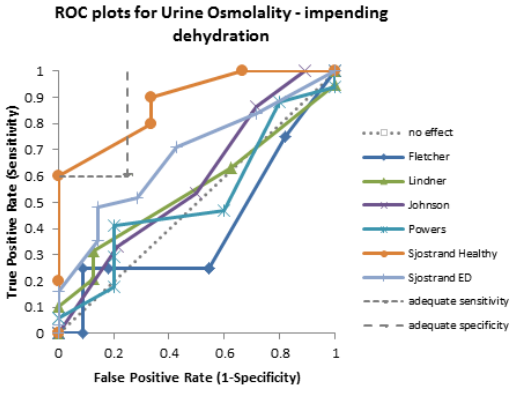
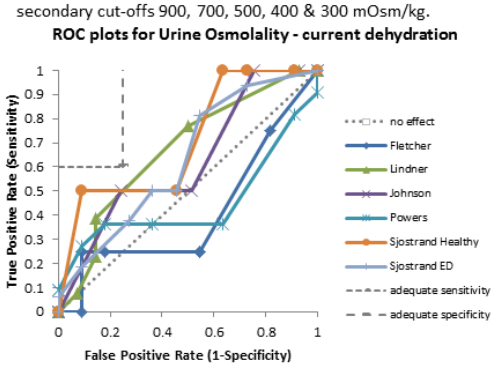
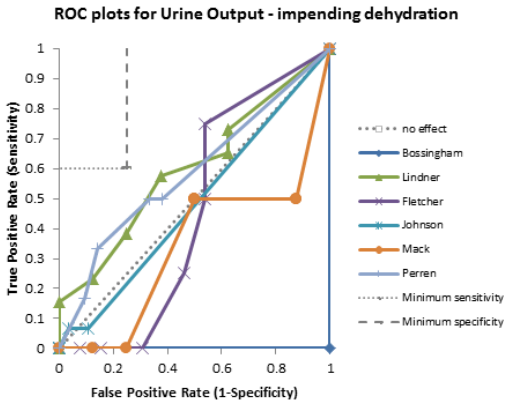


Figure 5. ROC plots for urine osmolality and urine output, for impending and for current dehydration. Better diagnostic accuracy (with sensitivity of at least 60% and specificity of at least 85%) is represented by a line falling within the grey-outlined oblong in the top left hand corner of each plot. For a clear introduction to the concepts of sensitivity, specificity, likelihood ratios and other measures, and interpretation of ROC plots see Linnet 2012 (downloadable from http://www.clinchem.org/content/early/2012/07/13/clinchem.2012.182543.full.pdf).



Secondary analyses: ROC plots for Urine Osmolality, review cut-offs at 1000, 800, 600 mOsm/kg, added secondary cut-offs 900, 700, 500, 400 & 300 mOsm/kg.





Secondary analyses: ROC plots for Urine Output, original cut-offs at 0.3, 0.5, 0.8L/d, additional cut-offs 1.0, 1.2, 1.4 and 1.6 L/d.

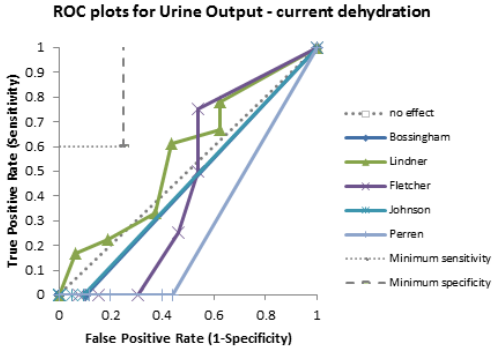
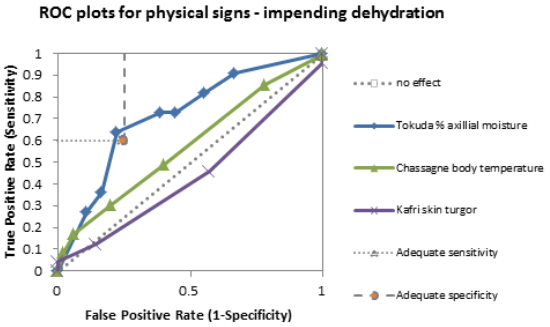
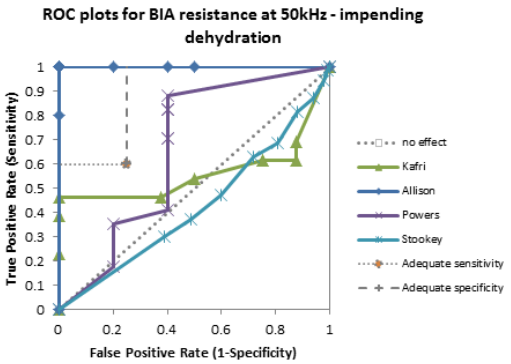


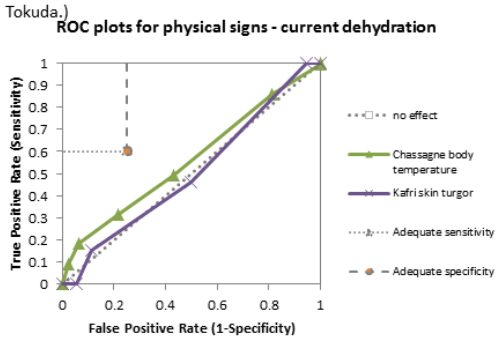
Figure 6. ROC plots for tests of dehydration and BIA resistance at 50kHz, for impending and for current dehydration. Better diagnostic accuracy (with sensitivity of at least 60% and specificity of at least 85%) is represented by a line falling within the grey-outlined oblong in the top left hand corner of each plot. For a clear introduction to the concepts of sensitivity, specificity, likelihood ratios and other measures, and interpretation of ROC plots see Linnet 2012 (downloadable from http://www.clinchem.org/content/early/2012/07/13/clinchem.2012.182543.full.pdf).



Secondary analyses: ROC plots for **Body Temperature**, review cut-offs at 38.2, 36.8 & 33.2 °C, added secondary cut-offs 37.85, 37.5, 37.15 °C. **Skin Turgor**, review cut-offs at 4, 3 & 1 secs, added secondary cut-off 2 secs. **Axillial moisture**, review cut-offs at 32, 37 & 42%, added secondary cut-offs 33, 34, 35 & 36%. (No current dehydration data available for Tokuda.)



Secondary analyses: ROC plots for **BIA resistance at 50kHz**, review cut-offs at 550, 450 & 350 ohms, added secondary cut-offs 375, 400, 425, 475, 500 & 525 ohms.



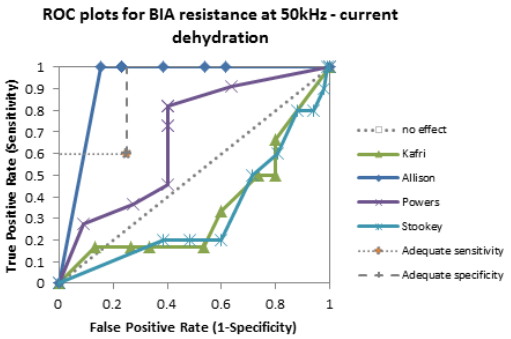
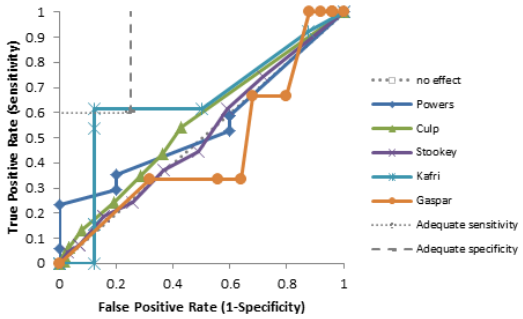
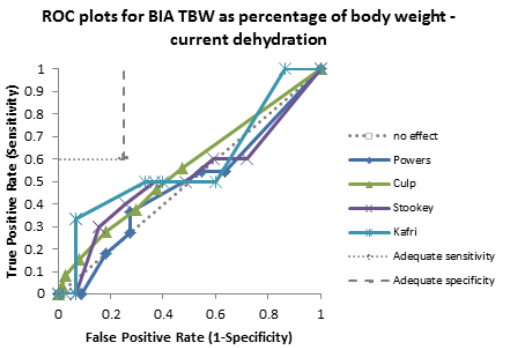
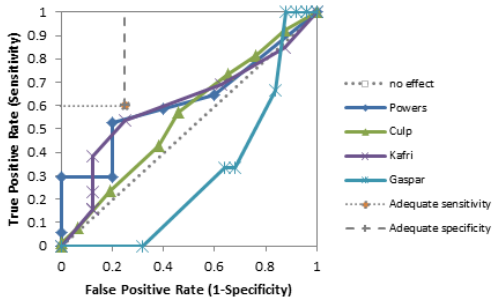


Figure 7. ROC plots for BIA total body water (TBW), intra-cellular water (ICW) and extra-cellular water (ECW) as % of body weight for impending dehydration and for BIA total body water as % body weight for current dehydration. Better diagnostic accuracy (with sensitivity of at least 60% and specificity of at least 85%) is represented by a line falling within the grey-outlined oblong in the top left hand corner of each plot. For a clear introduction to the concepts of sensitivity, specificity, likelihood ratios and other measures, and interpretation of ROC plots see Linnet 2012 (downloadable from http://www.clinchem.org/content/early/2012/07/13/clinchem.2012.182543.full.pdf).

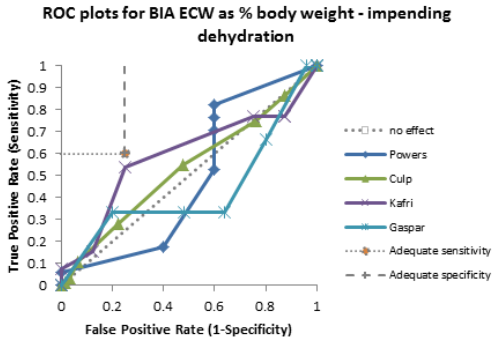


Secondary analyses: ROC plots for BIA TBW as % body weight, review cut-offs at 45, 47 & 49%, secondary cut-offs 37, 39, 41, 43, 51, 53, 55%.





Secondary analyses: ROC plots for BIA ICW as % body weight, review cut-offs at 25, 27 & 29%, added secondary cut-offs 17, 19, 21, 23, 31%.



Secondary analyses: ROC plots for BIA ECW as % body weight, review cut-offs at 18, 20 & 22%, added secondary cut-offs 24, 26, 28, 30%.

ROC plots appeared promising only for drinks intake, urine osmolality and axillial moisture (although neither quite reached the required sensitivity and specificity) and BIA resistance at 50 kHz, and BIA total body water assessment (although only one of the several studies curves reached the required sensitivity and specificity). However, it should be noted that as most studies are small the confidence intervals were very wide, so that ROC plots that appear to enter the rectangle of interest may not actually be as useful as they appear. Similarly, some plots that do not seem to enter the rectangle of interest may be more useful than they appear.

Adequate sensitivity and specificity for current dehydration (serum osmolality >300 mOsm/kg or equivalent) - secondary target condition

The diagnostic accuracy characteristics for current dehydration are shown in Table 4. The only test for which there was any suggestion of appropriate levels of sensitivity and specificity was BIA resistance at 50kHz at 450Ω, but this was only in one of the four studies that provided data (sensitivity was 1.00 [0.16, 1.00], specificity 0.77 [0.46, 0.95] in 15 people, Allison 2005, but sensitivity was 0.33 [0.04, 0.78], 0.73 [0.39, 0.94], 0.60 [0.26, 0.88] and specificity 0.40 [0.16, 0.68], 0.45 [0.17, 0.77], 0.19 [0.18, 0.21] in Kafri 2012, Powers 2012 and Stookey 2005 respectively). Because almost no tests reported useful sensitivity and specificity in single studies, meta-analysis was not felt to be appropriate.

Adequate sensitivity and specificity for impending

dehydration (serum osmolality 295 to 300 mOsm/kg or equivalent) - secondary target condition

As we had already carried out a large number of analyses assessing clinical symptoms, signs and tests of water-loss dehydration and also tests of current water-loss dehydration we decided not to run analyses of clinical symptoms, signs and tests of impending water-loss dehydration (the other secondary target condition). As few tests were useful for water-loss dehydration, or for current water-loss dehydration, the lack of power involved in excluding those with current dehydration, at the same time as searching for tests of the less severe impending dehydration, suggested that there was little point in running a further set of analyses.

Clinical symptoms, signs and tests that are not useful in screening for water-loss dehydration in older people

There was enough evidence to suggest that several stand-alone tests that are often used to assess dehydration in older people were not useful, in that of at least four studies assessing the test none suggested appropriate sensitivity and specificity in any study for either water-loss dehydration or current dehydration at any cut-off. Additionally none of the studies suggested any efficacy in the ROC plots (post-hoc analyses). The tests that were not appropriate to use and should not be relied on individually as ways of assessing presence or absence of dehydration in older people included assessments of fluid intake, urine specific gravity, urine colour, urine volume, heart rate, dry mouth, feeling thirsty and BIA assessment of intracellular water or extracellular water.

Comparison between promising tests for water-loss dehydration

We aimed to directly compare promising index tests (sensitivity $\geq$0.60 and specificity $\geq$0.75) where two or more were measured in a single study (direct comparison). There were only two promising measures for diagnosis of impending dehydration that could be compared: missing drinks between meals and expressing fatigue (each assessed in the same study, Kajii 2006). For missing drinks between meals the Kajii 2006 study of 71 frail elderly people living at home in Japan found sensitivity of 1.00 [0.59, 1.00] and specificity of 0.77 [0.64, 0.86], with a positive likelihood ratio of 4.27 and a negative likelihood ratio of zero. With a pre-test probability of 10% a positive test took the probability to 32%, and a negative test the post-test probability to 0%. For fatigue the point estimates of sensitivity (at 0.71 [0.29, 0.96]) and specificity (at 0.75 [0.63, 0.85]) were slightly less good, as were positive and negative likelihood ratios (at 2.86 and 0.38). The pre-test probability was of course also 10%, and the positive post-test probability was less useful at 24%, and the negative at 4%. It should be noted that Kajii 2006 was a small study and included only five older people with impending dehydration, and two with current dehydration. No other studies assessed the utility of missing drinks between meals, but fatigue (any degree of fatigue) was assessed in two studies, neither of which suggested high levels of diagnostic utility (Sjöstrand Healthy 2013 found sensitivity of 0.30 [0.07, 0.65] but specificity of 1.00 [0.29, 1.00], and Sjöstrand ED 2013 found sensitivity of 0.42 [0.23, 0.63] and specificity of 0.80 [0.28, 0.99]).
We also planned bivariate meta-regression to explore including a binary covariate for index test to understand if the expected sensitivity and specificity or both differed between index tests; however, there were insufficient studies with data on potentially useful tests to make this appropriate.

Combining several tests

We planned to carry out an exploratory analysis to assess the value of combining the best three index tests where the each had some predictive ability of their own, and individual studies included participants who had all three tests. There were no relevant three tests, but we did carry out an exploratory analysis to combine missing drinks between meals and expressing fatigue in the Kajii 2006 study data set (Table 5).
Combining two tests so that a person had to both miss some drinks between meals and express fatigue to be labelled as dehydrated, the test was both sensitive at 0.71 [0.29, 0.96] and specific 0.92 [0.83, 0.97], with positive likelihood ratios of 9.14 and negative likelihood ratio of 0.31. From a pre-test probability of 10% the probability of dehydration with a positive test jumped to 50%, and fell to 3% with a negative test. The diagnostic odds ratio was 29.5. Combining tests so that a positive test was represented by an individual expressing either fatigue or missing drinks between meals had high sensitivity of 1.00 [0.59, 1.00], but specificity fell to 0.59 [0.46, 0.71] (below our threshold).

Summary of findings

Tests which show some potential ability to diagnose water-loss dehydration (as stand-alone tests) in analyses of pre-defined cut-offs	Tests which show some potential ability to diagnose water-loss dehydration (as stand-alone tests) in post-hoc ROC analyses	Tests which are not useful, and should not be relied on individually as ways of assessing presence or absence of dehydration in older people (were not found to be useful in any study at either pre-specified cut-offs or in post-hoc ROC analyses
Expressing fatigue	Urine osmolality	Urine tests: urine volume, urine specific gravity, urine colour
BIA: bioelectrical impedance analysis (BIA) resistance at 50 kHz	Axillial moisture	BIA: bioelectrical impedance analysis (BIA) total body water, intracellular water and extracellular water
Missing some drinks between meals	Drinks intake	Other tests: heart rate, dry mouth, feeling thirsty

DISCUSSION

Summary of main results

We aimed to determine the diagnostic accuracy of state (one time), minimally invasive clinical symptoms, signs and tests (collectively referred to as tests) to be used in screening for water-loss dehydration (and current dehydration) in older people by systematically reviewing studies that have measured a reference standard and at least one index test in people aged 65 years and over. There are few published studies of the diagnostic accuracy of state, minimally invasive clinical symptoms, signs and tests to screen for water-loss dehydration, so to complete the review we sought, analysed and included raw data sets that measured a reference standard and at least one index test in people aged 65 years and over.

We found three studies with published diagnostic accuracy data and a further 21 data sets that we analysed and included (using individual participant data).

There were 67 tests assessed (often at three cut-offs) for diagnostic accuracy of water-loss dehydration. Only three tests showed any ability to diagnose water-loss dehydration (impending or current dehydration, serum osmolality ≥295 mOsm/kg) as stand-alone tests (with sensitivity ≥0.60 and specificity ≥0.75):

- **expressing fatigue** (sensitivity 0.71 [0.29, 0.96], specificity 0.75 [0.63, 0.85], in 71 participants, Kajii 2006, but we found two additional studies with lower sensitivity, Sjöstrand ED 2013; Sjöstrand Healthy 2013),
- **missing drinks between meals** (sensitivity 1.00 [0.59, 1.00], specificity 0.77 [0.64, 0.86], 71 participants, one study only Kajii 2006) and
- **BIA resistance at 50 kHz** (sensitivities 1.00 [0.48, 1.00] and 0.71 [0.44, 0.90] and specificities of1.00 [0.69, 1.00] and 0.80 [0.28, 0.99] in 15 and 22 people respectively for Allison 2005; Powers 2012, but with sensitivities of 0.54 [0.25, 0.81] and 0.69 [0.56, 0.79] and specificities of 0.50 [0.16, 0.84] and 0.19 [0.17, 0.21] in 21 and 1947 people respectively in Kafri 2012 and Stookey 2005).

Post-hoc ROC plot analyses suggested that drink intake, urine osmolality and axillial moisture may also have some diagnostic utility.

There was sufficient evidence to suggest that several stand-alone tests often used to assess water-loss dehydration in older people are not useful, and should not be relied upon, as for no individual study, and no meta-analyses at any cut-off were the point, and no post-hoc ROC plot were estimates of sensitivity ≥60% and specificity ≥75%. These tests that should not be used individually included fluid intake, urine specific gravity, urine colour, urine volume, heart rate, dry mouth, feeling thirsty and BIA assessment of intracellular water or extracellular water.

Missing drinks between meals and expressing fatigue were both assessed in a single study, and using a combination of these two tests improved the diagnostic utility of the assessment of impending dehydration, suggesting that combining tests may be a useful strategy to develop a diagnostic tool in future.

No tests were clearly useful in diagnosing current water-loss dehydration (serum osmolality >300mOsm/kg).

Strengths and weaknesses of the review

Strengths of the review included searching out and including data that could help to elucidate diagnostic accuracy of tests of dehydration in older people, but where diagnostic accuracy had not been previously analysed or published. Weaknesses of the review included some heterogeneity in the reference standards accepted, the (potential lack of) equivalence of different levels of cut-offs for the different reference standards, combining index tests that may have been carried out differently in different studies and with different equipment (in the case of bioelectrical impedance), having insufficient published data to confidently pre-set three appropriate cut-offs for continuous index tests, and lacking power to combine tests and develop a combined diagnostic test (which could be more powerful).

We accepted serum and plasma osmolality, serum osmolarity and weight change within seven days as reference standards. Serum and plasma osmolality are the ideal, and were used as the reference standard in 13 of the 24 included studies (Bossingham 2005; Fletcher 1999; Gaspar Acute & LTC 2011; Johnson 2003; Kafri 2012; Kajii 2006; Lindner 2009; Mack 1994; Sjöstrand ED 2013; Sjöstrand Healthy 2013; Stookey 2005; Stotts 2009; Walsh 2012). A further seven included studies used calculated serum osmolarity. Most of these were studies that had collected serum data (Chassagne 2006; Culp 2003; Powers 2012; Rowat 2011; Source Study 2001), so we applied a standard osmolarity equation (2Na + 2K + urea + glucose, where all measures were in mmol/L). However, two studies that were included as published (where we had no access to the data set) used different formulae. Shimizu 2012 used the formula 2Na + glucose /18 + BUN / 2.8 (units were not stated, but presumably glucose was measured in mg/dL). The formula used by Allison 2005 was not provided. Eaton 1994, whose data set was not obtainable, used a combination reference standard which declared dehydration when both serum osmolality was greater than 295 mOsm/kg and a urea/creatinine (mmol/L/μmol/L) ratio greater than 0.1. McGarvey 2010, Monahan 2006 and Perren 2011 measured body weight at baseline and again within seven days, and the reviewers used the change in weight over this period to assess dehydration, with weight change (up or down) of 3 to 5% of body weight indicating impending dehydration, and ≥ 5% current dehydration.

It was not clear that in older people there is a direct equivalence between serum or plasma osmolality at 295 mOsm/kg, serum osmolarity at 295 mOsm/L and a 3% weight loss (these were all the boundaries between being well hydrated and having impending

dehydration), and there is debate over the best formula to use for osmolarity.

A great number of formulae have been published, but not tested in community-dwelling older people to our knowledge (Fazekas 2013). Once a better understanding of the best formula to convert serum measures to predict measured osmolality is clear it may be appropriate to re-run the analyses within this review that use serum osmolarity, and until then any limitations in the formula may cause some bias in the predicted diagnostic accuracy of potential tests.

Where weight change was used as the reference standard we assessed weight change in the time gap provided, but it may be that within a given time span dehydration develops and then corrects itself, so the time span may not be ideal for picking up all cases of dehydration.

Another danger is that dehydration in older people may develop gradually over time, so that although the 3% weight change within any seven day period is never achieved, dehydration occurs gradually. Weight change works very well in children and the sports context, where fluid change and so weight change is rapid, but may be less helpful in older people (Armstrong 2007). Conversely, during the conduct of this systematic review, an author published data on weight change in well hydrated hospitalised older people (Vivanti 2013). Weight fluctuation of each of the 10 participants (mean age 80.2 years, SD 4.2 years) over three days ranged from 1.1 to 3.6%, with 20% having weight fluctuations of more than 3%. This variability appeared to be due to daily fluctuations, and weights measured at the same time each day were least variable. This suggests that unless weights were assessed at the same time each day in our studies that weight change may be misleading as an indicator of dehydration. Some of the differences in sensitivity and specificity of individual tests may be due to differing reference standards.

Serum and plasma osmolality cut-offs at 295 mOsm/kg (for impending dehydration) and > 300 mOsm/kg (for current dehydration) are widely used and recommended, but they are useful only if they are helpful in predicting health and well-being of older people. There is some research that serum tonicity > 300mOsm/L predicts mortality and disability in older people (Stookey 2004), but more information is needed to assess whether osmolality or tonicity and at which cut-offs are better predictors. Further work is needed to ensure that our reference standards for dehydration in older people are truly useful. We chose the boundary from hydration to impending dehydration (serum or plasma osmolality 295 mOsm/kg) for our primary analysis because we felt that tests of dehydration would ideally alert us to problems early, enabling remediation, and dehydration averted, before health consequences accrue.

A danger in having pre-set cut-offs for index tests, at which to assess diagnostic accuracy for this review, was that if we pre-chose poorly for the continuous measures (highly likely given very limited information available on appropriate cut-offs for most tests) that lack of diagnostic accuracy may simply reflect incorrect cut-offs. For this reason we decided to carry out post-hoc analyses to check the ROC plots in case diagnostic accuracy was actually high at another cut-off. These are post-hoc analyses, but can form the basis of further research on promising tests. These plots suggested that further research on measures of drinks intake, urinary osmolality, axillial moisture meters and BIA resistance at 50 kHz would be warranted.

Another potential weakness of the review is that we carried out a large number of analyses, increasing the probability of spurious raised sensitivity and specificity (although not many encouraging results were seen despite the large number of analyses). An advantage of assessing clinical symptoms, signs and tests of water-loss dehydration (inluding those with either impending or current dehydration, so using the cut-off for the reference tests of $\geq$295 mOsm/kg) is that it could be expected that any marker of impending dehydration would also work as a marker of current dehydration (cut-off >300 mOsm/kg). When we found that missing drinks between meals appeared to be a good a marker of water-loss dehydration in Kajii 2006 (sensitivity 100% and sepcificity 77%) as well as of current dehydration (sensitivity 100% and specificity 71%) this encouraged us to feel that this may be a useful marker of dehydration. Similarly, the sensitivity (71%) and specificity (75%) of fatigue for water-loss dehydration in Kajii 2006 were echoed for current dehydration (sensitivity 100%, specificity 72%). BIA resistance at 50 kHz with a cut-off of $\geq$ 450 Ω in Allison 2005 and Powers 2012 showed good sensitivity and specificity for both water-loss (Allison 2005 100%, 100% and Powers 2012 71%, 80%) and current dehydration (Allison 2005 100%, 85%, and Powers 2012 73%, 45%). However, it should be noted that sensitivity and specificity did not improve for current dehydration over water-loss dehydration as might be expected, so did not clearly confirm the utility of these index tests. Additionally these may be artefactual correlations from within the same studies, so may not reinforce the suggestion of useful diagnostic accuracy. For post-hoc ROC analyses drinks intake and BIA resistance at 50 kHz were positive at both water-loss dehydration and current dehydration cut-offs, but this was not the case for BIA total body water and we do not have any data for axillial moisture for current dehydration (so were unable to check).

None of the simple tests such as skin turgor or dry mouth were shown to be useful tests for water-loss dehydration (although not all were excluded). Those that had a better chance of being useful were nursing-type assessments (requiring an interviewer to ask about missing drinks between meals or feeling fatigue), that need response and recollection on the part of the older person, or were more technological (BIA resistance). If we are to use these tests with older people they will require careful attention to how any questions are asked or observations made, and whether the results can be generalised to other populations.

In clinical practice several tests may be intuitively or implicitly combined. This approach was not used in the review; we iso-

lated single tests, removed from the patient-frame or other signs or characteristics. We hoped to partially overcome this issue by combining potentially useful tests. This was possible for missing drinks between meals and expressing fatigue where a combination of these (so participants both missing some drinks between meals and expressing fatigue) produced a test with better sensitivity and specificity than either alone. This confirmed a promising avenue for exploring tests for dehydration in the future - to combine tests with some level of diagnostic accuracy (and possibly also taking into account particular participant characteristics).

Timing may be important. It has been suggested that urinary measures will reflect effects of plasma osmolality and fluid intake over the previous 60 to 90 minutes, but early morning collections may be a better reflection of hydration status than those during the day when status may change more quickly. However, the timing of most urine samples used in this review was unclear, and often samples appeared to have been pooled over several hours or days.

It was not clear how generalisable the findings were that missing some drinks between meals and expressing fatigue may be useful tests for indicating impending dehydration. Missing some drinks between meals was only assessed in one high quality study of Japanese frail elderly people (Kajii 2006). Expressing fatigue was tested in three studies, but only achieved useful levels of diagnostic accuracy in one (Kajii 2006). Two studies in elderly Swedish volunteers (Sjöstrand Healthy 2013) and attending an emergency department (Sjöstrand ED 2013) also found high specificity, but lower levels of sensitivity (Kajii 2006 71%, 75%; Sjöstrand ED 2013 42%, 80%; Sjöstrand Healthy 2013 30%, 100%). This is perhaps surprising because fatigue could be expected to be a very common symptom in the elderly, relating to a variety of chronic illnesses. Therefore, it would seem likely that specificity (proportion of correctly identified true negatives) would be low, if one starts at a general population of frail older subjects; however, this was not seen, and specificity remained consistently high. Sensitivity (proportion of true positives which are correctly identified by the test) was lower in the Swedish studies. This consistent ability to identify older people (in healthy or frail community dwelling participants, and those attending an emergency department in Japan and Sweden) who did not have impending or current dehydration could be a very useful part of a composite set of tests to identify dehydration risk in older people.

While effort was made to ensure that all relevant studies were included, we are aware of several data sets that exist (or existed) but could not be included because original data could not be supplied. In many cases original data sets could not be found or shared for a variety of reasons including loss over time, computer problems that lost data or made data unreadable or institutional rules that precluded sharing of data (Albert 1989; Bowser-Wallace 1985; Davies 1995; Faull 1993; Fredrix 1990; Gross 1992; Meuleman 1992; O'Neill 1992; O'Neill 1997; Olde Rikkert 1997; Olde Rikkert 1997a; Olde Rikkert 1998; Schut 2005; Telfer 1965; Thomas 2003; Tonstad 2006; Wakefield 2002a; Wakefield 2002b; Wakefield 2008). Furthermore, we were unable to establish contact with some authors to obtain data sets that almost certainly included relevant data (Bourdel-Marchasson 2004; Bruzzone 2004; Chen 2006; Gil Cama 2003; Leiper 2005; Martof 1997; Morgan 2002; Morgan 2003; Piccoli 2000; Roberts 1991; Roos 1995; Rosher 2004; Shiraki 1980; Sugaya 2008; van Kraaij 1999).

Although several of these papers refer to the same individual data sets, it was likely that further studies were not located. Because most publications (including those actually included in the review) were not focused on diagnostic accuracy it is possible that this level of missing data did not reflect any particular publication or data bias in the included data, but this is not certain. It was not possible to formally assess publication bias (or small study bias) in this review. We would be delighted to incorporate data from these studies, and any others we have missed in future updates of this review.

There may well be other clinical symptoms, signs and tests that can help identify water-loss dehydration in older people. Ongoing research is assessing a variety of measures including saliva flow and osmolality (Fortes & Walsh study 2013) and an e-nose (electronic sensing) tool for the diagnosis of dehydration (Olde Rikkert 2013), and duplication of promising tests is also underway (Hooper & Bunn 2013).

Other types of assessments, such as ultrasound to assess inferior vena cava or right ventricular diameter, have been suggested to have some diagnostic ability in hypovolaemia of people of mixed ages in emergency departments (de Lorenzo 2012; Zengin 2013). However, water-loss dehydration is primarliy intracellular dehydration, rather than hypovolaemia, so is unlikely to be assessable in the same way. Data sets are being created in which composite tools or classification trees for assessment of impending dehydration may be developed (Hooper & Bunn 2013). We hope to incorporate these results into future updates of this review.

Applicability of findings to the review question

Our primary objective was to determine the diagnostic accuracy of state (one time), minimally invasive clinical symptoms, signs and tests to screen for water-loss dehydration in older people by systematically reviewing studies that have measured a reference standard and at least one index test in people aged 65 years and over. We have assessed the diagnostic accuracy of a very long list of potential clinical symptoms, signs and tests in older people, and found limited evidence for the utility of missing some drinks between meals, expressing fatigue and a combination of these two tests, with weaker evidence for BIA resistance at 50 kHz. Further potentially useful tests (identified in post-hoc analyses) include drinks intake, urine osmolality and axillial moisture.

Secondary objectives included:

1. To assess the effect of different cut-offs of index test results assessed using continuous data on sensitivity and specificity in diagnosis of impending or current water-loss dehydration. We

achieved this by pre-specifying cut-offs for our index tests and applying post-hoc analyses checking ROC plots where we may have missed useful cut-offs. These plots suggested that further research on measures of drinks intake, urine osmolality, axillial moisture meters and BIA resistance at 50 kHz would be warranted

2. To identify clinical symptoms, signs and tests that may be used in screening for impending or current water-loss dehydration in older people. There was insufficient evidence to clarify any single or combined tests that can be confidently used to identify impending or current dehydration in older people, but several promising tests have been highlighted. Potentially useful tests include missing some drinks between meals, expressing fatigue and a combination of these two tests, with weaker evidence for BIA resistance at 50 kHz, drinks intake, urine osmolality and axillial moisture.

3. To identify clinical symptoms, signs and tests that are not useful in screening for impending or current water-loss dehydration in older people. Several tests that are commonly used by health professionals to assess dehydration in older people have been shown to be unhelpful, and their use misleading. These include urinary measures such as specific gravity and colour, orthostatic hypotension, skin turgor, capillary refill, dry mouth assessments, sunken eyes, thirst and headache. These should not be used as single measures to assess dehydration, however some of them may contribute to diagnostic accuracy in future combined tools.

4. To assess clinical symptoms, signs and tests of current dehydration (including all those with serum osmolality >300mOsm/kg). These analyses were limited as few participants had current dehydration (and some included studies had no participants with current dehydration) although it should theoretically be easier to identify as it has a stronger effect on the body. The only test found to be potentially useful was BIA resistance at 50kHz at 450Ω, though this was only seen to be useful in one of the four studies that assessed it.

5. To assess clinical symptoms, signs and tests of impending dehydration (including all those with serum osmolality 295 to 300mOsm/kg). These analyses were not carried out due to high numbers of analyses already completed and limited data.

6. To directly compare promising index tests (sensitivity ≥ 0.60 and specificity ≥ 0.75) where two or more are measured in a single study (direct comparison). We only had data to compare two tests which were both used in a single study (Kajii 2006): missing some drinks between meals and expressing fatigue. In this direct comparison missing drinks between meals (sensitivity 100%, specificity 77%) appeared slightly better than expressing fatigue (sensitivity 71%, specificity 75%), but given the small size of the study, this needs to be clarified.

7. To carry out an exploratory analysis to assess the value of combining the best three index tests where the three tests each have some predictive ability of their own, and individual studies include participants who had all three tests. We found that combining the two tests above (participants both missing some drinks between meals and expressing fatigue) produced a stronger test than either alone (sensitivity 71%, specificity 92%), but this needs to be confirmed.

AUTHORS' CONCLUSIONS

Implications for practice

At present there is no clear evidence for the use of any single clinical symptom, sign or test of water-loss dehydration in older people. Where healthcare professionals currently rely on single tests in their assessment of dehydration in this population this practice should cease because it is likely to miss cases of dehydration (as well as mis-classify those without water-loss dehydration).

Implications for research

Further research is needed to assess the utility of the promising single tests highlighted by this review (including missing drinks between meals, expressing fatigue, BIA resistance at 50 kHz, axillial moisture, urinary osmolality and assessment of drinks intake). Additionally, it will be useful to explore novel tests of dehydration in older people (including salivary and e-nose measures). It is feasible that combinations or classification trees of tests will create useful composite tools for identification of impending or current dehydration.

We suggest that being able to use simple tests to pick up impending dehydration is important as a public health measure as it will enable us to work with older people to prevent the health impacts of dehydration and prevent more serious dehydration. Screening for current dehydration is also important, and will help us to treat older people, but the most clinically relevant target condition for screening tools needed in future research is impending dehydration.

We need to improve our understanding of the comparability of serum osmolarity and osmolarity (using different formulae), as well as changes in weight, to improve our understanding of the comparability of different reference standards in older adults. Even more fundamentally we need to better understand how serum osmolality, osmolarity and weight change, as indicators of dehydration, are linked to future health and well being of older people.

Once a useful test or composite tool for detection of impending or current water-loss dehydration has been identified and verified (by duplication in similar and less similar populations of older people), its place in the clinical and non-clinical setting needs to be considered. In community settings such a test or tool may be used as an indicator to initiate support to improve drinking and/or assess medications to improve hydration. In the clinical setting, this

may be used as a triage test for assessment of dehydration by measuring serum or plasma osmolality, which might be followed by intravenous fluids where hydration is compromised. Randomised trials of screening for dehydration using the verified test or tool will be needed to ensure that screening (along with protocols to help older people to improve their hydration when problems are identified) delivers benefits for health and well-being (di Ruffano 2012).

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REFERENCES

References to studies included in this review

Allison 2005 *{published data only (unpublished sought but not used)}*
Allison RD, Ray Lewis A, Liedtke R, Buchmeyer ND, Frank H. Early identification of hypovolemia using total body resistance measurements in long-term care facility residents. *Gender Medicine* 2005;**2**(1):19–34. [MEDLINE: 16115595]

Bossingham 2005 *{published and unpublished data}*
Bossingham MJ, Carnell NS, Campbell WW. Water balance, hydration status, and fat-free mass hydration in younger and older adults. *American Journal of Clinical Nutrition* 2005;**81**(6):1342–50. [MEDLINE: 15941885]

Chassagne 2006 *{published and unpublished data}*
Chassagne P, Druesne L, Capet C, Menard JF, Bercoff E. Clinical presentation of hypernatremia in elderly patients: a case control study. *Journal of the American Geriatrics Society* 2006;**54**(8):1225–30. [MEDLINE: 16913989]

Culp 2003 *{published and unpublished data}*
* Culp K, Mentes J, Wakefield B. Hydration and acute confusion in long-term care residents. *Western Journal of Nursing Research* 2003;**25**(3):251–66. [MEDLINE: 12705111]
Culp KR, Wakefield B, Dyck MJ, Cacchione PZ, DeCrane S, Decker S. Bioelectrical impedance analysis and other hydration parameters as risk factors for delirium in rural nursing home residents. *Journals of Gerontology Series A: Biological Sciences & Medical Sciences* 2004;**59A**(8):813–7. [MEDLINE: 15345731]

Eaton 1994 *{published data only (unpublished sought but not used)}*
Eaton D, Bannister P, Mulley GP, Connolly MJ. Axillary sweating in clinical assessment of dehydration in ill elderly patients. *BMJ* 1994;**308**(6939):1271. [MEDLINE: 8205020]

Fletcher 1999 *{published and unpublished data}*
Fletcher SJ, Slaymaker AE, Bodenham AR, Vucevic M. Urine colour as an index of hydration in critically ill patients. *Anaesthesia* 1999;**54**(2):189–92. [MEDLINE: 10215718]

Gaspar Acute & LTC 2011 *{published and unpublished data}*
Ellenbecker SM, Stimpert PM, Gaspar PM, Forsyth D. Hydration status of the elderly: validity of non-invasive measures for assessment. 25th Anniversary Minnesota Geriatric Care Conference; 27 March, 2008; Mayo Civic Center, Rochester MN, USA. 2008.
Gaspar P, Forsyth D. Hydration status of the elderly: validity of non-invasive assessment measures. 31st Annual Midwest Nursing Research Society Conference; March-April 2007; Omaha, NE, USA. 2007. [: http://hdl.handle.net/10755/158527]
* Gaspar PM. Comparison of four standards for determining adequate water intake of nursing home residents. *Research and Theory for Nursing Practice* 2011;**25**(1):11–22. [MEDLINE: 21469538]

Johnson 2003 *{published and unpublished data}*
Johnson TM, Miller M, Pillion DJ, Ouslander JG. Arginine vasopressin and nocturnal polyuria in older adults with frequent nighttime voiding. *Journal of Urology* 2003;**170**(2 Pt 1):480–4. [MEDLINE: 12853804]

Kafri 2012 *{published and unpublished data}*
Kafri MW, Myint PK, Doherty D, Wilson AH, Potter JF, Hooper L. Hydration status following stroke and the relationship between hydration and functional status at discharge. Scientific report to the European Hydration Institute January 2012. [: http://www.europeanhydrationinstitute.org/wp–content/uploads/2012/08/Abstract˙M˙Kafri.pdf]
* Kafri MW, Myint PK, Doherty D, Wilson AH, Potter JF, Hooper L. The diagnostic accuracy of multi-frequency bioelectrical impedance analysis in diagnosing dehydration after stroke. *Medical Science Monitor* 2013;**19**:548–70. [DOI: 10.12659/MSM.883972; MEDLINE: 23839255]

Kajii 2006 *{published and unpublished data}*
Kajii F, Gomi I, Sugiyama M. Dehydration and water intake in frail elderly at home [Japanese]. *Bulletin of St.Luke's College of Nursing* 2006;**32**:43–50. [CINAHL: 2009164516; PUBMED: 9213446]

Lindner 2009 *{published and unpublished data}*
Lindner G, Kneidinger N, Holzinger U, Druml W, Schwarz C. Tonicity balance in patients with hypernatremia acquired in the intensive care unit. *American Journal of Kidney Diseases* 2009;**54**(4):674–9. [MEDLINE: 19515476]

Mack 1994 *{published and unpublished data}*
Mack GW, Weseman CA, Langhans GW, Scherzer H, Gillen CM, Nadel ER. Body fluid balance in dehydrated healthy older men: Thirst and renal osmoregulation. *Journal of Applied Physiology* 1994;**76**(4):1615–23. [MEDLINE: 8045840]

McGarvey 2010 *{published and unpublished data}*
McGarvey J, Thompson J, Hanna C, Noakes TD, Stewart J, Speedy D. Sensitivity and specificity of clinical signs for assessment of dehydration in endurance athletes. *British Journal of Sports Medicine* 2010;**44**(10):716–9. [DOI: 10.1136/bjsm.2008.053249; MEDLINE: 18981042]

Monahan 2006 *{published and unpublished data}*
Monahan K, Zhou C, Rose J, Adler D. Determinants of changes in B-type natriuretic peptide levels in hospitalized patients. *Journal of Clinical and Basic Cardiology* 2006;**9**(1-4):31–6. [EMBASE: 2008493123]

Perren 2011 *{published and unpublished data}*
Perren A, Markmann M, Merlani G, Marone C, Merlani P. Fluid balance in critically ill patients - should we really rely on it?. *Minerva Anestesiologica* 2011;**77**(8):802–11. [MEDLINE: 21730928]

Powers 2012 *{published and unpublished data}*
Powers JS, Buchowski M, Wang L, Otoo-Boameh A. Total body water in elderly adults - assessing hydration status by bioelectrical impedance analysis vs. urine osmolality. *Journal of the American Geriatrics Society* 2012;**60**(2):388–90. [MEDLINE: 22332693]

Rowat 2011 *{published and unpublished data}*
Rowat A, Smith L, Graham C, Lyle D, Horsburgh D, Dennis M. A pilot study to assess if urine specific gravity and urine colour charts are useful indicators of dehydration in acute stroke patients. *Journal of Advanced Nursing* 2011;**67**(9):1976–83. [MEDLINE: 21507048]

Shimizu 2012 *{published data only (unpublished sought but not used)}*
Kinoshita K, Hattori K, Ota Y, Kanai T, Shimizu M, Kobayashi H, Tokuda Y. The measurement of axillary moisture for the assessment of dehydration among older patients: a pilot study. *Experimental Gerontology* 2013;**48**(2):255–8. [MEDLINE: 23063989]
* Shimizu M, Kinoshita K, Hattori K, Ota Y, Kanai T, Kobayashi H, Tokuda Y. Physical signs of dehydration in the elderly. *Internal Medicine* 2012;**51**(10):1207–12. [MEDLINE: 22687791]

Sjöstrand ED 2013 *{published and unpublished data}*
Sjöstrand F, Rodhe P, Berglund E, Lundström N, Svensen C. The use of a noninvasive hemoglobin monitor for volume kinetic analysis in an emergency room setting. *Anesthesia and Analgesia* 2013;**116**(2):337–42. [DOI: 10.1213/ANE.0b013e318277dee3; MEDLINE: 23302975]

Sjöstrand Healthy 2013 *{unpublished data only}*
Rodhe PM. *Mathematical Modelling of Clinical Applications in Fluid Therapy [PhD thesis]*. Karolinska Institutet, 2010. [ISBN: 917457017X, 9789174570175; : http://publications.ki.se/xmlui/handle/10616/39713?locale–attribute=en</body></html>]

Source Study 2001 *{published and unpublished data}*
Ritz P and Investigators. Body water spaces and cellular hydration during healthy aging. *Annals of the New York Academy of Sciences* 2000;**904**(1):474–83. [EMBASE: 2000210649; MEDLINE: 10865791]
* Ritz P, Source Study. Bioelectrical impedance analysis estimation of water compartments in elderly diseased patients: the source study. *Journals of Gerontology Series A-Biological Sciences & Medical Sciences* 2001;**56**(6):M344–8. [MEDLINE: 11382792]
Ritz P, Source Study. Chronic cellular dehydration in the aged patient. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences* 2001;**56**(6):M349–52. [MEDLINE: 11382793]

Stookey 2005 *{published and unpublished data}*
Stookey JD. High prevalence of plasma hypertonicity among community-dwelling older adults: results from NHANES III. *Journal of the American Dietetic Association* 2005;**105**(8):1231–9. [MEDLINE: 16182639]

Stotts 2009 *{published and unpublished data}*
Stotts NA, Hopf HW, Kayser-Jones J, Chertow GM, Cooper BA, Wu H-S. Increased fluid intake does not augment capacity to lay down new collagen in nursing home residents at risk for pressure ulcers: a randomized controlled trial. *Wound Repair and Regeneration* 2009;**17**(6):780–8. [CINAHL: 2010458071]

Walsh 2012 *{published and unpublished data}*
Fortes MB, Diment BC, Di Felice U, Gunn AE, Kendall JL, Esmaeelpour M, et al.Tear fluid osmolarity as a potential marker of hydration status. *Medicine and Science in Sports and Exercise* 2011;**43**(8):1590-7. [DOI: 10.1249/MSS.0b013e31820e7cb6; MEDLINE: 21233774]
Walsh NP, Fortes MB, Purslow C, Esmeelpour M. Author response: Is whole-body hydration an important consideration in dry eye?. *Investigative Ophthalmology and Visual Science* 2013;**54**(3):1713-4. [DOI: 10.1167/iovs.13-11869; MEDLINE: 23471906]
* Walsh NP, Fortes MB, Raymond-Barker P, Bishop C, Owen J, Tye E, et al.Is whole-body hydration an important consideration in dry eye?. *Investigative Ophthalmology and Visual Science* 2012;**53**(10):6622–7. [DOI: 10.1167/iovs.12-10175; MEDLINE: 22952120]

References to studies excluded from this review

Albert 1989 *{published data only}*
Albert SG, Nakra BR, Grossberg GT, Caminal ER. Vasopressin response to dehydration in Alzheimer's disease. *Journal of the American Geriatrics Society* 1989;**37**(9):843–7.

Bennett 2004 *{published data only}*
Bennett JA, Thomas V, Riegel B. Unrecognized chronic dehydration in older adults: examining prevalence rate and risk factors. *Journal of Gerontological Nursing* 2004;**30**(11):22.

Bourdel-Marchasson 2004 *{published data only}*
Bourdel-Marchasson I, Proux S, Dehail P, Muller F, Richard-Harston S, Traissac T, et al.One-year incidence of

hyperosmolar states and prognosis in a geriatric acute care unit. *Gerontology* 2004;**50**(3):171–6.

Bowser-Wallace 1985 ***{published data only}***
Bowser-Wallace BH, Cone JB, Caldwell FT Jr. Hypertonic lactated saline resuscitation of severely burned patients over 60 years of age. *Journal of Trauma-Injury Infection & Critical Care* 1985;**25**(1):22–6.

Bruzzone 2004 ***{published data only}***
Bruzzone P, Chiumello D, Altavilla P, Saia G, Scopacasa F, Gattinoni L. The fluid balance in the critically ill patient. *Minerva Anestesiologica* 2004;**70**(5):431–6.

Buffa 2010 ***{published data only}***
Buffa R, Mereu RM, Putzu PF, Floris G, Marini E. Bioelectrical impedance vector analysis detects low body cell mass and dehydration in patients with Alzheimer's disease. *Journal of Nutrition, Health & Aging* 2010;**14**(10):823–7.

Chen 2006 ***{published data only}***
Chen LK, Lin MH, Hwang SJ, Chen TW. Hyponatremia among the institutionalized elderly in 2 long-term care facilities in Taipei. *Journal of the Chinese Medical Association: JCMA* 2006;**69**(3):115–9.

Chen 2010 ***{published data only}***
Chen CC, Dai Y, Yen C, Huang G, Wang C. Shared risk factors for distinct geriatric syndromes in older Taiwanese inpatients. *Nursing Research* 2010;**59**(5):340–7.

Cooper 1991 ***{published data only (unpublished sought but not used)}***
Cooper JW. Renal function assessment in nursing home patients: a prospective 6-month study in 282 patients. *Journal of Geriatric Drug Therapy* 1991;**5**(3):59–71.

Cunneen 2011 ***{published data only (unpublished sought but not used)}***
Cunneen S, Jones J, Davidson I, Bannerman E. An investigation of food provision and consumption in a care home setting. *British Journal of Community Nursing* 2011; **16**(5-suppl):22–28.

Davies 1995 ***{published data only (unpublished sought but not used)}***
Davies I, O'Neill PA, McLean KA, Catania J, Bennett D. Age-associated alterations in thirst and arginine vasopressin in response to a water or sodium load. *Age and Ageing* 1995; **24**:151–9.

Dijkstra 1998 ***{published data only}***
Dijkstra A, Sipsma DH, Dassen TWN. Care dependency and survival among female patients with Alzheimer's disease: A two-year follow-up. *Croatian Medical Journal* 1998;**39** (3):365–70.

Faull 1993 ***{published data only}***
Faull CM. *Anatomical and physiological relationships between central serotonin and vasopressin: thesis submitted for the degree of Doctor of Medicine*. Newcastle: Newcastle University, 1992.
Faull CM, Holmes C, Baylis PH. Water balance in elderly people: is there a deficiency of vasopressin?. *Age & Ageing* 1993;**22**(2):114–20.

Forsyth 2008 ***{published data only}***
Forsyth DM, Lapid MI, Ellenbecker SM, Smith LK, O'Neil ML, Low DJ, et al.Hydration status of geriatric patients in a psychiatric hospital. *Issues in Mental Health Nursing* 2008; **29**(8):853–62.

Fredrix 1990 ***{published data only}***
Fredrix EW, Saris WH, Soeters PB, Wouters EF, Kester AD, von Meyenfeldt MF, et al.Estimation of body composition by bioelectrical impedance in cancer patients. *European Journal of Clinical Nutrition* 1990;**44**(10):749–52.

Fuller 1996 ***{published data only}***
Fuller NJ, Sawyer MB, Laskey MA, Paxton P, Elia M. Prediction of body composition in elderly men over 75 years of age. *Annals of Human Biology* 1996;**23**(2):127–47.

Gaspar Nuns 2009 ***{unpublished data only}***
Gaspar P. Hydration status of independent dwelling and assisted living women: a comparison of assessment measures and associated factors. presentation to the Midwest Nursing Research Society. 2009:http://www.nursinglibrary.org/vhl/handle/10755/158955.

Gaspar Nursing Home 2011 ***{published and unpublished data}***
Gaspar PM. Comparison of four standards for determining adequate water intake of nursing home residents. *Research and Theory for Nursing Practice* 2011;**25**(1):11–22.

Gil Cama 2003 ***{published data only}***
Gil Cama A, Mendoza Delgado D. Accumulated fluid balance in patients admitted to the ICU: is it really reliable? . *Enfermeria intensiva/Sociedad Espanola de Enfermeria Intensiva y Unidades Coronarias* 2003;**14**(4):148–55.

Gross 1992 ***{published data only}***
Gross CR, Lindquist RD, Woolley AC, Granieri R, Allard K, Webster B. Clinical indicators of dehydration severity in elderly patients. *Journal of Emergency Medicine* 1992;**10**(3): 267–74.

Hodkinson 1981 ***{published data only (unpublished sought but not used)}***
Hodkinson HM, Piper M. Clinical and laboratory profile information in the prediction of death in elderly patients. *Age and Ageing* 1981;**10**:10–13.

Holben 1999 ***{published data only}***
Holben DH, Hassell JT, Williams JL, Helle B. Research and professional briefs. Fluid intake compared with established standards and symptoms of dehydration among elderly residents of a long-term-care facility. *Journal of the American Dietetic Association* 1999;**99**(11):1447–50.
Huszagh VA, Holben DH, Hassell JT. Fluid needs of older adults... "Fluid intake compared with established standards and symptoms of dehydration among elderly residents of long-term-care facility" (J Am Diet Assoc. 1999;99:1447-1450). *Journal of the American Dietetic Association* 2000; **100**(7):768.

Hoyle 2011 ***{published data only}***
Hoyle GE, Chua M, Soiza RL. Volaemic assessment of the elderly hyponatraemic patient: Reliability of clinical assessment and validation of bioelectrical impedance analysis. *Qjm* 2011;**104**(1):35–9.

Johnson 1994 ***{published data only (unpublished sought but not used)}***
Johnson AG, Crawford GA, Kelly D, Nguyen TV, Gyory AZ. Arginine vasopressin and osmolality in the elderly. *Journal of the American Geriatrics Society* 1994;**42**:399–404.

Kayser-Jones 1999 ***{published data only}***
Kayser-Jones J, Schell ES, Porter C, Barbaccia JC, Shaw H. Factors contributing to dehydration in nursing homes: inadequate staffing and lack of professional supervision. *Journal of the American Geriatrics Society* 1999;**47**(10): 1187–94.

Kehayias 2012 ***{published data only (unpublished sought but not used)}***
Kehayias JJ, Ribeiro SM, Skahan A, Itzkowitz L, Dallal G, Rogers G, Khodeir M. Water homeostasis, frailty and cognitive function in the nursing home. *J Nutr Health Aging* 2012;**16**(1):35–39.

Kuo 2002 ***{published data only}***
Kuo HC. Efficacy of desmopressin in treatment of refractory nocturia in patients older than 65 years. *Urology* 2002;**59** (4):485–9.

Leibovitz 2007 ***{published data only}***
Leibovitz A, Baumoehl Y, Lubart E, Yaina A, Platinovitz N, Segal R. Dehydration among long-term care elderly patients with oropharyngeal dysphagia. *Gerontology* 2007;**53**(4): 179–83.

Leiper 2005 ***{published data only}***
Leiper JB, Seonaid Primrose C, Primrose WR, Phillimore J, Maughan RJ, Leiper JB, et al.A comparison of water turnover in older people in community and institutional settings. *Journal of Nutrition, Health & Aging* 2005;**9**(3): 189–93.

Lennox 1980 ***{published data only}***
Lennox IM, Williams BO. Postural hypotension in the elderly. *Journal of Clinical and Experimental Gerontology* 1980;**2**(4):313–28.

Martof 1997 ***{published data only}***
Martof MT, Knox DK. The effect of xanthines on fluid balance. *Clinical nursing research* 1997;**6**(2):186–96.

Mentes 2003 ***{published data only (unpublished sought but not used)}***
Mentes JC, Culp K. Reducing hydration-linked events in nursing home residents. *Clinical Nursing Research* 2003;**12** (3):210–225.

Mentes 2008 ***{published and unpublished data}***
Mentes J. Feasibility of using salivary osmolality as a marker for hydration status in nursing home residents. Paper presented at the 61st Annual Scientific Meeting of the Gerontological Society of America, National Harbor, MD, USA. 2008 November:Program No. 430-2.

Meuleman 1992 ***{published data only}***
Meuleman JR, Hoffman NB, Conlin MM, Lowenthal DT, Delafuente JC, Graves JE. Health status of the aged: Medical profile of a group of functional elderly. *Southern Medical Journal* 1992;**85**(5):464–8.

Morgan 2002 ***{published data only}***
Morgan AL, Sinning WE, Weldy DL. Age effects on body fluid distribution during exercise in the heat. *Aviation Space and Environmental Medicine* 2002;**73**(8):750–7.

Morgan 2003 ***{published data only}***
Morgan AL, Masterson MM, Fahlman MM, Topp RV, Boardley D. Hydration status of community-dwelling seniors. *Aging-Clinical & Experimental Research* 2003;**15**(4): 301–4.

Norman 2007 ***{published data only}***
Norman K, Smoliner C, Valentini L, Lochs H, Pirlich M. Is bioelectrical impedance vector analysis of value in the elderly with malnutrition and impaired functionality?. *Nutrition* 2007;**23**(7-8):564–9.

O'Neill 1992 ***{published data only}***
O'Neill PA, Davies I, Fullerton KJ, Bennett D, O'Neill PA, Davies I, et al.Fluid balance in elderly patients following acute stroke. *Age & Ageing* 1992;**21**(4):280–5.

O'Neill 1997 ***{published data only}***
O'Neill PA, Duggan J, Davies I. Response to dehydration in elderly patients in long-term care. *Aging-Clinical & Experimental Research* 1997;**9**(5):372–7.

Olde Rikkert 1997 ***{published data only}***
Olde Rikkert MGM, Deurenberg P, Jansen RWMM, VaN'T Hof MA, Hoefnagels WHL. Validation of multi-frequency bioelectrical impedance analysis in detecting changes in fluid balance of geriatric patients. *Journal of the American Geriatrics Society* 1997;**45**(11):1345–51.

Olde Rikkert 1997a ***{published data only}***
Olde Rikkert MGM, Van Den Bercken JHL, Ten Have HAMJ, Hoefnagels WHL. Experienced consent in geriatrics research: A new method to optimize the capacity to consent in frail elderly subjects. *Journal of Medical Ethics* 1997;**23** (5):271–6.

Olde Rikkert 1998 ***{published data only}***
Olde Rikkert MGM, VaN'T Hof MA, Baadenhuysen H, Hoefnagels WHL. Individuality and responsiveness of biochemical indices of dehydration in hospitalized elderly patients. *Age and Ageing* 1998;**27**(3):311–9.

Palevsky 1996 ***{published data only (unpublished sought but not used)}***
Palevsky PM, Bhagrath R, Greenberg A. Hypernatremia in hospitalized patients. *Annals of Internal Medicine* 1996;**124** (2):197–203.

Perrier 2013 ***{published data only}***
Perrier E, Vergne S, Klein A, Poupin M, Rondeau P, Le Bellego L, Armstrong LE, Lang F, Stookey J, Tack I. Hydration biomarkers in free-living adults with different levels of habitual fluid consumption. *Br J Nutr.* 2013 (Epub 2012 Aug 31);**109**(9):1678–87. [DOI: 10.1017/S0007114512003601]

Phillips 1984 ***{published data only}***
Crowe MJ, Forsling ML, Rolls BJ, Phillips PA, Ledingham JG, Smith RF. Altered water excretion in healthy elderly men. *Age & Ageing* 1987;**16**(5):285–93.
Phillips PA, Rolls BJ, Ledingham JG, Forsling ML, Morton JJ, Crowe MJ, et al.Reduced thirst after water deprivation

in healthy elderly men. *New England Journal of Medicine* 1984;**311**(12):753–9.

Piccoli 2000 ***{published data only}***
Piccoli A, Pittoni G, Facco E, Favaro E, Pillon L. Relationship between central venous pressure and bioimpedance vector analysis in critically ill patients. *Critical Care Medicine* 2000;**28**(1):132–7.

Powers 2009 ***{published data only}***
Powers JS, Choi L, Bitting R, Gupta N, Buchowski M. Rapid measurement of total body water to facilitate clinical decision making in hospitalized elderly patients. *Journals of Gerontology Series A-Biological Sciences & Medical Sciences* 2009;**64**(6):664–9.

Rhodes 1995 ***{published data only}***
Rhodes KM. Letters to the editor. Can the measurement of intraocular pressure be useful in assessing dehydration and rehydration?. *Journal of the American Geriatrics Society* 1995;**43**(5):589–90.

Roberts 1991 ***{published data only}***
Roberts SB, Ferland G, Young VR, Morrow F, Heyman MB, Melanson KJ, et al.Objective verification of dietary intake by measurement of urine osmolality. *American Journal of Clinical Nutrition* 1991;**54**(5):774–82.

Robinson 1985 ***{published data only}***
Robinson SB, Demuth PL. Diagnostic studies for the aged: what are the dangers?... change in mental status and fluid status of those elderly undergoing a barium enema. *Journal of Gerontological Nursing* 1985;**11**(6):6.

Roos 1995 ***{published data only}***
Roos AN, Westendorp RGJ, Brand R, Souverijn JHM, Frolich M, Meinders AE. Predictive value of tetrapolar body impedance measurements for hydration status in critically ill patients. *Intensive Care Medicine* 1995;**21**(2):125–31.

Rosher 2004 ***{published data only}***
Rosher RB, Robinson SB, Rosher Richard B, Robinson Sherry B. Use of foot veins to monitor hydration in the elderly. *Journal of the American Geriatrics Society* 2004;**52**(2):322–4.

Rosler 2010 ***{published data only}***
Rosler A, Lehmann F, Krause T, Wirth R, Renteln-Kruse W. Nutritional and hydration status in elderly subjects: Clinical rating versus bioimpedance analysis. *Archives of Gerontology and Geriatrics* 2010;**50**(3):e81–5.

Rudolph 2011 ***{published data only (unpublished sought but not used)}***
Rudolph JL, Harrington MB, Lucatorto MA, Chester JG, Francis J, Shay KJ, Veterans Affairs and Delirium Working Group. Validation of a medical record-based delirium risk assessment. *Journal of the American Geriatrics Society* 2011;**59**:S289–S294.

Savalle 2012 ***{published data only (unpublished sought but not used)}***
Savalle M, Gillaizeau F, Maruani G, Puymirat E, Bellenfant F, Houillier P, Fagon JY, Faisy C. Assessment of body cell mass at bedside in critically ill patients. *Am J Physiol Endocrinol Metab* 2012;**303**(3):E389–96. [DOI: 10.1152/ajpendo.00502.2011]

Schols 1991 ***{published data only}***
Schols AMWJ, Wouters EFM, Soeters PB, Westerterp KR. Body composition by bioelectrical-impedance analysis compared with deuterium dilution and skinfold anthropometry in patients with chronic obstructive pulmonary disease. *American Journal of Clinical Nutrition* 1991;**53**(2):421–4.

Schut 2005 ***{published data only}***
Schut A, Dascendo V, Giraud K, Chatap G, Royand F, Blonde-Cynober F, et al.Is biolectrical impedance analysis a tool at bedside, during heat waves to assist geriatricians with discriminative diagnosis of hypertonic dehydration?. *Journal of Nutrition, Health & Aging* 2005;**9**(6):441–5.

Seinela 2003 ***{published data only}***
Seinela L, Pehkonen E, Laasanen T, Ahvenainen J, Seinela L, Pehkonen E, et al.Bowel preparation for colonoscopy in very old patients: a randomized prospective trial comparing oral sodium phosphate and polyethylene glycol electrolyte lavage solution. *Scandinavian Journal of Gastroenterology* 2003;**38**(2):216–20.

Shim 1987 ***{published data only}***
Shim C, King M, Williams MH Jr. Lack of effect of hydration on sputum production in chronic bronchitis. *Chest* 1987;**92**(4):679–82.

Ship 1997 ***{published data only}***
Ship JA, Fischer DJ. The relationship between dehydration and parotid salivary gland function in young and older healthy adults. *Journals of Gerontology Series A-Biological Sciences & Medical Sciences* 1997;**52**(5):M310–9.

Shiraki 1980 ***{published data only}***
Shiraki M, Takahashi R, Itoh H. The clinical study of hyponatremia in the elderly. Part two. Renal function in the aged hyponatremia. *Japanese Journal of Geriatrics* 1980;**17**(1):1–6.

Simmons 2001 ***{published data only}***
Simmons SF, Alessi C, Schnelle JF. An intervention to increase fluid intake in nursing home residents: prompting and preference compliance. *Journal of the American Geriatrics Society* 2001;**49**(7):926–33.

Singh 2013 ***{published data only}***
Singh NR, Peters EM. Markers of hydration status in a 3-day trail running event. *Clin J Sport Med* 2013;**0**:1-11 [epub ahead of print, April 2013].

Siregar 2010 ***{published data only}***
Siregar P, Setiati S. Urine osmolality in the elderly. *Acta Med Indones- Indones J Internal Med* 2010;**42**(1):24–6.

Spangler 1998 ***{published data only}***
Spangler AA, Chidester JC. Age, dependency and other factors influencing fluid intake by long term care residents. *Journal of Nutrition for the Elderly* 1998;**18**(2):21–35.

Sugaya 2008 ***{published data only (unpublished sought but not used)}***
Sugaya K, Nishijima S, Oda M, Owan T, Miyazato M, Ogawa Y. Biochemical and body composition analysis of nocturia in the elderly. *Neurology and Urodynamics* 2008;**27**:205–211.

Suhr 2004 *{published data only}*
Suhr JA, Hall J, Patterson SM, Niinisto RT, Suhr Julie A, Hall Jessica, et al.The relation of hydration status to cognitive performance in healthy older adults. *International Journal of Psychophysiology* 2004;**53**(2):121–5.

Suhr 2010 *{published data only}*
Suhr JA, Patterson SM, Austin AW, Heffner KL. The relation of hydration status to declarative memory and working memory in older adults. *Journal of Nutrition, Health & Aging* 2010;**14**(10):840–3.

Szewczyk 2008 *{published data only}*
Szewczyk MT, Jawien A, Kedziora-Kornatowska K, Moscicka P, Cwajda J, Cierzniakowska K, et al.The nutritional status of older adults with and without venous ulcers: a comparative, descriptive study. *Ostomy Wound Management* 2008;**54**(9):34.

Takahashi 1997 *{published data only}*
Takahashi N. Circannual variations in physical and laboratory data of the outpatients. *Journal of the Japanese Association of Physical Medicine Balneology and Climatology* 1997;**60**(4):240–8.

Tamura (REGARDS) 2010 *{published data only (unpublished sought but not used)}*
Tamura MK, Wadley VG, Newsome BB, Zakai NA, McClure LA, Howard G, Warnock DG, McClellan W. Hemoglobin concentration and cognitive impairment in the Renal REasons for Geographic And Racial Differences in Stroke (REGARDS) Study. *Journal of Gerontology A Biol Sci Med Sci* 2010;**65A**(12):1380–6.

Telfer 1965 *{published data only}*
Telfer N, Persoff M. The effect of tube feeding on the hydration of elderly patients. *Journal of Gerontology* 1965; **20**(4):536–43.

Thomas 2003 *{published data only}*
Thomas DR, Tariq SH, Makhdomm S, Haddad R, Moinuddin A. Physician misdiagnosis of dehydration in older adults. *Journal of the American Medical Directors Association* 2003;**4**(5):251–4.

Tonstad 2006 *{published data only}*
Tonstad S, Klemsdal TO, Landaas S, Hoieggen A. No effect of increased water intake on blood viscosity and cardiovascular risk factors. *British Journal of Nutrition* 2006; **96**(6):993–6.

Vache 1998 *{published and unpublished data}*
Vache C, Rousset P, Gachon P, Gachon AM, Morio B, Boulier A, et al.Bioelectrical impedance analysis measurements of total body water and extracellular water in healthy elderly subjects. *International Journal of Obesity* 1998;**22**(6):537–43.

van der Steen 2007 *{published data only (unpublished sought but not used)}*
van der Steen JT, Mehr DR, Kruse RL, Ribbe MW, van der Wal G. Dementia, Lower Respiratory Tract Infection, and Long-Term Mortality. *Journal of the American Directors Association* 2007;**8**(6):396–403.

van Kraaij 1999 *{published data only}*
van Kraaij DJ, Jansen RW, Hoefnagels WH, van Kraaij DJ, Jansen RW, Hoefnagels WH. Monitoring hypovolemia in healthy elderly subjects by measuring blood pressure response to Valsalva's maneuver. *Geriatric Nephrology & Urology* 1999;**9**(2):73–9.

Vazquez 2010 *{published data only}*
Vazquez R, Gheorghe C, Kaufman D, Manthous CA. Accuracy of bedside physical examination in distinguishing categories of shock: a pilot study. *Journal of Hospital Medicine (Online)* 2010;**5**(8):471–4.

Vivanti 2008 *{published and unpublished data}*
Vivanti A, Harvey K, Ash S, Battistutta D. Clinical assessment of dehydration in older people admitted to hospital: what are the strongest indicators?. *Archives of Gerontology & Geriatrics* 2008;**47**(3):340–55.

Vivanti 2010 *{published data only (unpublished sought but not used)}*
Vivanti A, Harvey K, Ash S. Developing a quick and practical screen to improve the identification of poor hydration in geriatric and rehabilitative care. *Archives of Gerontology & Geriatrics* 2010;**50**(2):156–64.

Wakefield 2002a *{published data only (unpublished sought but not used)}*
Wakefield B, Mentes J, Diggelmann L, Culp K. Monitoring hydration status in elderly veterans. *Western Journal of Nursing Research* 2002;**24**(2):132–42.

Wakefield 2002b *{published data only (unpublished sought but not used)}*
Wakefield BJ. Risk for acute confusion on hospital admission. *Clinical nursing research* 2002;**11**(2):153–72.

Wakefield 2008 *{published data only (unpublished sought but not used)}*
Wakefield BJ, Mentes J, Holman JE, Culp K. Postadmission dehydration: risk factors, indicators, and outcomes. *Rehabilitation Nursing* 2009;**34**(5):209–16.
Wakefield BJ, Mentes J, Holman JE, Culp K. Risk factors and outcomes associated with hospital admission for dehydration. *Rehabilitation Nursing* 2008;**33**(6):233–241.

Waldreus 2010 *{published and unpublished data}*
Waldréus N, Sjöstrand F, Hahn RG. Thirst in the elderly with and without heart failure. *Arch Gerontol Geriatr* 2011 (Epub 2010 Oct 28);**53**(2):174–178. [DOI: 10.1016/j.archger.2010.10.003]

Weinberg 1994 *{published data only}*
Weinberg AD, Pals JK, Levesque PG, Beal LF, Cunningham TJ, Minaker KL. Dehydration and death during febrile episodes in the nursing home. *Journal of the American Geriatrics Society* 1994;**42**(9):968–71.

Weinberg 1994a *{published data only}*
Weinberg AD, Pals JK, McGlinchey-Berroth R, Minaker KL. Indices of dehydration among frail nursing home patients: highly variable but stable over time. *Journal of the American Geriatrics Society* 1994;**42**(10):1070–3.

Weiss 2012 *{published data only (unpublished sought but not used)}*
Weiss JP, Zinner NR, Klein BM, Norgaard JP. Desmopressin orally disintegrating tablet effectively reduces nocturia: results of a randomized, double-blind, placebo-controlled trial. *Neurourology and Urodynamics* 2012;**31**:441–7.

Wise 2000 *{published data only}*
Wise LC, Mersch J, Racioppi J, Crosier J, Thompson C, Wise LC, et al.Evaluating the reliability and utility of cumulative intake and output. *Journal of Nursing Care Quality* 2000;**14**(3):37–42.

Yoshihara 2007 *{published data only}*
Yoshihara A, Hirotomi T, Takano N, Kondo T, Hanada N, Miyazaki H. Serum markers of chronic dehydration are associated with saliva spinability. *Journal of Oral Rehabilitation* 2007;**34**(10):733–8.

Yoshikawa 2012 *{published and unpublished data}*
Yoshikawa T, Kanazawa H. Association of plasma adiponectin levels with cellular hydration state measured using bioelectrical impedance analysis in patients with COPD. *Int J Chron Obstruct Pulmon Dis* 2012 (Epub 2012 Aug 10);**7**:515–521. [DOI: 10.2147/COPD.S34556]

References to studies awaiting assessment

El-Sharkwi 2014 *{published data only}*
* El-sharkawy AM, Sahota O, Maughan RJ, Lobo DN. Hydration in the older hospital patient - is it a problem?. *Age and Ageing* 2014;**43**:i33–i35. [DOI: 10.1093/ageing/afu046]

Ooi 1997 *{published data only}*
* Ooi SB, Koh-Tai B-C, Aw TC, Lau TC, Chan ST. Assessment of Dehydration in Adults Using Hematologicand Biochemical Tests. *Academic Emergency Medicine* 1997;**4**(8):840–844.

References to ongoing studies

Fortes & Walsh study 2013 *{published data only}*
Fortes MB, Owen JA, Raymond-Barker P, Bishop C, Elghenzai S, Oliver SJ, Walsh NP. Is This Elderly Patient Dehydrated? Diagnostic Accuracyof Hydration Assessment Using Physical Signs, Urine, andSaliva Markers. *Journal of the American Medical Directors Association* In press 2014. [DOI: 10.1016/j.jamda.2014.09.012]

Hooper & Bunn 2013 *{published and unpublished data}*
Hooper L, Bunn D. DRIE (Dehydration Recognition In our Elders). Development of a simple tool for diagnosis of water-loss dehydration: a diagnostic accuracy and cohort study. Research Register for Social Care (RRSC ID 122273) and http://driestudy.appspot.com/index.html 2012.

Johnson 2012 *{unpublished data only}*
Dehydration study. Ongoing study July 2012.

Johnson 2013 *{unpublished data only}*
SÄBO study. Ongoing study May 2013.

Olde Rikkert 2013 *{unpublished data only}*
Diagnosis of dehydration in elderly patients by electronic nose analysis of exhaled air: a pilot study. Ongoing study July 2013.

Additional references

Abdelhamid 2014
AbdelhamidA, Bunn D, Dickinson A, Killett A, Poland F, Potter J, Richardson K, Smithard D, Fox C, Hooper L. Effectiveness of interventions to improve, maintain or faciltate oral food and/or drink intake in people with dementia [http://www.crd.york.ac.uk/PROSPERO/display˙record.asp?ID=CRD42014007611]. PROSPERO 2014:CRD42014007611.

Arampatzis 2012
Arampatzis S, Frauchiger B, Fiedler GM, Leichtle AB, Buhl D, Schwarz C, Funk GC, Zimmermann H, Exadaktylos AK, Lindner G. Characteristics, symptoms, and outcome of severe dysnatremias present on hospital admission. *Am J Med* 2012;**125**(11):1125.e1–1125.e7. [DOI: 10.1016/j.amjmed.2012.04.041]

Armstrong 1998
Armstrong LE, Soto JA, Hacker FT Jr, Casa DJ, Kavouras SA, Maresh CM. Urinary indices during dehydration, exercise, and rehydration. *Int J Sport Nutr.* 1998;**8**(4):345–55.

Armstrong 2007
Armstrong LE. Assessing Hydration Status: The Elusive Gold Standard. *Journal of the American College of Nutrition* 2007;**26**(sup5):575S–584S. [DOI: 10.1080/07315724.2007.10719661]

Bhalla 2000
Bhalla A, Sankaralingam S, Dundas R, Swaminathan R, Wolfe CD, Rudd AG. Influence of raised plasma osmolality on clinical outcome after acute stroke. *Stroke* 2000;**31**(9):2043–8. [MEDLINE: 10978027]

Bunn 2012
Bunn D, Hooper L. Effectiveness of external factors to reduce the risk of dehydration in older people living in residential care: a systematic review. *PROSPERO* 2012;**CRD42012003100**:Availablefrom http://www.crd.york.ac.uk/PROSPERO˙REBRANDING/display˙record.asp?ID=CRD42012003100.

Bunn 2014
Bunn D, Jimoh FO, Howard Wilsher S, Hooper L. Increasing fluid intake and reducing dehydration risk in older people living in long-term care: a systematic review. *Journal of the American Medical Directors Association* Accepted October 2014.

Chan 2002
Chan J, Knutsen SF, Blix GG, Lee JW, Fraser GE. Water, other fluids, and fatal coronary heart disease: the Adventist Health Study. *American Journal of Epidemiology* 2002;**155**(9):827–33. [MEDLINE: 11978586]

Cheuvront 2010
Cheuvront SN, Ely BR, Kenefick RW, Sawka MN. Biological variation and diagnostic accuracy of dehydration assessment markers. *American Journal of Clinical Nutrition* 2010;**92**(3):565–73. [MEDLINE: 20631205]

Cheuvront 2013
Cheuvront SN, Kenefick RW, Charkoudian N, Sawka MN. Physiologic basis for understanding quantitative dehydration assessment. *Am J Clin Nutr* 2013;**97**:455–62.

Chidester & Spangler 1997
Chidester JC, Spangler AA. Fluid intake in the institutionalized elderly. *J Am Diet Assoc* 1997;**97**(1):23–8.

Churchill Livingstone Medical Dictionary 2008
Brooker C (editor). *Churchill Livingstone Medical Dictionary*. 16th Edition. London: Royal Society of Medicine, 2008.

De Castro 1992
De Castro JM. Age-related changes in natural spontaneous fluid ingestion. *Journal of Gerontology* 1992;**47**(5):321–30. [MEDLINE: 1512438]

de Groot 2011
de Groot JAH, Bossuyt PMM, Reitsma JB, Rutjes AWS, Dendukuri N, Janssen KJM, Moons KGM. Verification problems in diagnostic accuracy studies:consequences and solutions. *BMJ* 2011;**343**:d4770. [DOI: 10.1136/bmj.d4770]

de Lorenzo 2012
de Lorenzo RA, Morris MJ, Williams JB, Haley TF, Straight TM, Holbrook-Emmons VL, Medina JS. Does a simple bedside sonographic measurement of the inferior vena cava correlate to central venous pressure?. *J Emerg Med* 2012;**42**(4):429–436. [DOI: 10.1016/j.jemermed.2011.05.082]

de Vet 2008
de Vet HCW, Eisinga A, Riphagen II, Aertgeerts B, Pewsner D. Chapter 7: Searching for Studies. In: Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy Version 0.4 [updated September 2008]. The Cochrane Collaboration, 2008. Available from http://srdta.cochrane.org/.

di Ruffano 2012
di Ruffano LF, Hyde CJ, McCaffery KJ, Bossuyt PMM, Deeks JJ. Assessing the value of diagnostic tests: a framework for designing and evaluating trials. *BMJ* 2012;**344**:e686. [DOI: 10.1136/bmj.e686]

DoH and Nutrition Summit 2007
Jointly produced by the Department of Health and the Nutrition Summit stakeholder group. Improving Nutritional Care: A joint Action Plan. 2007. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH˙079931 (accessed 20 December 2011).

EFSA 2010
EFSA Panel on Dietetic Products. Scientific Opinion on Dietary reference values for water. *EFSA Journal* 2010;**8**(3):1459.

El-Sharkawy 2014
El-Sharkawy AM, Sahota O, Maughan RJ, Lobo DN. Hydration in the older hospital patient - is it a problem?. *Age and Ageing* 2014;**43**:i33–i35. [DOI: 10.1093/ageing/afu046]

Fazekas 2013
Fazekas AS, Funk G-C, Klobassa DS, Ruther H, Ziegler I, Zander R, Semmelrock H-J. Evaluation of 36 formulas for calculating plasma osmolality. *Intensive Care Medicine* 2013;**39**(2):302–8. [DOI: 10.1007/s00134-012-2691-0]

Fortes 2011
Fortes MB, Diment BC, Di Felice U, Gunn AE, Kendall JL, Esmaeelpour M, Walsh NP. Tear fluid osmolarity as a potential marker of hydration status. *Medicine & Science in Sports & Exercise* 2011;**43**(8):1590–7. [DOI: 10.1249/MSS.0b013e31820e7cb6]

Freeman 2011
Freeman R, Wieling W, Axelrod FB, Benditt DG, Benarroch E, Biaggioni I, Cheshire WP, Chelimsky T, Cortelli P, Gibbons CH, Goldstein DS, Hainsworth R, Hilz MJ, Jacob G, Kaufmann H, Jordan J, Lipsitz LA, Levine BD, Low PA, Mathias C, Raj SR, Robertson D, Sandroni P, Schatz IJ, Schondorf R, Stewart JM, van Dijk JG. Consensus statement on the definition of orthostatic hypotension, neurally mediated syncope and the postural tachycardia syndrome. *Auton Neurosci* 2011;**261**(1-2):46–8. [DOI: 10.1016/j.autneu.2011.02.004]

Goldman 2004
Goldman L, Ausiello DA. *Cecil Textbook of Medicine*. 22nd Edition. London: Saunders, 2004.

Hodgkinson 2003
Hodgkinson B, Evans D, Wood J. Maintaining oral hydration in older adults: a systematic review. *International Journal of Nursing Practice* 2003;**9**(3):S19–28. [MEDLINE: 12801253]

Hooper 2014
Hooper L, Bunn D, Jimoh FO, Fairweather-Tait SJ. Water-loss dehydration and aging. *Mechanisms of Ageing and Development* 2014;**136-7**:50–58. [DOI: 10.1016/j.mad.2013.11.009]

Kenkmann 2010
Kenkmann A, Price GM, Bolton J, Hooper L. Health, wellbeing and nutritional status of older people living in UK care homes: an exploratory evaluation of changes in food and drink provision. *BMC Geriatrics* 2010;**10**:28. [MEDLINE: 20507560]

Leeflang 2009
Leeflang MM, Bossuyt PM, Irwig L. Diagnostic test accuracy may vary with prevalence: implications for evidence-based diagnosis. *Journal of Clinical Epidemiology* 2009;**62**(1):5–12. [MEDLINE: 18778913]

Leeflang 2013
Leeflang MMG, Rutjes AWS, Reitsma JB, Hooft L, Bossuyt PMM. Variation of a test's sensitivity and specificity with disease prevalence. *CMAJ* 2013;**185**(11):e537–544. [DOI: 10.1503/cmaj.121286]

Lindeman 1985
Lindeman RD, Tobin J, Shock NW. Longitudinal studies on the rate of decline in renal function with age. *Journal of the American Geriatrics Society* 1985;**33**(4):278–85. [MEDLINE: 3989190]

Linnet 2012
Linnet K, Bossuyt PMM, Moons KGM, Reitsma JBR. Quantifying the Accuracy of a Diagnostic Test or Marker. *Clinical Chemistry* 2012;**58**:91292-1301, available at http://www.clinchem.org/content/early/2012/07/13/clinchem.2012.182543.full.pdf. [DOI: 10.1373/clinchem.2012.182543]

Luckey 2003
Luckey AE, Parsa CJ. Fluid and electrolytes in the aged. *Archives of Surgery* 2003;**138**(10):1055–60. [MEDLINE: 14557120]

Macaskill 2010
Macaskill P, Gatsonis C, Deeks JJ, Harbord RM, Takwoingi Y. Chapter10: Analysing and Presenting Results. In: Deeks JJ, Bossuyt PM, Gatsonis C (editors), Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy Version 1.0. The Cochrane Collaboration, 2010. Available from http://srdta.cochrane.org.

McGee 1999
McGee S, Abernethy WB 3rd, Simel DL. Is this patient hypovolemic?. *JAMA* 1999;**281**(11):1022–9. [MEDLINE: 10086438]

MedicineNet 2014
Wedro B. How is dehydration diagnosed?. http://www.medicinenet.com/dehydration/page5.htm 2014; Vol. accessed 18 November 2014.

Mentes 2006a
Mentes JC. Oral hydration in older adults. *American Journal of Nursing* 2006;**106**(6):40–9. [MEDLINE: 16728843]

Mentes 2006b
Mentes JC, Wakefield B, Culp K. Use of a urine color chart to monitor hydration status in nursing home residents. *Biological Research for Nursing* 2006;**7**(3):197–203. [MEDLINE: 16552947]

National Care Homes R&D Forum 2007
National Care Homes Research and Development Forum. *My Home Life, Quality of life in care homes: a review of the literature*. London: Help the Aged, 2007.

NHS 2013
NHS. Dehydration - Symptoms. http://www.nhs.uk/Conditions/Dehydration/Pages/Symptoms.aspx 2013: accessed 18 November 2014.

O'Bryant 2008
O'Bryant SE, Humphreys JD, Smith GE, Ivnik RJ, Graff-Radford NR, Petersen RC, Lucas JA. Detecting Dementia with the Mini-Mental State Examination (MMSE) in Highly Educated Individuals. *Archives of Neurology* 2008;**65**(7):963–67. [DOI: 10.1001/archneur.65.7.963]

Olde Rikkert 2009
Olde Rikkert MG, Melis RJ, Claassen JA. Heat waves and dehydration in the elderly. *BMJ* 2009;**339**:b2663. [MEDLINE: 19574318]

Panel on Dietary Reference Intakes 2004
Panel on Dietary Reference Intakes for Electrolytes, Water. Panel on Dietary Reference Intakes for Electrolytes and Water SCotSEoDRI. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Washington DC, USA: National Academies Press; 2004.. *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*. Washington DC, USA: National Academies Press, 2004.

Reid 2004
Reid J. Speech by Rt Hon John Reid MP, Secretary of State for Health, 11 March 2004: Managing new realities: integrating the care landscape. www.dh.gov.uk/en/News/Speeches/Speecheslist/DH˙4076406 (accessed 20 December 2011).

Reitsma 2005
Reitsma JB, Glas AS, Rutjes AW, Scholten RJ, Bossuyt PM, Zwinderman AH. Bivariate analysis of sensitivity and specificity produces informative summary measures in diagnostic reviews. *Journal of Clinical Epidemiology* 2005;**58**(10):982–90. [MEDLINE: 16168343]

Reitsma 2009a
Reitsma JB, Rutjes AW, Whiting P, Vlassov VV, Leeflang MM, Deeks JJ. Chapter 9: Assessing methodological quality. In: Deeks JJ, Bossuyt PM, Gatsonis C (editors), Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy Version 1.0.0. The Cochrane Collaboration, 2009. Available from http://srdta.cochrane.org/.

Reitsma 2009b
Reitsma JB, Rutjes AW, Khan KS, Coomarasamy A, Bossuyt PM. A review of solutions for diagnostic accuracy studies with an imperfect or missing reference standard. *Journal of Clinical Epidemiology* 2009;**62**(8):797–806. [MEDLINE: 19447581]

RevMan 5.2
The Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan). 5.2.6. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012.

Robinson 2002
Robinson SB, Rosher RB. Can a beverage cart help improve hydration?. *Geriatric Nursing* 2002;**23**(4):208–11. [MEDLINE: 12183746]

Rolland 2006
Rolland Y, Kim MJ, Gammack JK, Wilson MM, Thomas DR, Morley JE. Office management of weight loss in older persons. *American Journal of Medicine* 2006;**119**(12):1019–26. [MEDLINE: 17145241]

Rushing 2009
Rushing J. Assessing for dehydration in adults. *Nursing* 2009;**39**(4):14. [DOI: 10.1097/01.NURSE.0000348406.04065.6d]

Schloerb 1950
Schloerb PR, Friis-Hansen BJ, Edelman IS, Solomon AK, Moore FD. The measurement of total body water in the human subject by deuterium oxide dilution; with a consideration of the dynamics of deuterium distribution. *Journal of Clinical Investigation* 1950;**29**(10):1296–310. [MEDLINE: 14778892]

Shirreffs 2003
Shirreffs SM. Markers of hydration status. *European Journal of Clinical Nutrition* 2003;**57 Suppl 2**:S6–9. [MEDLINE: 14681707]

Siervo 2014
SiervoM, Bunn D, Prado C, Hooper L. Accuracy of prediction equations for serum osmolarity in frail older people with and without diabetes. *American Journal for Clinical Nutrition* 2014;**100**(3):867–876. [DOI: 10.3945/ajcn.114.086769]

Simard 1998
Simard M. The Mini-Mental State Examination: Strengths and weaknesses of a clinical instrument. The Canadian Alzheimer Disease Review. http://www.stacommunications.com/customcomm/Back–issue˙pages/AD˙Review/adPDFs/december1998/10.pdf, 1998; Vol. http://www.stacommunications.com/customcomm/Back–issue˙pages/AD˙Review/adPDFs/december1998/10.pdf:10–12.

Spangler & Chidester 1998
Spangler AA, Chidester JC. Age, dependency and other factors influencing fluid intake by long term care residents. *Journal of Nutrition for the Elderly* 1998;**18**:21–35.

StataCorp
StataCorp LP. StataCorp. 2009. Stata Statistical Software. Release 11.1. College Station, TX: StataCorp LP, 2009.

Stookey 2004
Stookey JD, Purser JL, Pieper CF, Cohen HJ. Plasma hypertonicity: Another marker of frailty?. *Journal of the American Geriatric Society* 2004;**52**(8):1313–20. [MEDLINE: 15271119]

Stookey 2005a
Stookey JD. High prevalence of plasma hypertonicity among community-dwelling older adults: results from NHANES III. *Journal of the American Dietetics Association* 2005;**105**(8):1231–9. [MEDLINE: 16182639]

Stookey 2005b
Stookey JD, Pieper CF, Cohen HJ. Is the prevalence of dehydration among community-dwelling older adults really low? Informing current debate over the fluid recommendation for adults aged 70 + years. *Public Health Nutrition* 2005;**8**(8):1275–85. [MEDLINE: 16372923]

Sund-Levander 2002
Sund-Levander M, Forsberg C, Wahren LK. Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review. *Scandinavian Journal of Caring Sciences* 2002;**16**(2):122–128. [PUBMED: 12000664]

Thomas 2008
Thomas DR, Cote TR, Lawhorne L, Levenson SA, Rubenstein LZ, Smith DA, et al.Understanding clinical dehydration and its treatment. *Journal of the American Medical Directors Association* 2008;**9**(5):292–301. [MEDLINE: 18519109]

Vivanti 2013
Vivanti A, Yu L, Palmer M, Dakin L, Sun J, Campbell K. Short-term body weight fluctuations in older well-hydrated hospitalised patients. *Journal of Human Nutrition and Dietetics* 2013;**26**(5):429-435. [DOI: 10.1111/jhn.12034]

Wachtel 1991
Wachtel TJ, Tetu-Mouradjian LM, Goldman DL, Ellis SE, O'Sullivan PS. Hyperosmolarity and acidosis in diabetes mellitus: a three-year experience in Rhode Island. *Journal of General Internal Medicine* 1991;**6**(6):495–502. [MEDLINE: 1765864]

Waikar 2009
Waikar SS, Mount DB, Curhan GC. Mortality after hospitalization with mild, moderate, and severe hyponatremia. *American Journal of Medicine* 2009;**122**(9):857–65. [MEDLINE: 19699382]

Walsh 2004A
Walsh NP, Laing SJ, Oliver SJ, Montague JC, Walters R, Bilzon JL. Saliva parameters as potential indices of hydration status during acute dehydration. *Med Sci Sports Exerc.* 2004;**36**(9):1535–42.

Walsh 2004B
Walsh NP, Montague JC, Callow N, Rowlands AV. Saliva flow rate, total protein concentration and osmolality as potential markers of whole body hydration status during progressive acute dehydration in humans. *Arch Oral Biol.* 2004;**49**(2):149–54.

Warren 1994
Warren JL, Bacon WE, Harris T, McBean AM, Foley DJ, Phillips C. The burden and outcomes associated with dehydration among US elderly, 1991. *American Journal of Public Health* 1994;**84**(8):1265–9. [MEDLINE: 8059883]

Water UK 2006
Water UK. Hydration Best Practice Toolkit for Care Homes. http//:www.water.org.uk/home/water-for-health/older-people/care-homes-toolkit (accessed 20 December 2011).

WebMD 2014
WebMD. Dehydration in adults. http://www.webmd.com/a-to-z-guides/dehydration-adults 2014:accessed 18 November 2014.

Weinberg 1995
Weinberg AD, Minaker KL. Dehydration: evaluation and management in older adults. Council on Scientific Affairs, American Medical Association. *JAMA* 1995;**274**(19):1552–6. [MEDLINE: 7474224]

Whiting 2006
Whiting PF, Westwood ME, Rutjes AW, Reitsma JB, Bossuyt PN, Kleijnen J. Evaluation of QUADAS, a tool for the quality assessment of diagnostic accuracy studies.

BMC Medical Research Methodology 2006;**6**:9. [MEDLINE: 16519814]

Whiting 2011

Whiting P, Westwood M, Beynon R, Burke M, Sterne JAC, Glanville J. Inclusion of methodological filters in searches for diagnostic test accuracy studies misses relevant studies. *Journal of Clinical Epidemiology* 2011;**64**(6):602–7. [MEDLINE: 21075596]

Wotton 2008

Wotton K, Crannitch K, Munt R. Prevalence, risk factors and strategies to prevent dehydration in older adults. *Contemporary Nurse* 2008;**31**(1):44–56. [MEDLINE: 19117500]

Xiao 2004

Xiao H, Barber J, Campbell ES. Economic burden of dehydration among hospitalized elderly patients. *American Journal of Health-System Pharmacy* 2004;**61**(23):2534–40. [MEDLINE: 15595228]

Zengin 2013

Zengin S, Al B, Genc S, Yildirim C, Ercan S, Dogan M, Altunbas G. Role of inferior vena cave and right ventricular diameter in assessment of volume status: a comparative study. Ultrasound and hypovolemia. *American Journal of Emergency Medicine* 2013;**31**:763–767. [DOI: 10.1016/j.ajem.2912.10.013]

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Allison 2005

Clinical features and settings	Long-term urban care facilities USA **Aim**: to determine the mean total body resistance in long term care residents, and correlate with fluid imbalance
Participants	Participants were residents of long term urban care facilities **Sample size**: 15 **Gender**: not stated **Age**: not stated **Nutritional status**: not stated
Study design	Reference standard (serum osmolality) was **retrospective** **2 x 2 table published**: no, reviewers used individual data published within the paper
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** **Method**: not stated (collected in standard practice care in several facilities, so methods may vary) **Cut-off**: < 295 vs. ≥ 295 mOsm/L
Index and comparator tests	**Total body resistance** at 50kHz, by BIA **Method**: Quantum II Bioimpedance Analyser & Cyprus Body Composition Analyzer software, RJL Systems, Michigan **Timing**: BIA and serum osmolarity were measured within 3 months of each other
Follow-up	**Flow**: Of 1225 selected residents medical charts of 118 were reviewed (unclear how these were chosen), of whom 44 had had clinical lab results measured in past 3 months and for whom individual data were reported. Of these 22 had had serum osmolality measured, and 15 had serum osmolarity of ≥ 275 mOsm/L, so were included in review analysis
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	Unclear	Yes - Older people living in care Unclear - method of recruitment unclear and only 22 of 1225 represented in data
Acceptable reference standard? All tests	No	Serum osmolarity (calculated rather than measured serum osmolality)
Acceptable delay between tests? All tests	No	Delay up to 3 months between reference standard and index tests

Allison 2005 (*Continued*)

Partial verification avoided? All tests	No	Serum osmolarity assessment was based on clinical criteria so was probably not random, and reference standard data were accessed retrospectively
Differential verification avoided? All tests	Unclear	Yes - reviewers chose the cut-off level used Unclear - method of measuring osmolarity unclear and may have differed between participants as based in different facilities
Incorporation avoided? All tests	Yes	The index test did not form any part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Unclear	Yes - reviewers chose cut-off levels Unclear whether any interpretation of total body resistance occurred
Relevant clinical information? All tests	Yes	Assessments made without reference to clinical data
Uninterpretable results reported? All tests	Unclear	Not stated
Withdrawals explained? All tests	No	>1000 participants not represented in data set
Free of commercial funding?	No	Study funding not stated, but first author worked for company that produce BIA equipment, another worked for the company that produce the software used

Bossingham 2005

Clinical features and settings	**Healthy older people living in the community** USA **Aim**: to assess effects of age on water input, output, balance and hydration status
Participants	Participants were older men and women with normal kidney, heart, liver, thyroid and blood pressure, without diabetes **Sample size**: 21 **Gender**: 11 women, 10 men **Age**, mean, yrs: women 75 (SD 4, range 70-81), men 72 (SD 4, range 63-79) **Nutritional status**: BMI women 27.4 (SD 4.2), BMI men 26.5 (SD 3.3)

Bossingham 2005 (*Continued*)

Study design	**Prospective** study **2x2 table published**: no, reviewers used data set provided by authors
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: plasma from fasting blood sample analysed in osmometer (Advanced Osmometer Model 3D3, Advanced Instruments Inc) **Cut-off:** < 295 vs ≥ 295 mOsm/kg
Index and comparator tests	**Ad lib water intake** Method: Water for drinking water, tea, coffee etc was provided as bottled water and use over 4 days was measured Timing: Water intake measured on days 7-10 of research period, serum osmolality on day 12 **Fluid intake** Method: Water content of duplicate samples of foods and drinks analysed plus metabolic water content estimated plus ad lib water content as above Timing: Unclear, probably days 7-10 of research period, serum osmolality on day 12 **Urine volume** Method: Urine collected for 4 days plus stool water measured plus insensible losses via respiration and skin estimated Timing: Urine volume measured on days 7-10 of research period, serum osmolality on day 12 **Water balance** Method: Urine volume (as above) subtracted from water input (as above) Timing: Measured on days 7-10 of research period, serum osmolality on day 12 **Urine specific gravity** Method: Assumed to equal urine density, assessed by weighing a set volume of urine Timing: measured on days 7-10 of research period, serum osmolality on day 12 *Also **total body water** measured by deuterium oxide dilution method, but not presented as a clinical symptom, sign or test *Also **thirst** assessed (participants asked "how strong is your feeling of thirst?" indicated by a 100mm VAS scale) but only asked of some participants, and data not presented in data set, so not used
Follow-up	**Flow**: 3/24 did not complete the study so were excluded. Of 21 older participants, reviewers omitted none (data set did not show participant ages, so although data for one male participant was aged 63 years he could not be removed), all were healthy and none had low serum osmolality (< 275 mOsm/kg)
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	Yes	Older people living in the community Method of recruitment was sequential, including those who fit the inclusion criteria

Bossingham 2005 (*Continued*)

Acceptable reference standard? All tests	Yes	Serum osmolality (measured) Reviewers set our own cut-offs
Acceptable delay between tests? All tests	No	> 2 hours for all tests
Partial verification avoided? All tests	Yes	Study prospective, all participants received all tests except for question on thirst (introduced part way through the study, when all women had completed)
Differential verification avoided? All tests	Yes	Serum osmolality assessed in all
Incorporation avoided? All tests	Yes	Index tests did not form any part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Reference standard measured after index tests
Relevant clinical information? All tests	Yes	Assessments made without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	3 did not complete and were excluded
Free of commercial funding?	Yes	Funded by NIH and US Dept of Agriculture, all authors worked for Purdue University

Chassagne 2006

Clinical features and settings	**7 short and long-term geriatric care facilities** France **Aim**: to assess early clinical signs in patients with hypernatraemia, and their prognostic value
Participants	Cases were inpatients aged ≥ 65 years with hypernatraemia, controls were matched for age, sex, type of facility and Barthel Index (2 controls per case) **Gender**: 257 women, 193 men **Age**, mean, years: cases 87.1 (SD 6.9, range 70 to 107), controls 86.4 (SD 6.8, range 70 to 106) **Nutritional status**: unclear

Chassagne 2006 (*Continued*)

Study design	**Prospective** study (case control) **2x2 table published**: no, reviewers used data set provided by authors
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** (Serum osmolality was measured, but only in cases, not controls) **Method**: calculated by reviewers from serum electrolytes measured in routine patient management, using osmolarity = (2Na + 2K + urea + glucose), all in mmol/L **Cut-off:** < 295 vs. ≥ 295 mOsm/L
Index and comparator tests	**Heart rate, beats/min (n = 305)** Method: at rest, method not stated Timing: unclear, author states tests assessed within 4 hours of abnormal biochemistry being confirmed, but not clear of timing of tests re serum biochemistry in controls **Orthostatic blood pressure (n = 144)** Method: decline of ≥ 20 mmHg systolic, or ≥ 10 mmHg diastolic at 1 or 3 minutes after moving from supine to sitting position Timing: as heart rate timing **Body temperature (n = 297)** Method: not stated Timing: as heart rate timing **Consciousness states (n = 305)** Method: classified as normal, mildly impaired and coma (no further details of how this was tested) Timing: as heart rate timing **Dry oral mucosa (n = 292)** Method: finger was placed inside cheek or the linguo-maxillary sulcus and assessed as wet or dry Timing: as heart rate timing **Skin turgor, subclavicular (n = 306), anterior forearm (n = 302), anterior thigh (n = 303), sternum (n = 304)** Method: assessed at each of four sites, and positive at each site when fold lasted for ≥ 3 seconds after 3 seconds of pinching Timing: as heart rate timing
Follow-up	**Flow**: Of 465 older participants there were no exclusions reported. Reviewers omitted 149 (124 due to renal disease, 13 due to heart failure, 12 due to missing data that did not allow serum osmolarity calculation, 2 had osmolarity < 275). Some missing data for each index test
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - all participants were hospitalised Unclear - unclear whether recruitment was of consecutive patients

Acceptable reference standard? All tests	No	No - serum osmolarity (calculated) had to be used as the reference standard as measured serum osmolality was only available for cases (who all had raised serum osmolality by definition) Yes - reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Unclear	Tests assessed within 24 hours of blood sample in cases and controls, but unclear if within 2 hours
Partial verification avoided? All tests	No	Yes - study prospective No - only cases had measured serum osmolality, 12 controls were missing some relevant data allowing calculation of serum osmolarity
Differential verification avoided? All tests	Yes	Serum osmolarity could be calculated for all included participants, so this was used as the reference standard
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	No	Cases chosen on the basis of serum sodium levels (closely related to serum osmolality and osmolarity)
Index test results blinded? All tests	Unclear	Tests may have been assessed in the knowledge of whether a participant was a case or a control
Relevant clinical information? All tests	Yes	Assessments made without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Unclear	While the numbers included were clear it was not clear why some data were missing
Free of commercial funding?	Yes	The author stated that the study was unfunded.

Culp 2003

Clinical features and settings	**13 rural long-term care (nursing home) facilities** USA **Aim**: to assess risk factors for delirium in older people
Participants	Older adults (aged ≥65) staying in skilled or intensive care beds for at least 30 days, with or without dementia **Gender**: 239 women, 74 men **Age**, mean, years: 86.1 (SD 7.2) **Nutritional status**: unclear
Study design	**Prospective** study **2x2 table published**: no, reviewers used data set provided by authors
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** **Method**: calculated by reviewers from serum electrolytes measured for study, using osmolarity = (2Na + 2K + urea + glucose), all in mmol/L **Cut-off:** < 295 vs ≥ 295 mOsm/L
Index and comparator tests	**Total body water (TBW), extracellular fluic (ECF) and intracellular fluid (ICF) in L, and as % body weight by single frequency BIA (n = 308)** Method: participant supine with arms and legs at 35 to 45 degrees to trunk, at least 2 hours after meals and 6 hours after diuretics, Using Quantum III, RJL systems Timing: all on same day **Urine specific gravity (n = 308)** Method: method not stated Timing: all on same day **Heart rate, BPM (data not in data set)** Method: method not stated Timing: all on same day **Blood pressure, mmHg (data not in data set)** Method: method not stated Timing: all on same day **Mini-mental state exam (MMSE) (n = 308)** Method: standard method, 9 item instrument, scored from 0 to 30 (where 30 is normal cognition) Timing: all on same day **Neecham confusion scale (n = 308)** Method: standard method, scored from 0 to 30 (where 24 or less suggests delirium) Timing: all on same day **Confusion Assessment Method (CAM) (n = 308)** Method: standard method, 9 operationalised criteria for delirium Timing: CAM on separate day to other assessments **Vigilance A (data not in data set)** Method: 60 letters are read out, participants indicate when 'A' is read, ≥ 2 errors considered abnormal Timing: all on same day **Body temperature (data not in data set)** Method: unclear Timing: all on same day

Follow-up	**Flow**: Of 3554 beds in 45 long-term care facilities, 13 facilities participated. 311 eligible participants were randomly selected to participate. Reviewers excluded 3 of these from analyses, 1 for being aged < 65 years, 2 for having serum osmolarity < 275 mOsm/L
Notes	Data on body temperature, heart rate, blood pressure and vigilance A not presented in data set, so not useable in analyses. Data on CAM were assessed as any positive measure over 4 weeks, so not necessarily at a time point near the reference standard, so not included in analyses

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	Yes	Older people living in long term care facilities Random sampling used
Acceptable reference standard? All tests	No	No - calculated serum osmolarity Yes - reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Unclear	All on same day of assessment (except CAM) but no indication that assessment would have been within 2 hours
Partial verification avoided? All tests	Yes	Study prospective All received both index tests and reference standard.
Differential verification avoided? All tests	Yes	Serum osmolarity could be calculated for all included participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Unclear	No information provided.
Relevant clinical information? All tests	Yes	Assessments made without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	No	311/313 participants reported, 311 in data set (reasons for 2 missing unclear)

Free of commercial funding?	Yes	Funded in part by National Institute on Aging, authors all worked in medical or academic settings

Eaton 1994

Clinical features and settings	**Hospital** UK **Aim**: to assess the value of axillary moisture in assessing hydration in ill elderly patients
Participants	Older adults (aged ≥ 70 years) consecutively admitted for acute medical conditions **Gender**: 62 women, 38 men **Age**, mean, years: 80.2 (SD unclear) **Nutritional status**: unclear
Study design	**Prospective** study **2x2 table published**: yes, no additional data available from authors
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured) plus serum urea/ creatinine ratio (mmol/L/μmol/L)** **Method**: no details provided **Cut-off:** > 295 mOsm/kg AND serum urea/ creatinine ratio (mmol/L/μmol/L) > 0.1 vs. all others
Index and comparator tests	**Axillary moisture, weighed (data not reported)** Method: pre-weighed tissue placed in participant's right (left if right hemiparesis) axilla for 15 minutes, with arm held at side, tissue re-weighed Timing: within 24 hours of admission **Axillary moisture, by touch (n = 86)** Method: assessed by 2 blinded observers in random order, coded as dry (0) or moist (1), agreement of coding in 80% of cases (k = 0.5), interval 1 to 6 hours, but only data from assessor 1 presented in 2 x 2 table Timing: within 24 hours of admission
Follow-up	**Flow**: 86/100 recruited appear in the 2 x 2 table, unclear why remaining 14 were excluded, but may be because only assessments by assessor 1 were presented (not the duplicate assessments)
Notes	Data on weighed moisture not presented in usable format, and data on duplicate assessments of axillary moisture by touch not presented in usable format

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	No	No - participants had acute medical conditions Yes - consecutive recruitment

Eaton 1994 (*Continued*)

Acceptable reference standard? All tests	No	Was a combination of serum osmolality and urea/ creatinine ratio
Acceptable delay between tests? All tests	No	Index test was within 24 hours of admission, but the timing of the duplicate assessments were 1 to 6 hours apart and timing of reference standard was not stated
Partial verification avoided? All tests	Unclear	Yes - study prospective Unclear- unclear whether all received both index tests and reference standard, or in what order
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Unclear	Not stated.
Index test results blinded? All tests	Unclear	Not stated
Relevant clinical information? All tests	Unclear	Unclear what clinical information was available or used
Uninterpretable results reported? All tests	Unclear	The cause of missing data was unclear
Withdrawals explained? All tests	No	Unclear why data from 86 participants were presented, when 100 were recruited
Free of commercial funding?	Unclear	Probably, funding source not stated but appears to be part of medical school training and all worked for health or academic bodies

Fletcher 1999

Clinical features and settings	**Intensive care, surgical higher dependency and neurosurgical high dependency units** UK **Aim**: to assess whether urine colour is a useful indicator of hydration status in critically ill patients

Participants	People consecutively admitted to intensive care, surgical higher dependency and neuro-surgical high dependency units **Gender**: 4 women, 13 men aged at least 65 (40 participants overall) **Age**, mean, years: 73 (SD 6.7) for those aged at least 65 years **Nutritional status**: unclear
Study design	**Prospective** study **2 x 2 table published**: no, data set provided by authors
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: no details provided, although blood was taken from indwelling arterial catheters **Cut-off:** < 295 vs. ≥ 295 mOsm/kg
Index and comparator tests	**Urine colour (n = 15)** Method: 20 mL of urine taken from catheter bag, and compared to Armstrong colour chart (score of 1 was lightest, 8 darkest) in natural light. Assessment of each sample was in duplicate by 2 doctors (and also by several nurses) Timing: unclear **Urine output (n = 15)** Method: urine output for 1 hour into catheter bag (multiplied up by 24 by reviewers for use in analysis) Timing: during hour before serum osmolality sample taken **Urine osmolality (n = 15)** Method: urine sample from catheter bag Timing: sample taken during hour before serum osmolality
Follow-up	**Flow**: Of 40 recruited and appearing in the data set, 17 were aged at least 65 years. Of these, 2 participants had serum osmolality < 275 mOsm/kg and so were not included in the review analysis, so 15 were included
Notes	Central venous pressure was also measured, but as this requires use of a central venous catheter it is not non-invasive, so data not included

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - participants were acutely ill in high dependency units Yes - consecutive recruitment
Acceptable reference standard? All tests	Yes	Serum osmolality (measured) Reviewers set our own cut-offs
Acceptable delay between tests? All tests	Yes	Urine sample and central venous pressure taken in hour before blood sample taken

Fletcher 1999 (*Continued*)

Partial verification avoided? All tests	Yes	Study prospective All received both index tests and reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Unclear	Not stated
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	All participants were included that fit our inclusion criteria
Free of commercial funding?	Yes	Funding by a hospital fund, and all authors worked for the hospital

Gaspar Acute & LTC 2011

Clinical features and settings	**Long-term care facility and acute medical psychiatric unit (people hospitalised to receive ECG treatment)** USA **Aim**: to assess whether BIA, urine specific gravity (USG) and urine colour are useful indicators of hydration status in older people
Participants	People aged ≥ 65 living in long-term care facilities or having ECG treatment in acute medical psychiatric units **Gender**: 28 women, 8 men (of whom 23 were from long term care facilities, 13 from psychiatric units) **Age**, mean, years: 81.0 (SD 9.5) **Nutritional status**: 1 participant had BMI<19, 6 BMI 19 to < 25, 8 BMI 25 to < 30, 12 BMI ≥ 30
Study design	**Prospective** study **2x2 table published**: no, data set provided by author

Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: no details provided **Cut-off:** < 295 vs. ≥ 295 mOsm/kg
Index and comparator tests	**Total body water, extracellular fluid (ECF) and intracellular fluid (ICF) as %body weight by multi-frequency BIA (n = 28)** Method: used Xithon Timing: within 2 hours of blood draw for serum osmolality **Mini-mental state exam (MMSE) (n = 17)** Method: standard method, 9-item instrument, scored from 0 to 30 (where 30 is normal cognition) Timing: within 2 hours of blood draw for serum osmolality
Follow-up	**Flow**: Of 36 recruited participants all appeared in the data set, 2 were removed as they had renal failure or oedema, and 6 were removed as their serum osmolality was < 275 mOsm/kg, so 28 were included. All 28 had BIA data, but only 17 had MMSE and CAM data
Notes	**USG** and **urine colour** were assessed in some participants, but as none had raised serum osmolality the data could not be used. **Confusion Assessment Method** (CAM) was assessed in some participants, but confusion was assessed as absent in all participants in whom it was assessed, so the data could not be used

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - while some participants were living in long term care facilities, some were in hospital for ECG treatment Unclear if recruitment was consecutive, or a random sample
Acceptable reference standard? All tests	Yes	Serum osmolality (measured) Reviewers set our own cut-offs
Acceptable delay between tests? All tests	Yes	BIA measures were taken within 2 hours of serum osmolality sample, BUT timing of MMSE and CAM were unclear as these were taken from notes
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard

Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	All participants were included that fit our inclusion criteria
Free of commercial funding?	Unclear	Funded by the Gerontological Nursing Interventions Research Center, Hartford Center of Geriatric Nursing Excellence and Graduate Program Mayo Research Funds (co-PIs Gaspar and Forsyth)

Johnson 2003

Clinical features and settings	**Community living people entered a residential research facility for 4 days** USA **Aim**: to assess whether frequent night-time voiding of urine is associated with urine overproduction at night and whether nocturnal polyuria is associated with arginine vasopressin levels or responsiveness
Participants	People aged ≥ 65 years living in the community **Gender**: 30 women, 13 men **Age**, mean, yrs: 73 (SD 6.6) **Nutritional status**: unclear
Study design	**Prospective** study **2 x 2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: no details provided, on a day following water deprivation from 7pm the previous evening, day 2 of 4 day stay **Cut-off:** < 295 vs. ≥ 295 mOsm/kg
Index and comparator tests	**24 hour urine volume (n = 43)** Method: observed by nursing staff while at research facility Timing: average over 4 days within research facility **Urine volume during day (n = 43)** Method: observed by nursing staff while at research facility, from 7am to 11pm Timing: average over 4 days within research facility

	Urine volume during night (n = 43) Method: observed by nursing staff while at research facility, from 11pm to 7am Timing: average over 4 days within research facility **Urine voids during day (n = 43)** Method: observed by nursing staff while at research facility, from 7am to 11pm Timing: average over 4 days within research facility **Urine voids during night (n = 43)** Method: observed by nursing staff while at research facility, from 11pm to 7am Timing: average over 4 days within research facility **Urine osmolality (n = 43)** Method: unclear Timing: on day 2 following water deprivation - similar time to serum osmolality
Follow-up	**Flow**: Of 190 people who replied to advertisements for volunteers and were given a telephone interview, 60 were given a screening physical exam and 48 admitted to the residential research unit. Of these 2 did not have serum osmolality recorded, and 3 had serum osmolality < 275 mOsm/kg, so were omitted from analysis
Notes	

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	Yes	Participants were resident in the community Consecutive recruitment
Acceptable reference standard? All tests	Yes	Serum osmolality (measured) Reviewers set our own cut-offs
Acceptable delay between tests? All tests	Unclear	Serum osmolality and urinary osmolality appear to have been taken around the same time on the same day, but urine volume and voiding were averaged over the 4 days of stay at the research facility
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs

Johnson 2003 (*Continued*)

Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	All participants were included that fit our inclusion criteria
Free of commercial funding?	Yes	Funding from National Institute on Aging, Emory University and Atlanta Veterans Affairs REhabilitation R&D Center and Birmingham Geriatrics Research Education and Clinical Center, authors all affiliated to healthcare or academic centres

Kafri 2012

Clinical features and settings	**People in hospital immediately following a stroke** UK **Aim**: to assess how dehydration is reflected in multi-frequency BIA
Participants	People admitted to hospital within 48 hours of a mild or moderate acute stroke **Gender**: 11 (35%) women, 20 men **Age**, mean, yrs: 77.6 years (SD 7.0) **Nutritional status**: mean BMI 27.4 kg/m² (SD 4.7), range 19 to 39.3 kg/m²
Study design	**Prospective** study **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: using freezing point depression on Advanced Instruments 2020 osmometer from venous blood sample, within 1 hour of index tests **Cut-off:** < 295 vs ≥ 295 mOsm/kg
Index and comparator tests	**Impedances at 5, 50 and 100 kHz, total body water as % of body weight, ECF and ICF as % of total body water by multi-frequency BIA (n = 21)** Method: participant supine, using Maltron BioScan 920-2 Timing: all within 20 minutes of reference standard **Dry tongue (n = 31)** Method: participant asked to stick out tongue, assessed by touch as damp, mildly dry, moderately dry or severely dry Timing: within 1 hour of blood sample for serum osmolality **Tongue furrowed (n = 31)** Method: participant asked to stick out tongue, assessed by touch as un-furrowed, mildly

	furrowed, moderately furrowed or severely furrowed Timing: within 1 hour of blood sample for serum osmolality **Skin turgor, back of hand (n = 31)** Method: skin on back of unaffected hand pinched then released, time taken for skin to return to normal timed (in seconds) Timing: within 1 hour of blood sample for serum osmolality **Capillary refill time, fingernail (n = 31)** Method:nail bed of middle finger of unaffected hand pressured until the nail is blanched, release pressure and time return of normal colour (in seconds) Timing: within 1 hour of blood sample for serum osmolality
Follow-up	**Flow**: Of 47 people recruited, 13 were aged < 65 years, 2 had no serum osmolality measure, and 1 had serum osmolality < 275 mOsm/kg, so 31 were included in the analyses. Additionally, 10 participants had invalid BIA data so their data were omitted from the BIA tables, leaving 21 in the BIA analyses
Notes	Intended to assess for presence of **orthostatic hypotension**, but almost none of the participants were able to stand up, so this was abandoned

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	No	No - participants were hospitalised (following a stroke) Yes - consecutive recruitment
Acceptable reference standard? All tests	Yes	Serum osmolality (measured) Reviewers set our own cut-offs
Acceptable delay between tests? All tests	Yes	Serum osmolality sample taken within 20 minutes of BIA and 1 hour of other index tests
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs

Kafri 2012 (*Continued*)

Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	All participants were included that fit our inclusion criteria
Free of commercial funding?	No	Funding provided by European Hydration Institute (independent but funded by some commercial interests), authors were employed in health care or academic institutions and the primary author was a PhD student

Kajii 2006

Clinical features and settings	**Frail elderly people living at home** Japan **Aim**: to determine the relationship between blood hypernatraemia or hyperosmolarity and risk factors associated with water intake and symptoms
Participants	Elderly people aged at least 65 years, living at home, visiting a community centre for the elderly and exhibiting risk factors for protein energy malnutrition (by a self-check questionnaire) **Gender**: 45 (63%) women, 26 (37%) men **Age**, mean, yrs: 76.0 (SD 7.0) **Nutritional status**: mean serum albumin 4.3g/dl (SD 0.25)
Study design	**Prospective** study **2 x 2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: using freezing point depression **Cut-off:** < 295 vs ≥ 295 mOsm/kg
Index and comparator tests	**All index tests (n=71)** Method:participants completed questionnaires answering the following questions. The wording was translated from Japanese by the authors, and is copied below. Each question was prefaced with "Please answer the situation for the past 3 days": Timing: questions were asked at the same home visit as the blood test, within 2 hours **Lips dry (n=71)** Method: answer to "Do you feel your lips get dry?" (yes or no allowed) **Mouth dry (n=71)** Method: answer to "Do you feel inside of your mouth get dry?" (yes or no allowed) **Feeling thirsty (n=71)** Method: answer to "Do you feel thirsty?" (yes or no allowed)

	Tongue smarts (n=71) Method: answer to "Do you feel your tongue smarts?" (yes or no allowed) **Mouth smarts (n=71)** Method: answer to "Do you feel anything except tongue inside of your mouth smarts?" (yes or no allowed) **Sticky mouth (n=71)** Method: answer to "Do you feel inside of your mouth is sticky?" (yes or no allowed) **Sticky saliva (n=71)** Method: answer to "Do you feel your saliva is sticky?" (yes or no allowed) **Fatigue (n=71)** Method: answer to "Do you feel fatigue?" (yes or no allowed) **Lassitude (n=71)** Method: answer to "Do you feel lassitude?" (yes or no allowed) **Dull (n=71)** Method: answer to "Do you feel dull?" (yes or no allowed) **Swallowing problems (n=71)** Method: answer to "Do you feel swallow disorder?" (yes or no allowed) **Enjoying food (n=71)** Method: answer to "Do you feel you can eat meal deliciously?" (yes or no allowed) **Appetite (n=71)** Method: answer to "Do you feel appetite?" (yes or no allowed) **Total daily intake of drinks (including drinks at and between meals) (n=71)** Method: answers to questions 1-6 on drinks intakes added up and multiplied by 200 mL per cup. Used as water intake in analysis Please answer your food custom (may answer no water, 1 cup, 2 cups, 3 cups or other, 1 cup is approximately 200 mL) 1. How much water do you drink at breakfast time? 2. How much water do you drink at lunch time? 3. How much water do you drink at dinner time? 4. How much water do you drink between breakfast and lunch? 5. How much water do you drink between lunch and dinner ? 6. How much water do you drink between dinner and next breakfast? **Ever misses drinking at meals? (n=71)** Method: answers 0 to at least one of questions 1-3 above **Ever misses drinking between meals? (n=71)** Method: answers 0 to at least one of questions 4-6 above
Follow-up	**Flow**: Of 74 people recruited, 3 had no serum osmolality measure so were excluded from our analysis
Notes	Paper in Japanese, relied on English abstract, author replies and the data set to describe the study. The authors did not ask whether participants had heart failure, so some people with heart failure may be included in the data set

Table of Methodological Quality

Item	Authors' judgement	Description

Representative spectrum? All tests	Unclear	Yes - participants were resident in the community Unclear - recruitment was from a community centre for older people, otherwise not described in English
Acceptable reference standard? All tests	Yes	Serum osmolality (measured) Reviewers set our own cut-offs
Acceptable delay between tests? All tests	Yes	Serum osmolality sample was taken at same home visit as index tests, within 2 hours
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	All participants were included that fit our inclusion criteria
Free of commercial funding?	Yes	Funded by Grants-in-Aid for Scientific Research <KAKENHI>, Japan Society for the Promotion of Science (http://www.jsps.go.jp/english/e-grants/index.html)

Lindner 2009

Clinical features and settings	**People in hospital intensive care unit (ICU)** Austria **Aim**: to quantitatively assess how a positive solute and/or negative fluid balance contributes to hypernatraemia
Participants	People in ICU admitted with serum sodium < 146 mEq/L but > 149 mEq/L during stay (acquired hypernatraemia) **Gender**: 13 (38%) women, 21 men **Age**, mean, yrs: 73.4 (SD 5.1) **Nutritional status**: mean BMI 27.0kg/m² (SD 5.2), range 19 to 36 kg/m² (for 22 of the 34 included participants, data not provided on the others)
Study design	**Retrospective** study **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: unclear **Cut-off:** < 295 vs ≥ 295 mOsm/kg
Index and comparator tests	**Heart rate (n=34)** Method: not stated Timing: within an hour of serum osmolarity blood sample **Fluid intake over 24 hours (n=34)** Method: including food and fluid, medications, enteral and parenteral nutrition and infusions Timing: serum osmolarity blood sample taken within 30 minutes of the end of 24 hour fluid balance assessment **Urine volume over 24 hours (n=34)** Method: from 24 hour urine collections Timing: serum osmolarity blood sample taken within 30 minutes of the end of 24 hour urine collection **Fluid balance over 24 hours (n=34)** Method: calculated from fluid intake and fluid losses Timing: serum osmolarity blood sample taken within 30 minutes of the end of 24 hour fluid balance assessment **Urine osmolality (n=27)** Method: not stated Timing: serum osmolarity blood sample taken within 30 minutes of the end of 24 hour urine collection
Follow-up	**Flow**: Of 981 people admitted to ICU 90 had hypernatraemia, of whom 69 developed it on the ward so were eligible. 24 were excluded due to missing data by the study authors. Of the remaining 45 participants 37 were aged at least 65 years, and 34 had both serum osmolality and fluid intake data. 34 participants are included in most analyses, but urine osmolality data were available for 27 participants only
Notes	Paper suggested that **body temperature** was measured, but these data were not in the data set we received. That serum osmolality was directly measured, and the timing of the tests, were confirmed with study authors

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - participants were hospitalised Yes - all appropriate patients were included over a specified time period
Acceptable reference standard? All tests	Yes	Measured serum osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	Serum osmolality sample taken within 1 hour of all index tests
Partial verification avoided? All tests	No	No - study retrospective Yes - all received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	All participants were included that fit our inclusion criteria
Free of commercial funding?	Yes	Paper states that no funding was used

Mack 1994

Clinical features and settings	**Healthy male volunteers aged at least 65 years** USA **Aim**: to examine the osmotic control of thirst and free water clearance in healthy older (and younger) individuals during a 6.5 hour dehydration-rehydration protocol
Participants	Healthy male volunteers aged at least 65 years, who had passed a physical examination and a stress test to ensure they could exercise safely **Gender**: 10 (100%) men **Age**, mean, yrs: 69 (SD 6.3), range 65-79 **Nutritional status**: mean weight 77.3kg (SD 8.9), range 58.7 to 87.1kg (no BMI provided)
Study design	**Prospective** study (before/after design), participants were measured at baseline, dehydrated through heat and exercise for 105mins, rested for 30mins, then allowed to rehydrate for 180mins **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: freezing point depression **Cut-off:** < 295 vs ≥ 295 mOsm/kg
Index and comparator tests	All data used were taken from the 0.5 hour recovery period (when mean serum osmolality was highest) **Urine volume (n=10)** Method: urine collected at 30 minutes after exercise ceased, multiplied up to volume over 24 hours Timing: serum osmolality blood sample taken at the same time as urine collection **Thirst (n=10)** Method: self-completed VAS thirst rating, VAS of 180mm, 0mm equates to "not thirsty at all", 125mm equates to "extremely thirsty" Timing: serum osmolality blood sample taken at the same time as VAS completion
Follow-up	**Flow**: Of 10 people aged at least 65 who were eligible and recruited none were excluded due to health problems or age or low serum osmolality. None were excluded due to missing data on urine volume or thirst rating
Notes	Paper suggested that **urine osmolality** and **sweat osmolality** were measured, but these data were not in the data set we received

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	Unclear	Yes - participants were living independently in the community Unclear - unclear how recruitment occurred

Mack 1994 (*Continued*)

Acceptable reference standard? All tests	Yes	Measured serum osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	Urine and blood samples taken at the same time
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	There did not appear to be any withdrawals
Free of commercial funding?	Yes	Funding was from National Institute on Aging, and all authors have academic affiliations

McGarvey 2010

Clinical features and settings	**Aukland marathon participants** New Zealand **Aim**: to investigate the diagnostic accuracy of commonly used signs of dehydration in marathon runners
Participants	Full marathon competitors **Gender**: 9 (82%) men, 2 women **Age**, Unclear, participants classified as aged 65-69 (7), 70-74 (3) and ≥75 years (1) **Nutritional status**: mean weight 70.2kg (SD 10.0), range 55.2 to 88.5kg (no BMI provided)

Study design	**Prospective** diagnostic accuracy study, participants were measured at registration and end of marathon **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Weight change** **Method**: body weight change from race registration (on Thursday, Friday or Saturday by personnel on duty) to following the marathon (held on the following Sunday morning, weighed by another volunteer), both times in running clothes and with shoes removed cut-off**:** <3% change in body weight vs. ≥3% change
Index and comparator tests	**Sunken eyes (n=11)** Method: assessed by examiner Timing: Immediately after the race and before drinking any fluids **Dry oral mucous membranes (n=11)** Method: visual assessment of tongue and inside of cheeks, by examiner in bright daylight without a torch Timing: Immediately after the race and before drinking any fluids **Reduced skin turgor on back of hand (n=11)** Method: assessed by pinching the middle of the back of the hand, and subjectively deciding whether obviously altered, by examiner. Not formally timed Timing: Immediately after the race and before drinking any fluids **Unable to spit (n=11)** Method: asked to spit into a cup, marked as able to or not Timing: Immediately after the race and before drinking any fluids **Feels thirsty (n=11)** Method: asked whether they feel thirsty Timing: Immediately after the race and before drinking any fluids
Follow-up	**Flow**: Of 1068 competitors, 701 gave consent and were weighed at race registration. Of these 606 were examined and weighed post-race, and of these 11 were aged at least 65 years, and included in this data set
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	Yes	Participants were living in community All appropriate participants appear to have been included
Acceptable reference standard? All tests	No	Reference standard was weight change, and while exercise was not unusual in these participants (they will have trained for the marathon) it was not usual exercise for this age group. Weight change was measured 12-72 hours before the race commenced,

		and compared to immediately post-race
Acceptable delay between tests? All tests	No	Pre-marathon weight was measured at registration 12-72 hours before the race, however the index tests were measured just before the second assessment of weight
Partial verification avoided? All tests	Yes	Prospective, and all received index tests and reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used in all participants
Incorporation avoided? All tests	Yes	Index tests and reference standard were distinct
Reference standard results blinded? All tests	Yes	The second weight was measured after the index tests by a study volunteer who did not assess the index tests and was not aware of the results of these tests
Index test results blinded? All tests	Yes	Index tests assessed by first author, before the second weight was measured (by a study volunteer)
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	No un interpretable data appeared in the data set as provided
Withdrawals explained? All tests	Yes	Exclusions were explained.
Free of commercial funding?	Yes	Funding not mentioned in paper, but first author states he covered the costs (which were not high), all authors were employed by academic or health institutions

Monahan 2006

Clinical features and settings	**Hospitalised people with multiple BNP measurements** USA **Aim**: to assess whether BNP (B-type Natriuretic Peptide) is influenced by factors other than volume status
Participants	Hospitalised people, not in intensive care, with multiple BNP measurements **Gender**: 7 (70%) women, 3 men **Age**, mean, yrs: 79.0 (SD 7.3), range 67-90

	Nutritional status: unclear (no BMI provided)
Study design	**Retrospective** study **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Weight change, within 7 days** **Method**: daily weight assessment cut-off**:** <3% of weight change vs ≥3% of weight change
Index and comparator tests	**Fluid balance over 24 hours (n=10)** Method: obtained from bedside flow sheets Timing: mean fluid balance over same period of weight assessment
Follow-up	Of 60 patients in the original paper we were provided with data from 40, of whom 12 were aged <65 years, 14 had heart failure, 1 renal failure, 3 did not have weight data over an appropriate period, leaving 10 people in our data set
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - participants hospitalised Unclear - chosen retrospectively for BNP measurements
Acceptable reference standard? All tests	No	No - weight change Yes - reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	Mean fluid balance over same period of weight assessment
Partial verification avoided? All tests	No	Study retrospective All did not have weight assessment
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	No	Fluid balance will affect weight change
Reference standard results blinded? All tests	Unclear	Weight measured, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs

Monahan 2006 (*Continued*)

Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Unclear	Of the 60 participants in the data set, we had data for 40
Withdrawals explained? All tests	Unclear	Of the 60 participants in the data set, we had data for 40 (unclear why 20 missing)
Free of commercial funding?	Unclear	Funding (or lack of it) not reported, authors provided academic affiliations

Perren 2011

Clinical features and settings	**Intensive Care Unit (ICU) patients** Switzerland **Aim**: to assess agreement between fluid balance and standardised body weight measurements for patients in ICU
Participants	ICU patients, consecutive patients admitted between October 2006 and March 2007 who stayed for at least 9 hours **Gender**: 58 (39%) women, 89 men (for whole population, not just those aged ≥65) **Age**, mean, yrs: 65 (SD 16) (for whole population) **Nutritional status**: no data
Study design	**Prospective** study **2x2 table published**: no, data set provided by authors
Target condition and reference standard(s)	**Weight change between admission and discharge to ICU** **Method**: weight change between admission and discharge, only stays of 7 days or less included (in standardised clothing following bed calibration) cut-off**:** <3% of weight change vs ≥3% of weight change (cut-off for current dehydration at 5% weight change)
Index and comparator tests	**Fluid Balance (n=27)** Method: sum of all daily fluid balance assessments (summing all daily inputs and outputs, including urine, GI and other drainage tubes, watery diarrhoea, estimated insensible losses) Timing: daily, over period of ICU stay **Fluid Intake (n=27)** Method: sum of total daily fluid inputs, using fluid balance chart, including all fluids, nutrition, medications and blood products regardless of the route of administration Timing: daily, over period of ICU stay **Urine output (n=27)** Method: sum of all daily urine output Timing: daily, over period of ICU stay

Follow-up	Of a total of 385 patients admitted to ICU during the study period 238 were excluded due to missing body weight or fluid balance chart data, or very short stay (leaving 147 participants). There were 151 patients in the original data set provided to the reviewers, 63 were aged less than 65 years, 10 had renal disease, 33 had cardiac insufficiency, 1 was in shock, 2 had invalid weight data (as stayed in ICU longer than 7 days), and 15 had a surgical procedure while in hospital. This left 27 participants to contribute data to the systematic review
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - participants hospitalised Yes - consecutive patients were eligible, but excluded if body weight was not measured at admission or discharge, or if any one fluid balance chart was incomplete
Acceptable reference standard? All tests	No	No - weight change Yes - reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	Mean fluid balance over same period of weight assessment
Partial verification avoided? All tests	Unclear	Yes - study prospective No - those who did not have weight assessment at admission or discharge were excluded (unclear how many)
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	No	Fluid balance will affect weight change
Reference standard results blinded? All tests	Unclear	Weight measured, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Unclear	No un interpretable data found in the data set offered

Withdrawals explained? All tests	Yes	Exclusions explained
Free of commercial funding?	Yes	The authors stated that the study was unfunded.

Powers 2012

Clinical features and settings	**Inpatients and outpatients in a geriatric facility** USA **Aim**: to assess the relationship between total body water predicted by BIA, urine osmolality and clinical criteria
Participants	Inpatients and outpatients at Acute Care for the Elderly **Gender**: 14 (64%) women, 8 men. **Age**, mean, yrs: 79.4 (SD 8.6), range 65-94 **Nutritional status**: mean BMI 27.4 (SD 6.5), range 14.7-41.0
Study design	**Prospective** study (cross-sectional) **2x2 table published**: no
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** **Method**: calculated by reviewers from serum electrolytes measured for study, using osmolarity = (2Na + 2K + urea/2.8 + glucose/18), with Na and K in mmol/L, urea and glucose in mg/dL cut-off**:** <295 vs ≥295 mOsm/L
Index and comparator tests	**Urine osmolality (n=22)** Method: measured by hospital clinical laboratory (method not stated), estimated from Urine specific gravity in 4 of the original 63 participants Timing: tests completed within 1 to 3 days of admission or in the outpatient centre at time of routine office visits **Heart rate (n=22)** Method: no method stated Timing: tests completed within 1 to 3 days of admission or in the outpatient centre at time of routine office visits **BIA resistance at 50kHz (n=22)** Method: measured on left and right sides using a Real Time Analyzer, RJL Systems, average of left and right measurements used for each participant Timing: tests completed within 1 to 3 days of admission or in the outpatient centre at time of routine office visits **Total body water by BIA at 50kHz (n=22)** Method: measured on left and right sides using a Real Time Analyzer, RJL Systems, average of left and right measurements used for each participant Timing: tests completed within 1 to 3 days of admission or in the outpatient centre at time of routine office visits **ECW by BIA at 50kHz (n=22)** Method: measured on left and right sides using a Real Time Analyzer, RJL Systems,

	average of left and right measurements used for each participant Timing: tests completed within 1 to 3 days of admission or in the outpatient centre at time of routine office visits
Follow-up	Of 82 volunteers, 63 participants were included in the published data. Of these 33 were excluded as having no serum sodium data, 4 for lacking serum urea, 2 for having heart failure and 2 for having serum osmolarity <275mOsm/L. This left 22 participants all aged at least 65 years
Notes	Urine Specific Gravity was collected in some participants, but available for only 3 of the 22 participants, so not assessed for review

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	No	No - mixture of inpatient (hospitalised) and outpatient (community dwelling) older people Unclear - randomly recruited between 2005 and 2010
Acceptable reference standard? All tests	No	No - calculated serum osmolarity Yes - reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Unclear	Unclear whether all tests conducted at same time, but were conducted on the same day for each participant
Partial verification avoided? All tests	No	Prospective, but 37 of 63 participants did not have serum osmolarity data
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data

Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	There did not appear to be any withdrawals, aside from reviewer exclusions
Free of commercial funding?	Yes	National Institutes of Health and the Bureau of Health Professions

Rowat 2011

Clinical features and settings	**Hospitalised people with suspected stroke** UK **Aim**: to assess whether urine colour and specific gravity provide early warning of dehydration in stroke patients
Participants	Patients admitted to a stroke unit with suspected ischaemic or haemorrhagic stroke and at risk of dehydration (severe stroke, dysphagia, immobile and/or reduced consciousness level) **Gender**: 11 (61%) women, 7 men **Age**, mean, yrs: 79.9 (SD 6.0), range 67-88 **Nutritional status**: unclear (no BMI provided)
Study design	**Prospective** study, participants were measured at baseline, and over the following 10 days **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** **Method**: calculated from serum electrolytes measured for study, using osmolarity = (2Na + 2K + urea + glucose), all in mmol/L cut-off**:** <295 vs ≥295 mOsm/L
Index and comparator tests	**Urine specific gravity - dipstick (n=18) & refractometer (n=17)** Method: assessed by dipstick (Multistix, Bayer) and by refractometer (digital hand-held DR-303 Index instruments) - refractometer data used in analysis Timing: all assessments were taken on day 0, but timing was not more specific **Urine colour (n=17)** Method: on 8-point chart under constant lighting Timing: all assessments were taken on day 0, but timing was not more specific **Skin turgor (n=18)** Method: site and method not specified in the study, the only instructions on the form were *"Doesn't bounce back if pinched"*, assessed as "yes" or "no" Timing: all assessments were taken on day 0, but timing was not more specific **Dry mouth (n=18)** Method: no specific instructions were provided to assessors, assessed as "yes" or "no" Timing: all assessments were taken on day 0, but timing was not more specific **Blue lips (n=18)** Method: no specific instructions were provided to assessors, assessed as "yes" or "no"

	Timing: all assessments were taken on day 0, but timing was not more specific **Sunken eyes (n=18)** Method: no specific instructions were provided to assessors, assessed as "yes" or "no" Timing: all assessments were taken on day 0, but timing was not more specific
Follow-up	All patients admitted to the stroke unit between 1 April 2007 and 30 April 2008 were assessed for inclusion. 20 were suitable and gave their informed consent, 2 were omitted from our analysis as they were aged <65 years, 18 were included in the review data set. Data on urine colour and specific gravity by refractometer missing in one participant with serum osmolarity >300mmol/L
Notes	Nurse assessment was also recorded, but no specific instructions were provided, and the authors stated that "assessment may have included information regarding blood tests data and USG (dipstick)" - so these data were not included in this systematic review. Index tests were carried out on days 1 to 10 of the study, but as serum osmolarity was only calculable at baseline, only baseline index test data have been used in the review

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	No	No - participants hospitalised Yes - all relevant patients assessed for inclusion, sequential recruitment
Acceptable reference standard? All tests	No	Serum osmolarity (calculated rather than measured serum osmolality)
Acceptable delay between tests? All tests	Unclear	All measurements appear to have been taken during the day of admission
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data

Rowat 2011 (*Continued*)

Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	There did not appear to be any withdrawals, aside from reviewer exclusions
Free of commercial funding?	Yes	Funded by NHS Lothian Research and Development, authors employed as health professionals or academics

Shimizu 2012

Clinical features and settings	**Older patients with acute medical conditions** Japan **Aim**: to assess the utility of physical signs of dehydration in the elderly
Participants	Patients aged at least 65 years who presented to an acute care teaching hospital and consecutively admitted to the Department of Medicine with acute medical conditions **Gender**: 12 (41%) women, 17 men **Age**, mean, yrs: 84.0 (SD 4.2) dehydrated males, 85.0 (SD 7.5) dehydrated females, 83.3 (SD 6.4) hydrated males, 89.5 (SD 5.3) hydrated females **Nutritional status**: BMI mean (SD) not stated
Study design	**Prospective** study (cross-sectional) **2x2 table published**: yes, data provided in published papers
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** **Method**: calculated using osmolarity = (2Na + glucose/18 + BUN/2.8), where BUN is blood urea nitrogen cut-off**:** ≤295 vs >295 mOsm/L (slightly different from the review cut-off)
Index and comparator tests	**Dry mouth (n=27)** Method: assessed by internal medicine residents, present when both mucous membrane and tongue were dry by inspection Timing: time between blood sample and assessment of mouth unclear **Dry axilla to touch (n=29)** Method: assessed by internal medicine residents, present when bilateral axillary skin was dry when palpated using examiners second to fifth fingers Timing: time between blood sample and assessment of axilla unclear **Dry axilla to skin moisture meter (n=29)** Method: assessed by internal medicine residents, measured while patient supine at centre of axilla, with a skin moisture metre (MCE-3259, Macros Corporation) Timing: time between blood sample and assessment of axilla unclear **Sunken eyes (n=29)** Method: assessed by internal medicine residents, present when bilateral eyeballs seemed abnormally sunken Timing: time between blood sample and assessment of eyes unclear **Skin turgor (n=29)**

	Method: assessed by internal medicine residents, abnormal when anterior chest skin returned to its normal position slowly after being pinched between examiners thumb and forefinger Timing: time between blood sample and assessment of skin unclear **Capillary refill time (n=27)** Method: assessed by internal medicine residents, slow when normal colour took more than 2 seconds to return after distal phalanx of patient's middle finger was compressed for 5 seconds when level with the patients heart Timing: time between blood sample and assessment of finger unclear **Consciousness level (n=27)** Method: assessed by primary physicians, noted as decreased or normal Timing: time between blood sample and assessment of consciousness unclear
Follow-up	Consecutively admitted patients with informed consent - data for 29 are presented in one paper, 27 in the other (unclear why there is a difference)
Notes	Requested data set from authors so that we could analyse tests against measured serum osmolality (rather than calculated serum osmolarity), and omit any participants with heart failure. Not obtained to date

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - participants were in hospital and acutely ill Unclear - all those who were eligible and were consecutively enrolled, but differing numbers unclear
Acceptable reference standard? All tests	No	Serum osmolarity (calculated rather than measured serum osmolality)
Acceptable delay between tests? All tests	Unclear	Timing unclear
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, standard cut-off

Shimizu 2012 (*Continued*)

Index test results blinded? All tests	Yes	Dichotomous and continuous data, researchers set cut-offs, blood test taken after tests assessed
Relevant clinical information? All tests	Unclear	Unclear whether clinical information was used to inform any judgements by researchers
Uninterpretable results reported? All tests	Unclear	2 participants missing for some index tests
Withdrawals explained? All tests	Unclear	2 participants missing for some index tests
Free of commercial funding?	No	One author worked for Terumo Corporation which manufactures and sells medical products and equipment

Sjöstrand ED 2013

Clinical features and settings	**Elderly people attending an emergency room of a tertiary care centre** Sweden **Aim**: to describe fluid status in young and older patients in an emergency department setting, using volume kinetics and signs of dehydration
Participants	People aged 75-97 years old who attended the emergency room of a tertiary care centre and who were not terminally ill, and without heart failure (NYHA IV), renal insufficiency, cognitive dysfunction, chest pain, arrhythmias, open fractures or required immediate emergency room attention. People aged 20-39 years were also included in the study, but not in the review analysis **Gender**: 23 (58%) women, 17 men **Age**, mean, yrs: 83.9 (SD 6.0), range 75-97 **Nutritional status**: BMI mean 23.7 (SD 4.9), range 11.2 to 35.4 kg/m^2 (BMI data provided for 39 of 40 participants)
Study design	**Prospective** study, observational, participants were measured at baseline, then during volume expansion (through infusion of buffered crystalline glucose solution. Baseline data only are used for this analysis **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: measured with an osmometer (Fiske 2400, Advanced Instruments, Norwood MA) cut-off**:** <295 vs ≥295 mOsm/kg
Index and comparator tests	**Urine colour (n=36)** Method: using Armstrong colour chart Timing: assessed on baseline urine sample

	Urine osmolality (n=38) Method: measured with an osmometer (Fiske 2400, Advanced Instruments, Norwood MA) Timing: assessed on baseline urine sample **Participant expression of symptoms (n=31)** Method: asked (in a paper-based questionnaire, with verbal instructions) whether was experiencing the symptom, and if "yes" asked to state severity on 100mm VAS (with no symptoms marked as 0), severe symptoms at top of scale. Symptoms included **balance problems, headache, nausea, dry mouth, muscle weakness, tiredness, thirst, dizziness**. Timing: time 0 (baseline) before infusion, the same time as serum osmolality blood sample obtained
Follow-up	168 patients were asked whether they would like to participate, of whom 102 were excluded as they did not meet the inclusion criteria (79) or did not give informed consent or presented logistic problems. Of the 66 participants recruited, 41 were aged at least 70, the remaining 15 participated in the younger group (not analysed here). One of the 41 was excluded as unrealistic (serum osmolality of 445), leaving 40 in our data set. Of these 36 had urine colour data, 38 had urine osmolality, and 31 provided data on symptoms
Notes	Data were also collected on heart rate and urine specific gravity but not provided by the authors (as they were stored in a separate location and not accessible). Data were also collected on BIA (USD 6000 bioimpedance machine) but the data were not provided as the author felt that the equipment did not reflect the large changes in body composition achieved in this intervention, and that its use was difficult in the older people included

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	No	No - participants were attending an emergency room Unclear - unclear how recruitment occurred
Acceptable reference standard? All tests	Yes	Measured serum osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	Data were all taken from study baseline, before intervention, within 30 minutes of each other
Partial verification avoided? All tests	Yes	All received reference standard Prospective
Differential verification avoided? All tests	Yes	All had serum osmolality (directly measured) as the reference standard

Sjöstrand ED 2013 (*Continued*)

Incorporation avoided? All tests	Yes	The index tests did not form any part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	Missing data on urine colour, urine osmolality, and symptoms were due to participants being too ill, not being able to get to the toilet, and lack of an examination room in the emergency department (so that some interviews took place in the corridor where privacy could not be assured)
Free of commercial funding?	Yes	Financial support was provided through the regional agreement on medical training and clinical research (ALF) between Stockholm County Council and Karolinska Institutet and an unrestricted grant by Masimo Inc., Irvine, CA. (Masimo Inc produce the spectrophotometric adhesive sensor used to monitor haemoglobin concentration, peripheral perfusion index, oxygen saturation, and pulse rate). These measures were not relevant to our review

Sjöstrand Healthy 2013

Clinical features and settings	**Elderly volunteers** Sweden **Aim**: to examine effects of drinking vs intravenous infusion of a set volume of fluid (crossover intervention study, data compared between older and younger people)
Participants	People aged 70-90 years old who responded to advertisements and without dementia, heart failure (NYHA III-IV), and not taking diuretics or ACE medications **Gender**: 7 (54%) women, 6 men **Age**, mean, yrs: 81.2 (SD 4.0), range 74-88 **Nutritional status**: BMI mean 25.1 (SD 3.9), range 18.6 to 31.1 kg/m^2 (BMI data provided for 11 of 13 participants)

Study design	**Prospective** study, cross-over intervention study, participants were measured at baseline, then during fluid infusion or consumption, but baseline data on iv visit only used in this analysis **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: measured with an osmometer (Fiske 2400, Advanced Instruments, Norwood MA) cut-off**:** <295 vs ≥295 mOsm/kg
Index and comparator tests	**Urine specific gravity (n=12)** Method: urine test strips (Urisys 1100 and Combur 10 Test M, both from Roche Diagnostics, Scandinavia, Bromma, Sweden) Timing: time 0 (baseline) in iv arm of intervention study, the same time as serum osmolality blood sample obtained **Urine colour (n=10)** Method: using Armstrong colour chart Timing: assessed on baseline urine sample **Urine osmolality (n=13)** Method: measured with an osmometer (Fiske 2400, Advanced Instruments, Norwood MA) Timing: assessed on baseline urine sample **Heart rate (n=13)** Method: digital blood pressure monitor (Omron, Kyoto, Japan) Timing: time 0 (baseline) in iv arm of intervention study, the same time as serum osmolality blood sample obtained **Participant expression of symptoms (n=13)** Method: asked whether was experiencing the symptom, and if "yes" asked to state severity on 100mm VAS (with no symptoms marked as 0), severe symptoms at top of scale. Symptoms included **balance problems, headache, nausea, dry mouth, muscle weakness, tiredness, thirst, dizziness**. Timing: time 0 (baseline) in iv arm of intervention study, the same time as serum osmolality blood sample obtained
Follow-up	Thirteen appropriate older volunteers were found, none dropped out, 13 people aged at least 70 had serum osmolality measures and of these all had urine osmolality, heart rate and symptom data, 12 had urine specific gravity and 10 had urine colour
Notes	Data were also collected on BIA (USD 6000 bioimpedance machine) but the data were not provided as the author felt that the equipment did not reflect the large changes in body composition achieved in this intervention, and that its use was difficult in the older people included

Table of Methodological Quality

Item	Authors' judgement	Description

Sjöstrand Healthy 2013 (*Continued*)

Representative spectrum? All tests	Unclear	Yes - participants were free-living volunteers Unclear - unclear how recruitment occurred
Acceptable reference standard? All tests	Yes	Measured serum osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	Data were all taken from study baseline, before intervention, within several minutes of each other
Partial verification avoided? All tests	Yes	All received reference standard Prospective
Differential verification avoided? All tests	Yes	All had serum osmolality (directly measured) as the reference standard
Incorporation avoided? All tests	Yes	The index tests did not form any part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	Author reports no withdrawals
Free of commercial funding?	Yes	Funded by Stockholm County (PickUp Funding)

Source Study 2001

Clinical features and settings	**Residents of 6 long-stay or step-down institutions** France **Aim**: to validate BIA equations derived to estimate total body water and ECW in healthy elderly people

Source Study 2001 (*Continued*)

Participants	People aged at least 60 years living in French institutions who gave written informed consent (could have infections, organ failure, weight loss, heart failure, kidney failure, stroke or hydration problems, but not limb abnormality, artificial nutrition, ascites, intensive care or end of life) **Gender**: 103 (63%) women, 61 men **Age**, mean, yrs: 82.6 (SD 7.4), range 65-97 **Nutritional status**: BMI mean (SD) in 60 men 23.9 (4.0), in 109 women 24.9 (4.8)
Study design	**Prospective** study (cross-sectional) **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolarity, mOsm/L (calculated)** **Method**: calculated by researchers from serum electrolytes measured for study, using osmolarity = (2Na + 2K + urea + glucose), all in mmol/L cut-off**:** <295 vs ≥295 mOsm/L
Index and comparator tests	**Skin turgor, thigh (n=162)** Method: presence or not of skin turgor, coded as "lasting skinfold on anterior side of the thigh" or normal Timing: unclear, all measurements appear to have been taken over 5 hours **Mucosal dryness (n=164)** Method: not described, coded as abnormal (dry) or normal Timing: unclear, all measurements appear to have been taken over 5 hours **Feeling of Thirst (n=164)** Method: asked "Do you feel thirsty?", answered yes or no Timing: unclear, all measurements appear to have been taken over 5 hours **Presence of bed sores (n=164)** Method: not described, coded as yes or no Timing: unclear, all measurements appear to have been taken over 5 hours **Total body water (TBW) assessed by ^{18}O isotope dilution as % body weight (n=157)** Method: 50g of 2% 18O-enriched water was given orally, plasma and urine samples were taken at baseline and 4 and 5 hours after the isotope dose Timing: unclear, all measurements appear to have been taken over 5 hours **Extracellular water (ECW) assessed by bromide dilution as % of total body water (n=76)** Method: 20g potassium bromide syrup (1g bromide) was given to half the participants, plasma and urine samples were taken at baseline and 4 and 5 hours after the isotope dose Timing: unclear, all measurements appear to have been taken over 5 hours
Follow-up	Of 177 participants in the original data set, 5 were excluded as they were aged <65 years, and 8 more excluded from our data analysis as they lacked serum potassium data, data were analysed on 164 people. Only half the sample had bromide dilution (n=76), and some individuals had missing data for total body water (7) and skin turgor (1)
Notes	We were unable to omit those with heart or renal failure. Impedance data at 5, 50 and 100kHz were measured but not available for analysis (left in previous place of work)

Source Study 2001 (*Continued*)

Table of Methodological Quality		
Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	Unclear	Yes - participants were living in long-term or step-down care Unclear - unclear how recruitment occurred
Acceptable reference standard? All tests	No	Serum osmolarity (calculated rather than measured serum osmolality)
Acceptable delay between tests? All tests	Unclear	All measurements appear to have been taken over 5 hours
Partial verification avoided? All tests	Yes	Study prospective All (except 5 with no potassium data) received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Unclear	Yes - For continuous data reviewers set cut-offs Unclear - For dichotomous data (yes/no)
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	There did not appear to be any withdrawals, aside from reviewer exclusions
Free of commercial funding?	No	Supported by the Institut de l'Eau Perrier Vittel

Stookey 2005

Clinical features and settings	**Nationally representative sample of older people** USA **Aim**: to assess the prevalence of dehydration in older people
Participants	Non-institutionalised people aged at least 65 years who participated in the Third National Health and Nutrition Examination Survey (NHANES III, see http://www.cdc.gov/nchs/nhanes.htm) including non-Hispanic white, non-Hispanic African-American and Mexican-American respondents **Gender**: 1002 (51%) women, 945 men **Age**, mean, yrs: 74.8 (SD 6.8), range 65-90 **Nutritional status**: BMI mean (SD) 27.0 (5.0)
Study design	**Prospective** study (cross-sectional) **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: not stated cut-off**:** <295 vs ≥295 mOsm/kg
Index and comparator tests	**Total body water (TBW) assessed by BIA as % body weight (n=1946)** Method: single frequency (50kHz) BIA (Valhalla Scientific Body Composition Analyzer, model 1990), measured in supine position with electrodes attached to the right wrist, hand, ankle and foot Timing: BIA and blood sample for serum osmolarity taken during a single mobile centre interview **BIA resistance at 50kHz (n=1947)** Method: as above Timing: BIA and blood sample for serum osmolarity taken during a single mobile centre interview
Follow-up	Of 18,110 participants in NHANES III, 14,855 people had phlebotomy data and were included in the original data set, and of these 3688 were aged at least 65. Of these, 342 were removed as they had heart failure or oedema, 360 had serum osmolality less than 275mOsm/kg, 877 did not have a measured serum osmolality, and 162 did not have any BIA measures. This left 1947 participants for inclusion in the review
Notes	**Total fluid intake** was also assessed (all fluids except pure water recorded in a single 24-hour recall), but this was not used due to the exclusion of water in fluid intake assessment. **Serum tonicity** was also calculated from serum sodium, potassium and glucose (we used serum osmolality as the reference standard instead)

Table of Methodological Quality

Item	**Authors' judgement**	**Description**
Representative spectrum? All tests	Yes	Participants were living in the community Recruitment ensured a representative sample of the population

Stookey 2005 (*Continued*)

Acceptable reference standard? All tests	Yes	Measured serum osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Unclear	BIA and blood sample for serum osmolarity taken during a single mobile centre interview
Partial verification avoided? All tests	Yes	Study prospective All those included received the reference standard so long as there was a large enough blood sample (877 did not have serum osmolality measured)
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	Some data were missing but this appeared to be due to blood sample handling
Free of commercial funding?	Yes	NHANES was funded by the National Center for Health Statistics, Stookey's analysis by the National Heart, Lung and Blood Institute

Stotts 2009

Clinical features and settings	**Nursing home residents at risk for pressure ulcers** USA **Aim**: to assess whether supplemental fluid intake enhances collagen deposition, body water and subcutaneous tissue oxygenation, and is safe

Participants	Nursing home residents expected to remain resident for at least 3 weeks, at risk for pressure ulcers (Braden Scale Score ≤18) with BMI 20-29.9kg/m^2 and white blood cell count ≥2000/mm^3, excluding those with heart failure, chronic kidney disease, recent acute illness, glycosylated haemoglobin >8% or known or suspected dehydration **Gender**: 31 (65%) women, 17 men **Age**, mean, yrs: 80.0 (SD 8.1), range 65-95 **Nutritional status**: BMI mean (SD) not stated
Study design	**Prospective** study (RCT of fluid intervention) **2x2 table published**: no, data set (of baseline data) provided by author
Target condition and reference standard(s)	**Serum osmolality, mOsm/kg (directly measured)** **Method**: not stated cut-off**:** <295 vs ≥295 mOsm/kg
Index and comparator tests	**Fluid intake over 24 hours (n=48)** Method: including drinks and foods liquid at room temperature, observed by research nurse from 8am to 8pm (measured with graduated cylinder) and by facility staff from 8pm to 8am Timing: serum osmolality blood sample was taken on day 1, the 24 hour fluid intake on day 2 of the study baseline period **Type of fluid intake (n=48)** Method: participants were classified as oral intake without thickener, oral intake with thickener or nasogastric feed Timing: serum osmolality blood sample and type of fluid intake appear to correspond in time (day 2 during study baseline)
Follow-up	Of 2443 nursing home residents screened 311 were eligible (261 were unclear, 1871 ineligible), of whom 181 refused and the doctor of 66 refused, so that 64 were enrolled in the study and randomly assigned (53 completed). Of 62 participants in the data set received by the review (on day 2, during the observation period before the intervention) , 3 were removed as they were aged <65 years, 9 had no measured serum osmolality (as 1 was returned as a lab error and 8 dropped out as 2 were in hospital, 2 had raised blood sugars, 2 had infections and 2 withdrew) and 2 had serum osmolality <275mOsm/kg, so our analysis was on the remaining 48 participants
Notes	**Total body water** was also assessed by BIA (single frequency 50kHz RJL Quantum II machine, participant supine and electrodes placed on right metatarsals and ankle and metacarpals and wrist and measurements completed in less than a minute) however not reported as a proportion of body weight, so not used

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	Yes	Participants were living in nursing homes All those who were eligible and gave consent were enrolled

Stotts 2009 (*Continued*)

Acceptable reference standard? All tests	Yes	Measured serum osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	No	Serum osmolality on day 1, 24-hour fluid intake on day 2 of the study baseline
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Data were continuous, reviewers set cut-offs, data collectors were not informed of lab findings, so were blinded
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	Most exclusions were by reviewers (only 2 lost from data set)
Free of commercial funding?	Yes	Funding from National Institute of Nursing Research, all authors appear affiliated to health or academic institutions

Walsh 2012

Clinical features and settings	**Older people admitted to an acute medical unit** UK **Aim**: to assess whether those with dry eye have higher serum osmolality than those without dry eye
Participants	People aged at least 60 years admitted to acute medical care (without recent eye surgery, contact lens use or eye drop use) **Gender**: 51 (48%) women, 55 men **Age**, mean, yrs: 78.8 (SD 7.7), range 65-101 **Nutritional status**: not stated

Study design	**Prospective** study (cross-sectional) **2x2 table published**: no, data set provided by author
Target condition and reference standard(s)	**Plasma osmolality, mOsm/kg (directly measured)** **Method**: freezing point depression osmometer (Model 330 MO, Advanced Instruments) cut-off**:** <295 vs ≥295 mOsm/kg
Index and comparator tests	**Dry eye questionnaire, DEQ-5 (n=104)** Method: Scores frequency and severity of eye discomfort, eye dryness and frequency of watery eyes during the evening of a typical day in the last month, with each scored 0 (never experience) to 5 (extremely severe), the highest possible score is 25 Timing: all measures (index and then reference standard) taken within 30 minutes **Visual analogue scale, VAS (n=104)** Method: Perceived eye dryness in response to "How dry do your eyes feel right now?", from 0mm "not at all dry" to 100mm "very dry" Timing: all measures (index and then reference standard) taken within 30 minutes **Non-invasive tear film break up time, NITBUT (n=104)** Method: Using Tearscope-Plus (Keeler Instruments), measured 3 times, median used in analyses. A shorter NITBUT time is indicative of dry eye Timing: all measures (index and then reference standard) taken within 30 minutes **Tear osmolarity, mOsm/L (n=89)** Method: Tear fluid collected by TearLab Osmolarity System (TearLab, San Diego California). Participant blinked 3 times and squeezed eyes shut, then tear fluid collected from right eye with TearLab pen, which beeped once 50nL of fluid was collected, then osmolarity displayed once pen was docked (calibrated daily). Assessment of tear osmolarity was by electrical impedance Timing: all measures (index and then reference standard) taken within 30 minutes
Follow-up	Of 165 participants who met the inclusion criteria, 130 gave informed consent and had plasma osmolality data. Of these 10 people were excluded as aged <65 years, 1 was excluded as they had heart failure, 1 due to renal disease and 13 excluded as having plasma osmolality <275mOsm/kg, leaving 105 participants. Of these results for index tests were missing for 1 person for each test apart from tear osmolality (where results were missing for 16 participants - 9 were unable to tolerate the test, 7 were unable to provide sufficient volume of eye fluid)
Notes	

Table of Methodological Quality

Item	Authors' judgement	Description
Representative spectrum? All tests	No	No - participants were admitted to an acute medical unit Unclear - unclear how recruitment occurred

Walsh 2012 (*Continued*)

Acceptable reference standard? All tests	Yes	Measured plasma osmolality Reviewers set our own cut-offs as we had access to the full data set
Acceptable delay between tests? All tests	Yes	All measures (index and then reference standard) taken within 30 minutes
Partial verification avoided? All tests	Yes	Study prospective All received the reference standard
Differential verification avoided? All tests	Yes	The same reference standard was used for all participants
Incorporation avoided? All tests	Yes	The index tests did not form part of the reference standard
Reference standard results blinded? All tests	Yes	Biochemical measures used, reviewers set cut-offs
Index test results blinded? All tests	Yes	Continuous data, reviewers set cut-offs
Relevant clinical information? All tests	Yes	Assessments made by reviewers without reference to clinical data
Uninterpretable results reported? All tests	Yes	Gaps in the data set clear (full data set provided)
Withdrawals explained? All tests	Yes	Withdrawals were explained (12 did not have appropriate tear osmolality data, 7 were unable to tolerate the test, 5 were unable to provide sufficient volume of eye fluid), aside from reviewer exclusions
Free of commercial funding?	No	This study was a bolt-on study to a larger study funded by HydraDX, but the company did not benefit from these results

TBW total body water, ICF intracellular fluid, ECF extracellular fluid, USG urine specific gravity

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Albert 1989	Authors replied that they could not find the data set, but would forward it if found
Bennett 2004	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Bourdel-Marchasson 2004	It appears that the dataset includes a reference standard (serum osmolality) and index tests (thirst, dry mouth, axillary dryness, ocular membrane dryness, skin elasticity and body temperature) but not in a format that can be utilised in the review, and no dataset received
Bowser-Wallace 1985	Contact replied that main collaborators have died, so no-one has access to the data set any longer
Bruzzone 2004	The published paper suggests that data were collected on a reference standard (weight change) and at least one index test (fluid balance, which is likely to include assessment of fluid intake), however data are not in a format that can be used for this review and contact not established with author
Buffa 2010	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Chen 2006	The published paper suggests that data were collected on a reference standard (plasma osmolality) and at least one index test (urine volume), however data were not in a format that could be used for this review, and contact with the authors could not be established
Chen 2010	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Cooper 1991	Author replied that they did collect relevant reference standard data, but no longer have access to the data set
Cunneen 2011	The contact author, Elaine Bannerman, replied that they did not collect a relevant reference standard
Davies 1995	The first author, Ioan Davies, replied that he is no longer able to find the dataset
Dijkstra 1998	It is not clear from the published paper whether data were collected on a reference standard and/or at least one index test (as it was not clear how dehydration status was assessed), and contact not established with author
Faull 1993	Authors state that they no longer have access to the original data set, and the thesis did not contain enough data for our analysis
Forsyth 2008	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Fredrix 1990	The authors replied that the data are no longer available.

(*Continued*)

Fuller 1996	Data set received in full, but no data available on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Gaspar Nuns 2009	Full data set provided by author. 70 religious sisters had serum osmolality and BIA measured but none had serum osmolality of at least 295 mOsm/kg, so the data could not be used
Gaspar Nursing Home 2011	Author confirmed that none of our reference standards was measured
Gil Cama 2003	The published paper suggests that data were collected on a reference standard (weight change) and at least one index test (fluid balance, which is likely to include assessment of fluid intake), however data are not in a format that can be used for this review and contact could not be established with author
Gross 1992	Author replied that they no longer had the data.
Hodkinson 1981	The study appears to have assessed an index test (mental test score and "assessment of dehydration", method unclear) and may have assessed serum osmolarity (calculated, if serum sodium, potassium, glucose and urea are all available) but contact not established with the authors to confirm
Holben 1999	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Hoyle 2011	The published paper suggests that data were collected on at least one index test (BIA assessment of total body water, orthostatic hypotension), however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
Johnson 1994	The first author replied to our query and stated that the raw data for his study had not been kept, and are no longer available
Kayser-Jones 1999	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Kehayias 2012	The author, J Kehayias, confirmed that they did not collect reference standard data
Kuo 2002	The published paper suggests that data were collected on at least one index test (urine specific gravity) , however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
Leibovitz 2007	The author replied that the person who carried out the statistical analyses and kept the data is no longer available, so the data are no longer accessible
Leiper 2005	The published paper suggests that data were collected on a reference standard (weight change) and at least one index test (urine volume, urine osmolality), however data are not in a format that can be used for this review and contact could not be established with author
Lennox 1980	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity

(*Continued*)

Martof 1997	The published paper suggests that data were collected on a reference standard (serum osmolality and weight change) and at least one index test (fluid balance, fluid intake, urine volume, sunken eyes, dry mucous membranes, tenting), however data are not in a format that can be used for this review and contact could not be established with author
Mentes 2003	Authors state that they did not collect any reference standard data
Mentes 2008	Saliva osmolality collected, but no reference standard measured
Meuleman 1992	Authors state that they no longer have access to the data set
Morgan 2002	The published paper suggests that data were collected on a reference standard (serum osmolality) and at least one index test (heart rate), however data are not in a format that can be used for this review and contact could not be established with author
Morgan 2003	The published paper suggests that data were collected on a reference standard (serum osmolality) and at least one index test (urine osmolality, urine specific gravity), however data are not in a format that can be used for this review and contact could not be established with author
Norman 2007	The published paper suggests that data were collected on at least one index test (BIA assessment of total body water), however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
O'Neill 1992	Authors replied that they no longer have access to the data set
O'Neill 1997	Authors replied that they no longer have access to the data set
Olde Rikkert 1997	Authors replied that data sets have been lost in computer upgrades
Olde Rikkert 1997a	Authors replied that data sets have been lost in computer upgrades
Olde Rikkert 1998	Authors replied that data sets have been lost in computer upgrades
Palevsky 1996	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Perrier 2013	Participants were aged 25-40 years, none were aged 65+ years
Phillips 1984	Professor Rolls posted us the PhD thesis that this paper was based on, but unfortunately it did not contain enough detail for us to create 2x2 tables (for serum osmolality vs. thirst, dry mouth, water intake and bad taste). Professor Phillips confirmed that the original data sets could not be located
Piccoli 2000	The published paper suggests that data were collected on a reference standard (plasma osmolality) and at least one index test (BIA), however data are not in a format that can be used for this review and contact could not be established with author
Powers 2009	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity

(*Continued*)

Rhodes 1995	The published paper suggests that data were collected on at least one index test (intra ocular pressure, orthostatic hypotension), however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
Roberts 1991	The published paper suggests that data were collected on a reference standard (weight change) and at least one index test (urine osmolality, urine output), however data are not in a format that can be used for this review and contact could not be established with author
Robinson 1985	The published paper suggests that data were collected on at least one index test (orthostatic hypotension, skin turgor, axillial moisture, tongue, vein filling), however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
Roos 1995	It appears that the dataset includes a reference standard (weight change) and index tests (BIA assessment of total body water, skin turgor, dry mucous membranes, sunken eyes) but not in a format that can be utilised in the review, and no contact could be established with researchers
Rosher 2004	It appears that the dataset includes a reference standard (weight change) and index tests (BIA assessment of total body water, extracellular water, foot vein filling, skin turgor, dry mucous membranes, sunken eyes, tongue furrows, pulse rate) but not in a format that can be utilised in the review, and no contact could be established with researchers
Rosler 2010	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Rudolph 2011	Authors replied that they did not collect any data we could use as a reference standard (no serum osmolality or components of osmolarity)
Savalle 2012	Corresponding author, Christophe Faisy, replied to say that no reference standard was collected
Schols 1991	Authors replied that the data were gathered too long ago to be recollected
Schut 2005	It appears that the dataset includes a reference standard (plasma osmolality) and index tests (BIA assessment of total body water, dry tongue, tongue furrows, thirst perception, heart rate, orthostatic hypotension, dry mucous membranes) but not in a format that can be utilised in the review, and no dataset received (researcher stated he was ill and would consider this when he recovered)
Seinela 2003	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Shim 1987	It appears that the dataset aimed to induce dehydration but this was not clearly confirmed using a reference standard. Index tests (sputum production and elasticity) were asessed. No contact could be established with the authors
Ship 1997	Dena Fischer replied that she had no access to the raw data, and that her colleague, J Ship, had died
Shiraki 1980	It appears that the dataset includes a reference standard (serum osmolality) and index tests (urine output) but not in a format that can be utilised in the review, and no dataset received as contact could not be established with the authors

(*Continued*)

Simmons 2001	The authors replied that they no longer have access to the original data set
Singh 2013	No participants were aged at least 65 years.
Siregar 2010	Urine osmolality assessed in elderly people but no reference standard collected
Spangler 1998	The published paper suggests that data were collected on at least one index test (fluid intake), however it was not clear whether data were collected on at least one reference standard. The authors suggested that no reference standard was collected, but did not confirm this
Sugaya 2008	It appears that the dataset includes a reference standard (serum osmolality) and index tests (urine osmolality) but not in a format that can be utilised in the review, and no dataset received as contact could not be established with the authors
Suhr 2004	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Suhr 2010	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Szewczyk 2008	The published paper suggests that data were collected on at least one index test (fluid intake), however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
Takahashi 1997	The published paper suggests that data were collected on at least one reference standard (serum osmolality and osmolarity) and index test (BIA, TBW) but the data were not in a format that could be used directly in the review, the ages of participants were unclear, and contact could not be established with the authors
Tamura (REGARDS) 2010	Primary investigator, George Howard, replied and Mary Cushman confirmed, that this study did not collect a reference standard
Telfer 1965	Authors replied that data are now missing and could not be found following extensive contact with several possible institutions
Thomas 2003	It appears that the dataset includes a reference standard (serum osmolality) and index tests (orthostatic blood pressure change) but not in a format that can be utilised in the review, and no dataset received (discs containing statistical data not found, and new statistical programme now used)
Tonstad 2006	Authors replied that they were not able to access the data set due to computer problems (also, few aged >65 years)
Vache 1998	The only index tests used were total body water (TBW) as a percentage of body weight by 18O isotope dilution and extracellular water (ECW) as a percentage of total body water by bromide dilution. These methods were decided to be too complex to be useful signs to use in the community
van der Steen 2007	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity

(*Continued*)

van Kraaij 1999	It appears that the dataset includes a reference standard (weight change and plasma osmolality) and index tests (dry oral mucosa, thirst, blood pressure, heart rate) but not in a format that can be utilised in the review, and contact could not be established with the authors
Vazquez 2010	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Vivanti 2008	Authors provided data set including serum osmolality, but none of the participants serum osmolality measures was greater than 291mOsm/kg (so none had impending or current dehydration) so the data could not be used
Vivanti 2010	Authors confirmed that they did not collect data on serum osmolality, short term weight change or serum data that would allow calculation of serum osmolarity
Wakefield 2002a	The dataset includes a reference standard (serum osmolality) and index tests (urine colour, urine osmolality, urine specific gravity) in 89 cognitively intact older people aged at least 65 years and staying in an acute care or rehabilitation unit, however authors are unable to share the data set with the review
Wakefield 2002b	The dataset includes a reference standard (calculated serum osmolarity) and index tests (fluid balance, which may include fluid intake and urine output) in 117 older people aged at least 65 years admitted to general medical units, however authors are unable to share the data set with the review
Wakefield 2008	The dataset includes a reference standard (calculated serum osmolarity and measured serum osmolality) and index tests (skin turgor, dryness of oral mucosa, urine output) in people admitted to hospital with dehydration or who developed dehydration during their stay. Some participants were aged at least 65 years, however authors are unable to share the data set with the review
Waldreus 2010	The first author, Nana Waldreus, replied that they did not collect a reference standard
Weinberg 1994	It appears that the dataset includes a reference standard (serum osmolality) but not necessarily an index test and no contact could be established with the authors
Weinberg 1994a	It appears that the dataset includes a reference standard (serum osmolality) but not necessarily an index test and no contact could be established with the authors
Weiss 2012	Unclear whether any reference standard was measured, but index tests (nocturia, sleep quality) were assessed. Contact could not be established with the authors
Wise 2000	It appears that the dataset includes a reference standard (weight change) and index tests (fluid balance) but not in a format that can be utilised in the review, and no contact could be established with the researchers
Yoshihara 2007	The published paper suggests that data were collected on at least one index test (saliva spinability), however it was not clear whether data were collected on at least one reference standard, and contact could not be established with the author
Yoshikawa 2012	Unclear whether any reference standard was collected, contact could not be established with study authors

Characteristics of ongoing studies *[ordered by study ID]*

Fortes & Walsh study 2013

Trial name or title	Walsh & Fortes Saliva Study
Target condition and reference standard(s)	**Plasma osmolality, mOsm/kg (directly measured)** **Method**: depression of freezing point (Model 330 MO, Advanced Instruments Inc, MA) **Cut-off:** < 295 vs. ≥ 295 mOsm/kg
Index and comparator tests	**Heart rate** - Tachycardia (resting heart rate > 100 BPM) assessed as yes/no**(n =130)** **Low resting systolic blood pressure** (< 100 mmHg) assessed as yes/no**(n = 130)** **Dry mucous membrane** (clinical research fellow looked at inside of cheek and assessed as dry vs. wet)**(n=130)** **Axillary dryness** (assessed by clinical research fellow palpating under armpit, dry vs wet)**(n=130)** **Poor skin turgor** (pinching skin on the dorsum of the hand, observing whether skin fold returned to normal immediately, yes /no**(n=130)** **Sunken eyes** (assessed subjectively by clinical research fellow, as yes/no)**, (n = 130)** **Long capillary refill time** (> 2 seconds after holding hand at heart level, blanching right index finger and assessing time to return of normal colour)**(n = 130)** **Assessment of dehydration according to assessor's gut feeling (n = 130)** **Saliva flow rate** (unstimulated saliva collected from a pre-weighed absorbent swab, Versi-sal, Oasis Technologies, placed under tongue for 4 minutes, assuming saliva density was 1 g/ mL),**μL/min (n = 130)** **Saliva osmolality** (sample taken from Versi-Sal, centrifuged at 1500 g for 10 min to harvest saliva, analysed as for plasma osmolality)**(n = 98,** insufficient saliva for analysis, <20 μL, collected from 32 participants**)** **Urine colour** (mid-flow urine sample analysed immediately for urine colour as in Armstrong 1998)**(n=84,** 45 participants not able to urinate in 30 minute time frame, 1 participant had blood in urine) **Urine specific gravity** (sample as above, analysed using Atago handheld refractometer, Atago, Japan)**(n=85,** 45 participants not able to urinate in 30 minute time frame**)** **Timing:** all tests (index tests followed by blood sample for reference standard) carried out within 30 minutes
Starting date	May 2011
Contact information	Professor Neil Walsh, School of Sport, Health and Exercise Science, Bangor University, George Building, Holyhead Road, Bangor, Gwynedd LL57 2PZ, UK. n.walsh@bangor.ac.uk
Notes	Protocol provided as personal communication, data collection and analysis complete and being prepared for publication as of November 2013

Hooper & Bunn 2013

Trial name or title	DRIE (Dehydration Recognition In our Elders)
Target condition and reference standard(s)	**Plasma osmolality, mOsm/kg (directly measured)** **Method**: depression of freezing point cut-off**:** <295 vs. ≥295 mOsm/kg
Index and comparator tests	**Heart rate and blood pressure** - assessed as a continuous measure **Tongue and mouth** - various measures of dryness, tongue furrows, coated tongue, saliva consistency **Axillary dryness -** assessed by palpating under armpit **Skin turgor -** pinching skin on the dorsum of the hand, inner lower arm, foot, sternum, at various angles, skin return timed **Sunken eyes -** assessed subjectively as yes/no) **Capillary refill time -** blanching nail of middle finger, and just above nail, assessing time to return of normal colour **Assessment of dehydration according to assessor's gut feeling, and carers assessment of risk** **Urine volume, colour, specific gravity and dipsticks** **Questions** - including feelings of thirst, tiredness, headache, dry tongue, dry eyes **Drinks** schedule, missing drinks, variety of drinks **MMSE** (cognition test) **Timing:** all tests carried out within 120 minutes of blood test for later analysis of serum osmolality
Starting date	March 2012
Contact information	Lee Hooper: l.hooper@uea.ac.uk
Notes	This is an ongoing study, recruiting 200 care home residents in the UK. Data collection is due to be completed in July 2013. Protocol can be downloaded from http://driestudy.appspot.com/cohort.html. Data collection complete and analysis about to commence as of November 2013

Johnson 2012

Trial name or title	Dehydration study
Target condition and reference standard(s)	**Plasma osmolarity, mOsm/L (calculated)**
Index and comparator tests	**Urine colour (scale of 1-8)** (mid-flow urine sample analysed for urine colour as in Armstrong 1998) **Urinary components, including specific gravity, glucose, bilirubin, ketones, erythrocytes, leukocytes, pH, urobilinogen, protein,** and**nitrite** (all using Urisys 1100™, Roche Diagnostics Scandinavia, Bromma, Sweden along with the Combur$_{10}$ Test M urine strip test), **creatinine, albumin** (using DCA- Vantage, Siemens) **Plasma Creatinine** **Plasma C-reactive protein (CRP)** **Haemoglobin**

Johnson 2012 (*Continued*)

	Pulse rate **Resting blood pressure** **Fluid balance assessment**
Starting date	July 2012
Contact information	Dr Peter Johnson, Department of Internal Medicine and Geriatrics, Södertälje Hospital, SE-152 86 Södertälje, Sweden. Email: peter.johnson@sodertaljesjukhus.se
Notes	This study recruited 317 acutely admitted patients aged over 65 years. Data collection was completed and analyses are underway as of January 2014

Johnson 2013

Trial name or title	SÄBO study
Target condition and reference standard(s)	**Plasma osmolality, mOsm/kg (directly measured)** **Plasma osmolarity, mOsm/L (calculated)**
Index and comparator tests	**Urine colour (scale of 1-8)** (mid-flow urine sample analysed for urine colour as in Armstrong 1998) **Urinary components, including specific gravity, glucose, bilirubin, ketones, erythrocytes, leukocytes, pH, urobilinogen, protein,** and**nitrite** (all using Urisys 1100™, Roche Diagnostics Scandinavia, Bromma, Sweden along with the Combur$_{10}$ Test M urine strip test), **creatinine, albumin** (using DCA- Vantage, Siemens), **sodium, potassium, osmolality** (using certified hospital laboratory) **Plasma C-reactive protein (CRP)** (using certified hospital laboratory) **Haemoglobin** (using certified hospital laboratory) **Pulse rate** **Resting blood pressure** **Thirst** (assessed on a VAS scale, 100mm line) **Dry mucous membranes** (clinical research fellow looked at inside of cheek and assessed as dry, moist or wet) **Dry or furrowed tongue** (clinical research fellow assessed longitudinal lines on tongue in 3 steps) **Skin turgor** (pinching skin at dorsum of hand, observing whether skin returns to normal immediately, yes or no) **Sunken eyes** (assessed subjectively by clinical researcher as yes or no) **Staff assessment** (staff asked if participant is considered dehydrated)
Starting date	May 2013
Contact information	Dr Peter Johnson, Department of Internal Medicine and Geriatrics, Södertälje Hospital, SE-152 86 Södertälje, Sweden. Email: peter.johnson@sodertaljesjukhus.se
Notes	This study aims to recruit 100 nursing home patients, 60 currently recruited as of January 2014

Olde Rikkert 2013

Trial name or title	Diagnosis of dehydration in elderly patients by electronic nose analysis of exhaled air: a pilot study
Target condition and reference standard(s)	**Plasma osmolarity, mOsm/L (calculated) and clinical judgement**
Index and comparator tests	**eNose sensor** - manufactured by eNose company, Zutphen, The Netherlands **Tongue and oral mucous membranes** - visual assessment of dryness **Axillary dryness** **Skin turgor** - assessed at sternum **Heart rate and blood pressure** - assessed as a continuous measure **Weight and weight change** **Body temperature**
Starting date	July 2013
Contact information	Marcel Olde Rikkert, Marcel.OldeRikkert@Radboudumc.nl
Notes	This study recruited patients admitted to a geriatric department, and dehydrated patients from the emergency department. Data collection was completed in October 2013, and analysis and writing up is underway as of November 2013

CRP C-reactive protein.

DATA

Presented below are all the data for all of the tests entered into the review.

Tests. Data tables by test

Test	No. of studies	No. of participants
1 Drinks intake 295, very low	2	92
2 Drinks intake 295, low	2	92
3 Drinks intake 295, moderate	2	92
4 Drinks intake 295, standard	2	92
5 Fluid intake 295, very low	4	130
6 Fluid intake 295, low	4	130
7 Fluid intake 295, moderate	4	130
8 Misses drinks between meals 295	1	71
9 Misses drinks at meals 295	1	71
10 Urine vol 295 - <300 mL/d	6	150
11 Urine vol 295, <500 mL/d	6	150
12 Urine vol 295, <800 mL/d	6	150
13 Urine vol 295, fluid recs	6	150
14 Urine vol daytime 295, <900 mL	1	43
15 Urine vol daytime 295, <1420 mL	1	43
16 Urine vol daytime 295, <1940 mL	1	43
17 Urine vol night 295, >450 mL/night	1	43
18 Urine vol night 295, >860 mL/night	1	43
19 Urine vol night 295, >1270 mL/night	1	43
20 Urine voids daytime 295, ≥11/day	1	43
21 Urine voids daytime 295, ≥7/day	1	43
22 Urine voids daytime 295, ≥4/day	1	43
23 Urine voids night 295, ≥1.5/night	1	43
24 Urine voids night 295, ≥2.6/night	1	43
25 Urine voids night 295, ≥4.1/night	1	43
26 Nocturnal polyuria 295	1	43
27 Fluid balance 295, <-180 mL/d	4	92
28 Fluid balance 295, <+180 mL/d	4	92

29 Fluid balance 295, <+1700 mL/d	4	92
30 USG 295, ≥1.035	4	358
31 USG 295, ≥1.028	4	358
32 USG 295, ≥1.020	4	358
33 Urine colour 295, >6	4	78
34 Urine colour 295, >4	4	78
35 Urine colour 295, >2	4	78
36 Urine osmolality 295, >1000 mOsm/kg	6	158
37 Urine osmolality 295, >800 mOsm/kg	6	158
38 Urine osmolality 295, >600 mOsm/kg	6	158
39 Tear osmolarity 295, >324 mOsm/L	1	89
40 Tear osmolarity 295, >316 mOsm/L	1	89
41 Tear osmolarity 295, >310 mOsm/L	1	89
42 Heart rate 295, ≥120 bpm	4	373
43 Heart rate 295, 100 bpm	4	373
44 Heart rate 295, 80 bpm	4	373
45 Orthostatic hypotension 295	1	143
46 Body temperature 295, ≥38.2°C	1	295
47 Body temperature 295, ≥36.8°C	1	295
48 Body temperature 295, ≥33.2°C	1	295
49 Skin turgor, anterior forearm 295, ≥3 sec	1	300
50 Skin turgor, anterior thigh 295, ≥3 sec	1	301
51 Skin turgor, anterior thigh 295, abnormal	1	162
52 Skin turgor, subclavicular 295, ≥3 sec	1	304
53 Skin turgor, sternum 295, ≥3 sec	1	302
54 Skin turgor, anterior chest 295, slow	1	29
55 Skin turgor, hand 295, ≥4 sec	1	31
56 Skin turgor, hand 295, ≥3 sec	1	31
57 Skin turgor, hand 295, ≥1 sec	1	31
58 Skin turgor, hand 295, abnormal	1	11
59 Skin turgor, site unspecified 295, abnormal	1	18
60 Capillary refill 295, ≥4 sec	1	31
61 Capillary refill 295, ≥3 sec	2	58

62 Capillary refill 295, ≥2 sec	1	31
63 Dry axilla by touch 295	2	115
64 Dry axilla by meter 295, <32%	1	29
65 Dry axilla by meter 295, <37%	1	29
66 Dry axilla by meter 295, <42%	1	29
67 Consciousness level 295, ≥coma	1	303
68 Consciousness level 295, ≥stupor	2	330
69 Consciousness level 295, ≥obsessed	1	303
70 MMSE 295 <10	2	325
71 MMSE 295 <20	2	325
72 MMSE 295 <25	2	325
73 Neecham 295 <27	1	308
74 Neecham 295, ≤24	1	308
75 Neecham 295, <20	1	308
76 Tiredness 295, severe	2	44
77 Tiredness 295, moderate or severe	2	44
78 Fatigue 295, any	3	115
79 Lassitude 295	1	71
80 Feels dull 295	1	71
81 Dry oral mucosa 295, cheek	1	290
82 Tongue furrows 295, ≥mild	1	31
83 Tongue furrows 295, ≥moderate	1	31
84 Tongue furrows 295, ≥severe	1	31
85 Tongue dry 295, ≥mild	1	31
86 Tongue dry 295, ≥moderate	1	31
87 Tongue dry 295, severe	1	31
88 BIA Resistance 50kHz 295, ≥550 ohms	4	2005
89 BIA Resistance 50kHz 295, ≥450 ohms	4	2005
90 BIA Resistance 50kHz 295, ≥350 ohms	4	2005
91 BIA Resistance 100kHz 295, ≥550 ohms	1	21
92 BIA Resistance 100kHz 295, ≥450 ohms	1	21
93 BIA Resistance 100kHz 295, ≥350 ohms	1	21
94 BIA Resistance 200kHz 295, ≥550 ohms	1	21
95 BIA Resistance 200kHz 295, ≥450 ohms	1	21
96 BIA Resistance 200kHz 295, ≥350 ohms	1	21
97 BIA TBW% 295, <45%	5	2325
98 BIA TBW% 295, <47%	5	2325

99 BIA TBW% 295, <49%	5	2325
100 BIA ICW% 295, <25%	4	379
101 BIA ICW% 295, <27%	4	379
102 BIA ICW% 295, <29%	4	379
103 BIA ECW% 295, <18%	4	379
104 BIA ECW% 295, <20%	4	379
105 BIA ECW% 295, <22%	4	379
106 Insufficient tears 295	1	105
107 Insufficient tears or not tolerated 295	1	105
108 Oral thickener used 295	1	48
109 Oral fluid without thickener 295	1	48
110 Lips dry 295	1	71
111 Dry mouth 295, severe	2	44
112 Dry mouth 295, moderate or severe	2	44
113 Dry mouth 295, any	8	623
114 Unable to spit 295	1	11
115 Thirst VAS rating 295, severe	3	54
116 Thirst VAS rating 295, moderate plus	3	54
117 Thirst VAS rating 295, mild plus	1	10
118 Thirsty 295, any degree	6	300
119 Tongue smarts 295	1	71
120 Mouth smarts 295	1	71
121 Sticky saliva 295	1	71
122 Sticky mouth 295	1	71
123 Blue lips 295	1	18
124 Sunken eyes 295	3	58
125 Bed sores 295	1	164
126 Swallowing problems 295	1	71
127 Enjoyment of food 295	1	71
128 Appetite 295	1	71
129 Dry eye severity by DEQ-5 295, >12	1	104
130 Dry eye severity by DEQ-5 295, >6	1	104
131 Dry eye severity by DEQ-5 295, >3	1	104
132 Dry eye severity by VAS 295, >5.0 cm	1	104
133 Dry eye severity by VAS 295, >1.1 cm	1	104
134 Dry eye severity by VAS 295, >0.6 cm	1	104
135 NITBUT 295 <6 secs	1	104
136 NITBUT 295 <10 secs	1	104
137 NITBUT 295 <27 secs	1	104
138 Balance 295, severe	2	44
139 Balance 295, ≥moderate	2	44

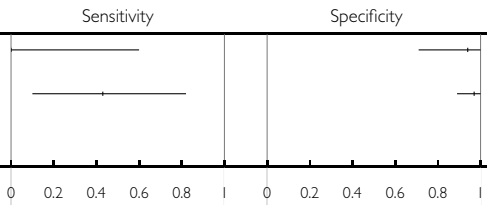
140 Balance 295, any degree	2	44
141 Headache 295, severe	2	44
142 Headache 295, moderate+	2	44
143 Headache 295, any degree	2	44
144 Nausea 295, severe	2	44
145 Nausea 295, ≥moderate	2	44
146 Nausea 295, any degree	2	44
147 Muscle weakness 295, severe	2	44
148 Muscle weakness 295, ≥moderate	2	44
149 Muscle weakness 295, any degree	2	44
150 Dizziness 295, severe	2	44
151 Dizziness 295, ≥moderate	2	44
152 Dizziness 295, any degree	2	44
153 Combined drinks AND fatigue	1	71
154 Combined, drinks OR fatigue	1	71

Test 1. Drinks intake 295, very low.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 1 Drinks intake 295, very low

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	1	4	16	0.0 [0.0, 0.60]	0.94 [0.71, 1.00]
Kajii 2006	3	2	4	62	0.43 [0.10, 0.82]	0.97 [0.89, 1.00]

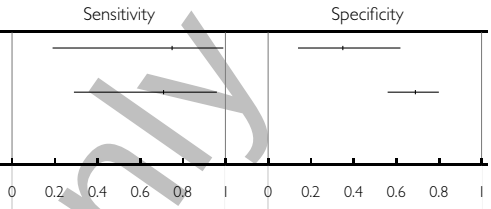


Test 2. Drinks intake 295, low.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 2 Drinks intake 295, low

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	3	11	1	6	0.75 [0.19, 0.99]	0.35 [0.14, 0.62]
Kajii 2006	5	20	2	44	0.71 [0.29, 0.96]	0.69 [0.56, 0.80]

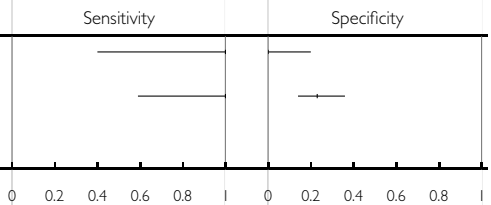


Test 3. Drinks intake 295, moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 3 Drinks intake 295, moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	4	17	0	0	1.00 [0.40, 1.00]	0.0 [0.0, 0.20]
Kajii 2006	7	49	0	15	1.00 [0.59, 1.00]	0.23 [0.14, 0.36]

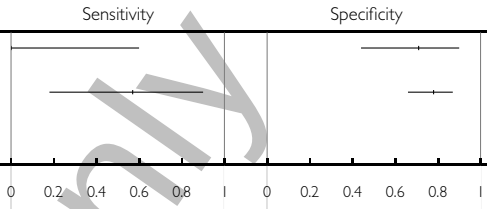


Test 4. Drinks intake 295, standard.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 4 Drinks intake 295, standard

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	5	4	12	0.0 [0.0, 0.60]	0.71 [0.44, 0.90]
Kajii 2006	4	14	3	50	0.57 [0.18, 0.90]	0.78 [0.66, 0.87]

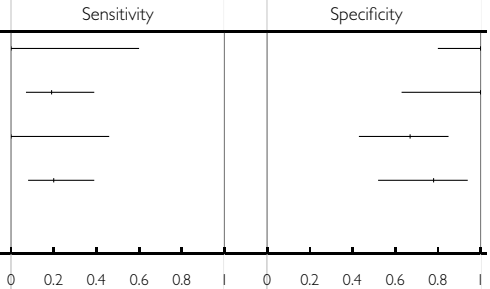


Test 5. Fluid intake 295, very low.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 5 Fluid intake 295, very low

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	4	17	0.0 [0.0, 0.60]	1.00 [0.80, 1.00]
Lindner 2009	5	0	21	8	0.19 [0.07, 0.39]	1.00 [0.63, 1.00]
Perren 2011	0	7	6	14	0.0 [0.0, 0.46]	0.67 [0.43, 0.85]
Stotts 2009	6	4	24	14	0.20 [0.08, 0.39]	0.78 [0.52, 0.94]

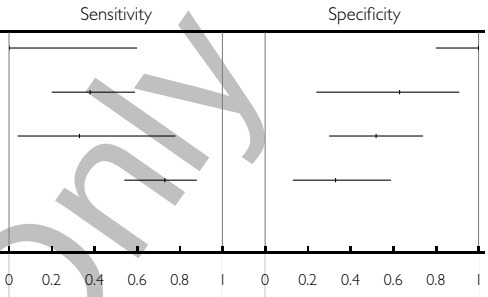


Test 6. Fluid intake 295, low.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 6 Fluid intake 295, low

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	4	17	0.0 [0.0, 0.60]	1.00 [0.80, 1.00]
Lindner 2009	10	3	16	5	0.38 [0.20, 0.59]	0.63 [0.24, 0.91]
Perren 2011	2	10	4	11	0.33 [0.04, 0.78]	0.52 [0.30, 0.74]
Stotts 2009	22	12	8	6	0.73 [0.54, 0.88]	0.33 [0.13, 0.59]

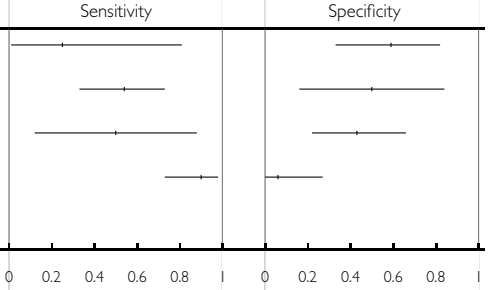


Test 7. Fluid intake 295, moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 7 Fluid intake 295, moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	1	7	3	10	0.25 [0.01, 0.81]	0.59 [0.33, 0.82]
Lindner 2009	14	4	12	4	0.54 [0.33, 0.73]	0.50 [0.16, 0.84]
Perren 2011	3	12	3	9	0.50 [0.12, 0.88]	0.43 [0.22, 0.66]
Stotts 2009	27	17	3	1	0.90 [0.73, 0.98]	0.06 [0.00, 0.27]

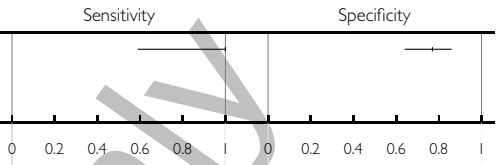


Test 8. Misses drinks between meals 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 8 Misses drinks between meals 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	7	15	0	49	1.00 [0.59, 1.00]	0.77 [0.64, 0.86]

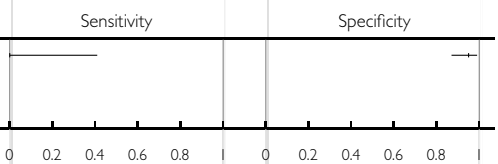


Test 9. Misses drinks at meals 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 9 Misses drinks at meals 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	0	3	7	61	0.0 [0.0, 0.41]	0.95 [0.87, 0.99]

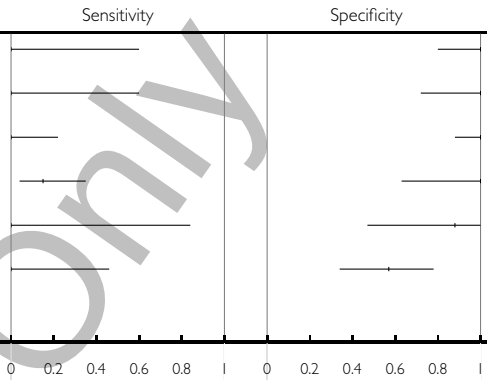


Test 10. Urine vol 295 - <300 mL/d.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 10 Urine vol 295 - <300 mL/d

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	4	17	0.0 [0.0, 0.60]	1.00 [0.80, 1.00]
Fletcher 1999	0	0	4	11	0.0 [0.0, 0.60]	1.00 [0.72, 1.00]
Johnson 2003	0	0	15	28	0.0 [0.0, 0.22]	1.00 [0.88, 1.00]
Lindner 2009	4	0	22	8	0.15 [0.04, 0.35]	1.00 [0.63, 1.00]
Mack 1994	0	1	2	7	0.0 [0.0, 0.84]	0.88 [0.47, 1.00]
Perren 2011	0	9	6	12	0.0 [0.0, 0.46]	0.57 [0.34, 0.78]

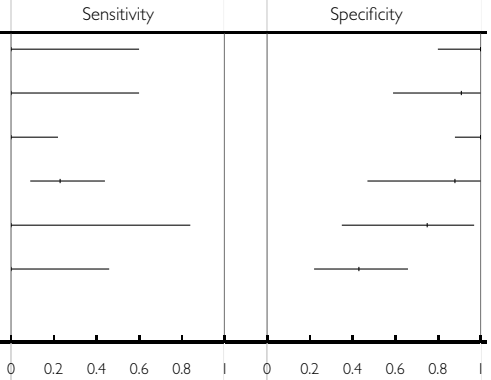


Test 11. Urine vol 295, <500 mL/d.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 11 Urine vol 295, <500 mL/d

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	4	17	0.0 [0.0, 0.60]	1.00 [0.80, 1.00]
Fletcher 1999	0	1	4	10	0.0 [0.0, 0.60]	0.91 [0.59, 1.00]
Johnson 2003	0	0	15	28	0.0 [0.0, 0.22]	1.00 [0.88, 1.00]
Lindner 2009	6	1	20	7	0.23 [0.09, 0.44]	0.88 [0.47, 1.00]
Mack 1994	0	2	2	6	0.0 [0.0, 0.84]	0.75 [0.35, 0.97]
Perren 2011	0	12	6	9	0.0 [0.0, 0.46]	0.43 [0.22, 0.66]

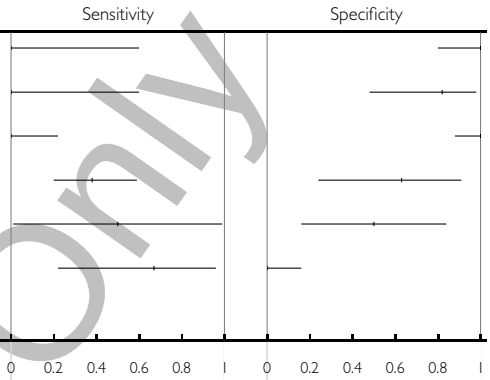


Test 12. Urine vol 295, <800 mL/d.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 12 Urine vol 295, <800 mL/d

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	4	17	0.0 [0.0, 0.60]	1.00 [0.80, 1.00]
Fletcher 1999	0	2	4	9	0.0 [0.0, 0.60]	0.82 [0.48, 0.98]
Johnson 2003	0	0	15	28	0.0 [0.0, 0.22]	1.00 [0.88, 1.00]
Lindner 2009	10	3	16	5	0.38 [0.20, 0.59]	0.63 [0.24, 0.91]
Mack 1994	1	4	1	4	0.50 [0.01, 0.99]	0.50 [0.16, 0.84]
Perren 2011	4	21	2	0	0.67 [0.22, 0.96]	0.0 [0.0, 0.16]

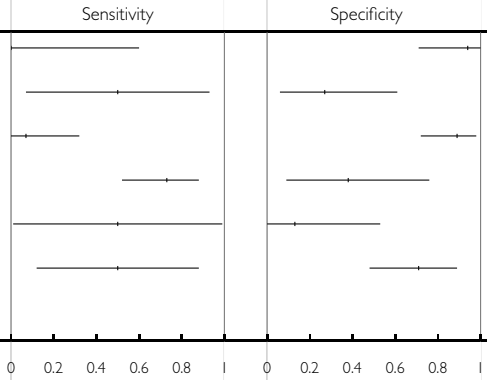


Test 13. Urine vol 295, fluid recs.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 13 Urine vol 295, fluid recs

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	1	4	16	0.0 [0.0, 0.60]	0.94 [0.71, 1.00]
Fletcher 1999	2	8	2	3	0.50 [0.07, 0.93]	0.27 [0.06, 0.61]
Johnson 2003	1	3	14	25	0.07 [0.00, 0.32]	0.89 [0.72, 0.98]
Lindner 2009	19	5	7	3	0.73 [0.52, 0.88]	0.38 [0.09, 0.76]
Mack 1994	1	7	1	1	0.50 [0.01, 0.99]	0.13 [0.00, 0.53]
Perren 2011	3	6	3	15	0.50 [0.12, 0.88]	0.71 [0.48, 0.89]

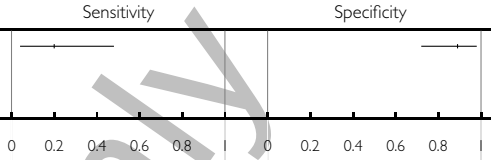


Test 14. Urine vol daytime 295, <900 mL.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 14 Urine vol daytime 295, <900 mL

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	3	3	12	25	0.20 [0.04, 0.48]	0.89 [0.72, 0.98]

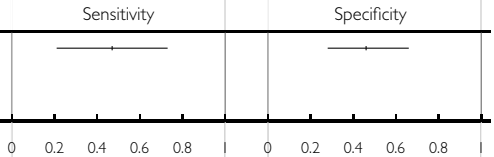


Test 15. Urine vol daytime 295, <1420 mL.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 15 Urine vol daytime 295, <1420 mL

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	7	15	8	13	0.47 [0.21, 0.73]	0.46 [0.28, 0.66]

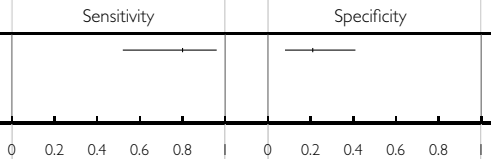


Test 16. Urine vol daytime 295, <1940 mL.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 16 Urine vol daytime 295, <1940 mL

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	12	22	3	6	0.80 [0.52, 0.96]	0.21 [0.08, 0.41]

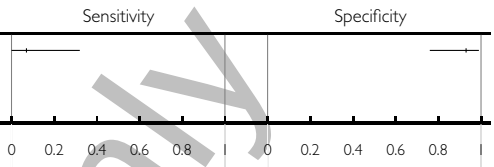


Test 17. Urine vol night 295, >450 mL/night.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 17 Urine vol night 295, >450 mL/night

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	1	2	14	26	0.07 [0.00, 0.32]	0.93 [0.76, 0.99]

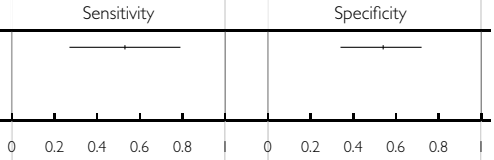


Test 18. Urine vol night 295, >860 mL/night.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 18 Urine vol night 295, >860 mL/night

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	8	13	7	15	0.53 [0.27, 0.79]	0.54 [0.34, 0.72]

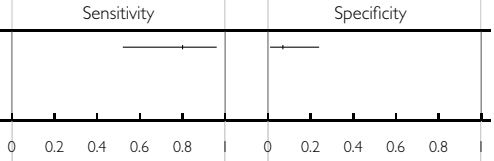


Test 19. Urine vol night 295, >1270 mL/night.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 19 Urine vol night 295, >1270 mL/night

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	12	26	3	2	0.80 [0.52, 0.96]	0.07 [0.01, 0.24]

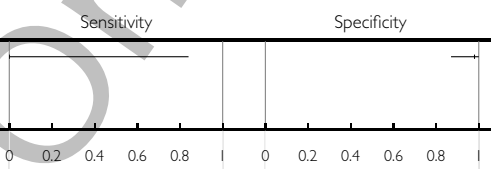


Test 20. Urine voids daytime 295, ≥11/day.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 20 Urine voids daytime 295, ≥11/day

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	0	1	2	40	0.0 [0.0, 0.84]	0.98 [0.87, 1.00]

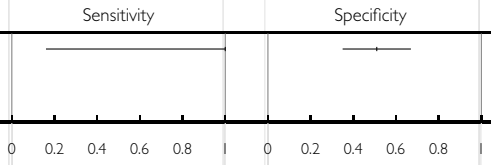


Test 21. Urine voids daytime 295, ≥7/day.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 21 Urine voids daytime 295, ≥7/day

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	2	20	0	21	1.00 [0.16, 1.00]	0.51 [0.35, 0.67]

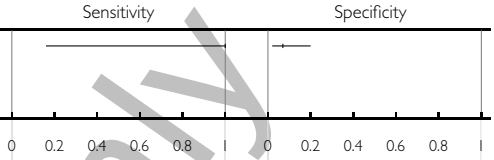


Test 22. Urine voids daytime 295, ≥4/day.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 22 Urine voids daytime 295, ≥4/day

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	2	38	0	3	1.00 [0.16, 1.00]	0.07 [0.02, 0.20]

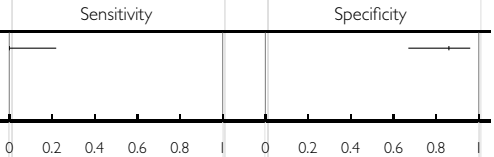


Test 23. Urine voids night 295, ≥1.5/night.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 23 Urine voids night 295, ≥1.5/night

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	0	4	15	24	0.0 [0.0, 0.22]	0.86 [0.67, 0.96]

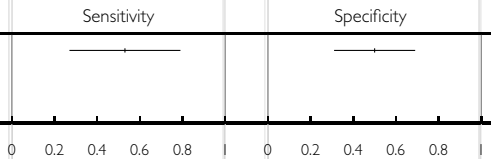


Test 24. Urine voids night 295, ≥2.6/night.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 24 Urine voids night 295, ≥2.6/night

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	8	14	7	14	0.53 [0.27, 0.79]	0.50 [0.31, 0.69]

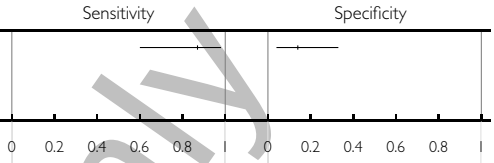


Test 25. Urine voids night 295, ≥4.1/night.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 25 Urine voids night 295, ≥4.1/night

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	13	24	2	4	0.87 [0.60, 0.98]	0.14 [0.04, 0.33]

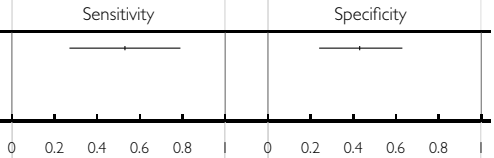


Test 26. Nocturnal polyuria 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 26 Nocturnal polyuria 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Johnson 2003	8	16	7	12	0.53 [0.27, 0.79]	0.43 [0.24, 0.63]

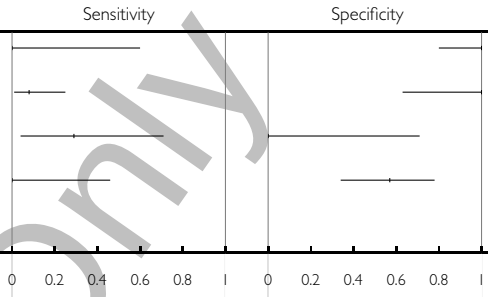


Test 27. Fluid balance 295, <-180 mL/d.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 27 Fluid balance 295, <-180 mL/d

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	4	17	0.0 [0.0, 0.60]	1.00 [0.80, 1.00]
Lindner 2009	2	0	24	8	0.08 [0.01, 0.25]	1.00 [0.63, 1.00]
Monahan 2006	2	3	5	0	0.29 [0.04, 0.71]	0.0 [0.0, 0.71]
Perren 2011	0	9	6	12	0.0 [0.0, 0.46]	0.57 [0.34, 0.78]

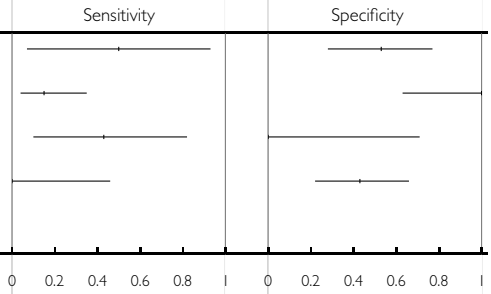


Test 28. Fluid balance 295, <+180 mL/d.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 28 Fluid balance 295, <+180 mL/d

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	2	8	2	9	0.50 [0.07, 0.93]	0.53 [0.28, 0.77]
Lindner 2009	4	0	22	8	0.15 [0.04, 0.35]	1.00 [0.63, 1.00]
Monahan 2006	3	3	4	0	0.43 [0.10, 0.82]	0.0 [0.0, 0.71]
Perren 2011	0	12	6	9	0.0 [0.0, 0.46]	0.43 [0.22, 0.66]

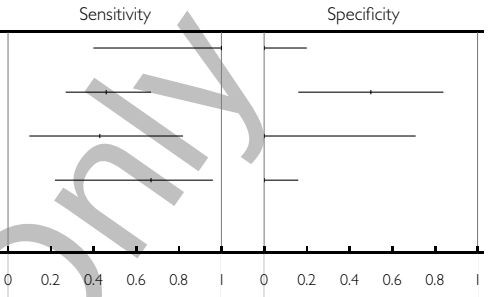


Test 29. Fluid balance 295, <+1700 mL/d.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 29 Fluid balance 295, <+1700 mL/d

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	4	17	0	0	1.00 [0.40, 1.00]	0.0 [0.0, 0.20]
Lindner 2009	12	4	14	4	0.46 [0.27, 0.67]	0.50 [0.16, 0.84]
Monahan 2006	3	3	4	0	0.43 [0.10, 0.82]	0.0 [0.0, 0.71]
Perren 2011	4	21	2	0	0.67 [0.22, 0.96]	0.0 [0.0, 0.16]

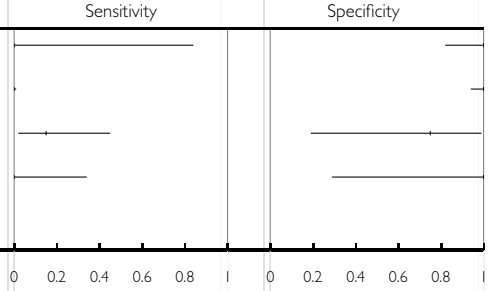


Test 30. USG 295, ≥1.035.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 30 USG 295, ≥1.035

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	2	19	0.0 [0.0, 0.84]	1.00 [0.82, 1.00]
Culp 2003	0	0	245	63	0.0 [0.0, 0.01]	1.00 [0.94, 1.00]
Rowat 2011	2	1	11	3	0.15 [0.02, 0.45]	0.75 [0.19, 0.99]
Sjöstrand Healthy 2013	0	0	9	3	0.0 [0.0, 0.34]	1.00 [0.29, 1.00]

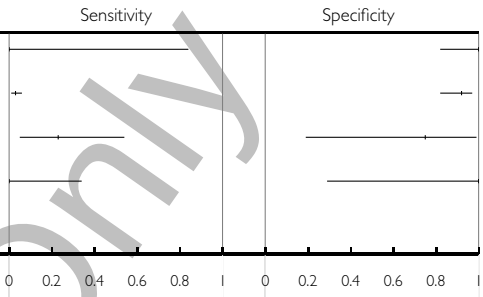


Test 31. USG 295, ≥1.028.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 31 USG 295, ≥1.028

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	2	19	0.0 [0.0, 0.84]	1.00 [0.82, 1.00]
Culp 2003	7	5	238	58	0.03 [0.01, 0.06]	0.92 [0.82, 0.97]
Rowat 2011	3	1	10	3	0.23 [0.05, 0.54]	0.75 [0.19, 0.99]
Sjöstrand Healthy 2013	0	0	9	3	0.0 [0.0, 0.34]	1.00 [0.29, 1.00]

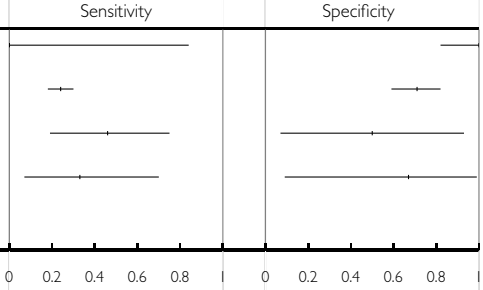


Test 32. USG 295, ≥1.020.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 32 USG 295, ≥1.020

Study	TP	FP	FN	TN	Sensitivity	Specificity
Bossingham 2005	0	0	2	19	0.0 [0.0, 0.84]	1.00 [0.82, 1.00]
Culp 2003	58	18	187	45	0.24 [0.18, 0.30]	0.71 [0.59, 0.82]
Rowat 2011	6	2	7	2	0.46 [0.19, 0.75]	0.50 [0.07, 0.93]
Sjöstrand Healthy 2013	3	1	6	2	0.33 [0.07, 0.70]	0.67 [0.09, 0.99]

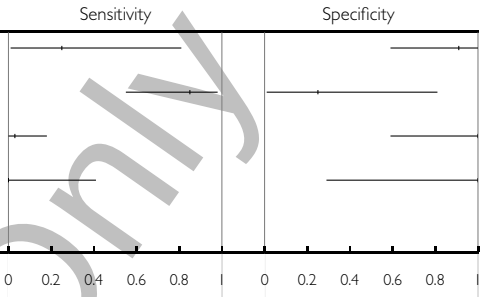


Test 33. Urine colour 295, >6.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 33 Urine colour 295, >6

Study	TP	FP	FN	TN	Sensitivity	Specificity
Fletcher 1999	1	1	3	10	0.25 [0.01, 0.81]	0.91 [0.59, 1.00]
Rowat 2011	11	3	2	1	0.85 [0.55, 0.98]	0.25 [0.01, 0.81]
Sjöstrand ED 2013	1	0	28	7	0.03 [0.00, 0.18]	1.00 [0.59, 1.00]
Sjöstrand Healthy 2013	0	0	7	3	0.0 [0.0, 0.41]	1.00 [0.29, 1.00]

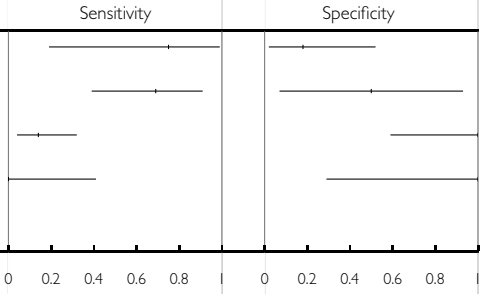


Test 34. Urine colour 295, >4.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 34 Urine colour 295, >4

Study	TP	FP	FN	TN	Sensitivity	Specificity
Fletcher 1999	3	9	1	2	0.75 [0.19, 0.99]	0.18 [0.02, 0.52]
Rowat 2011	9	2	4	2	0.69 [0.39, 0.91]	0.50 [0.07, 0.93]
Sjöstrand ED 2013	4	0	25	7	0.14 [0.04, 0.32]	1.00 [0.59, 1.00]
Sjöstrand Healthy 2013	0	0	7	3	0.0 [0.0, 0.41]	1.00 [0.29, 1.00]

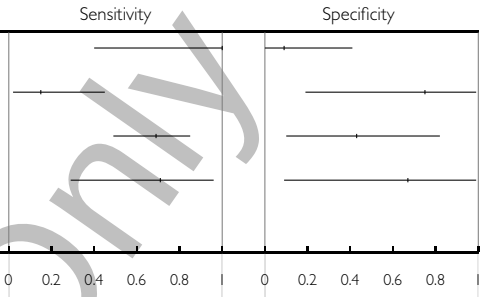


Test 35. Urine colour 295, >2.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 35 Urine colour 295, >2

Study	TP	FP	FN	TN	Sensitivity	Specificity
Fletcher 1999	4	10	0	1	1.00 [0.40, 1.00]	0.09 [0.00, 0.41]
Rowat 2011	2	1	11	3	0.15 [0.02, 0.45]	0.75 [0.19, 0.99]
Sjöstrand ED 2013	20	4	9	3	0.69 [0.49, 0.85]	0.43 [0.10, 0.82]
Sjöstrand Healthy 2013	5	1	2	2	0.71 [0.29, 0.96]	0.67 [0.09, 0.99]

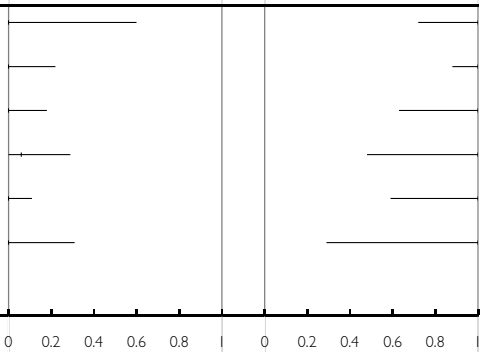


Test 36. Urine osmolality 295, >1000 mOsm/kg.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 36 Urine osmolality 295, >1000 mOsm/kg

Study	TP	FP	FN	TN	Sensitivity	Specificity
Fletcher 1999	0	0	4	11	0.0 [0.0, 0.60]	1.00 [0.72, 1.00]
Johnson 2003	0	0	15	28	0.0 [0.0, 0.22]	1.00 [0.88, 1.00]
Lindner 2009	0	0	19	8	0.0 [0.0, 0.18]	1.00 [0.63, 1.00]
Powers 2012	1	0	16	5	0.06 [0.00, 0.29]	1.00 [0.48, 1.00]
Sjöstrand ED 2013	0	0	31	7	0.0 [0.0, 0.11]	1.00 [0.59, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

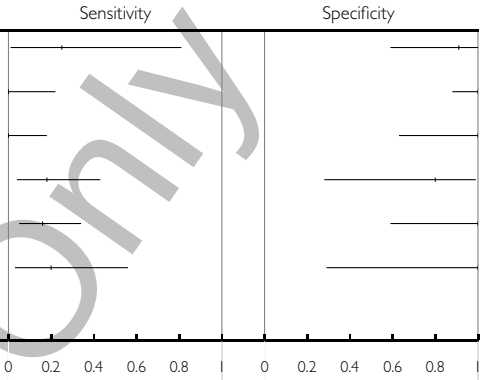


Test 37. Urine osmolality 295, >800 mOsm/kg.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 37 Urine osmolality 295, >800 mOsm/kg

Study	TP	FP	FN	TN	Sensitivity	Specificity
Fletcher 1999	1	1	3	10	0.25 [0.01, 0.81]	0.91 [0.59, 1.00]
Johnson 2003	0	0	15	28	0.0 [0.0, 0.22]	1.00 [0.88, 1.00]
Lindner 2009	0	0	19	8	0.0 [0.0, 0.18]	1.00 [0.63, 1.00]
Powers 2012	3	1	14	4	0.18 [0.04, 0.43]	0.80 [0.28, 0.99]
Sjöstrand ED 2013	5	0	26	7	0.16 [0.05, 0.34]	1.00 [0.59, 1.00]
Sjöstrand Healthy 2013	2	0	8	3	0.20 [0.03, 0.56]	1.00 [0.29, 1.00]

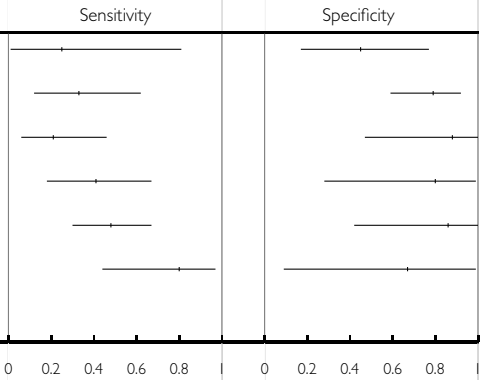


Test 38. Urine osmolality 295, >600 mOsm/kg.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 38 Urine osmolality 295, >600 mOsm/kg

Study	TP	FP	FN	TN	Sensitivity	Specificity
Fletcher 1999	1	6	3	5	0.25 [0.01, 0.81]	0.45 [0.17, 0.77]
Johnson 2003	5	6	10	22	0.33 [0.12, 0.62]	0.79 [0.59, 0.92]
Lindner 2009	4	1	15	7	0.21 [0.06, 0.46]	0.88 [0.47, 1.00]
Powers 2012	7	1	10	4	0.41 [0.18, 0.67]	0.80 [0.28, 0.99]
Sjöstrand ED 2013	15	1	16	6	0.48 [0.30, 0.67]	0.86 [0.42, 1.00]
Sjöstrand Healthy 2013	8	1	2	2	0.80 [0.44, 0.97]	0.67 [0.09, 0.99]

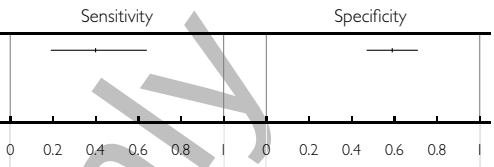


Test 39. Tear osmolarity 295, >324 mOsm/L.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 39 Tear osmolarity 295, >324 mOsm/L

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	8	28	12	41	0.40 [0.19, 0.64]	0.59 [0.47, 0.71]

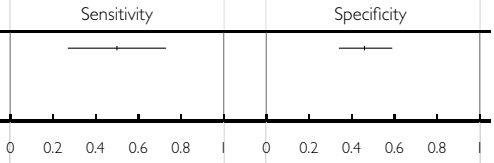


Test 40. Tear osmolarity 295, >316 mOsm/L.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 40 Tear osmolarity 295, >316 mOsm/L

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	10	37	10	32	0.50 [0.27, 0.73]	0.46 [0.34, 0.59]



Test 41. Tear osmolarity 295, >310 mOsm/L.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 41 Tear osmolarity 295, >310 mOsm/L

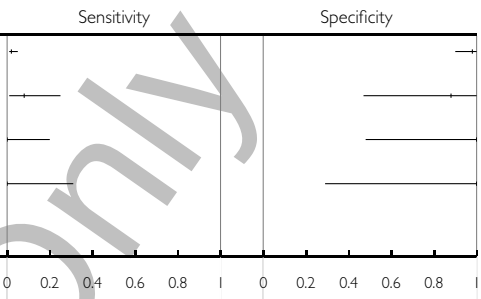
Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	11	49	9	20	0.55 [0.32, 0.77]	0.29 [0.19, 0.41]

Test 42. Heart rate 295, ≥120 bpm.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 42 Heart rate 295, ≥120 bpm

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	6	1	246	51	0.02 [0.01, 0.05]	0.98 [0.90, 1.00]
Lindner 2009	2	1	24	7	0.08 [0.01, 0.25]	0.88 [0.47, 1.00]
Powers 2012	0	0	17	5	0.0 [0.0, 0.20]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

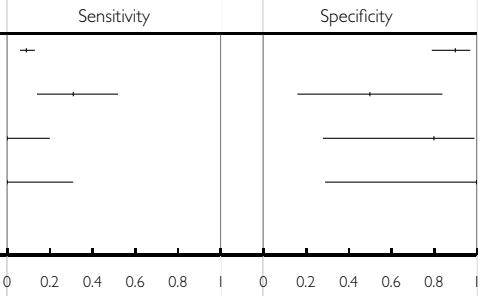


Test 43. Heart rate 295, 100 bpm.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 43 Heart rate 295, 100 bpm

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	23	5	229	47	0.09 [0.06, 0.13]	0.90 [0.79, 0.97]
Lindner 2009	8	4	18	4	0.31 [0.14, 0.52]	0.50 [0.16, 0.84]
Powers 2012	0	1	17	4	0.0 [0.0, 0.20]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

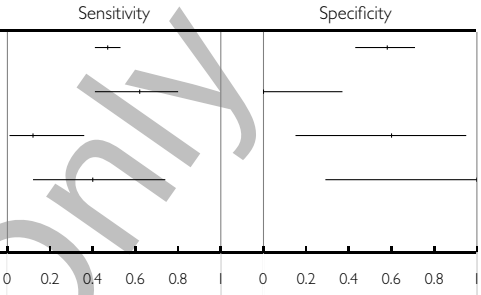


Test 44. Heart rate 295, 80 bpm.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 44 Heart rate 295, 80 bpm

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	118	22	134	30	0.47 [0.41, 0.53]	0.58 [0.43, 0.71]
Lindner 2009	16	8	10	0	0.62 [0.41, 0.80]	0.0 [0.0, 0.37]
Powers 2012	2	2	15	3	0.12 [0.01, 0.36]	0.60 [0.15, 0.95]
Sjöstrand Healthy 2013	4	0	6	3	0.40 [0.12, 0.74]	1.00 [0.29, 1.00]



Test 45. Orthostatic hypotension 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 45 Orthostatic hypotension 295

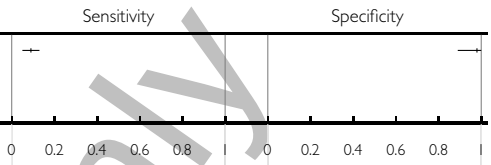
Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	19	4	100	20	0.16 [0.10, 0.24]	0.83 [0.63, 0.95]

Test 46. Body temperature 295, ≥38.2°C.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 46 Body temperature 295, ≥38.2 C

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	21	1	224	49	0.09 [0.05, 0.13]	0.98 [0.89, 1.00]

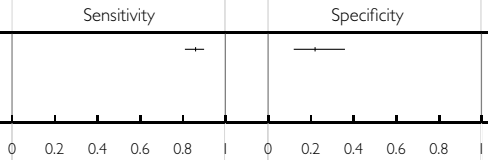


Test 47. Body temperature 295, ≥36.8°C.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 47 Body temperature 295, ≥36.8 C

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	210	39	35	11	0.86 [0.81, 0.90]	0.22 [0.12, 0.36]

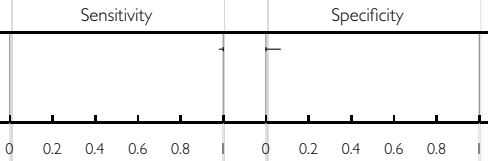


Test 48. Body temperature 295, ≥33.2°C.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 48 Body temperature 295, ≥33.2 C

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	244	50	1	0	1.00 [0.98, 1.00]	0.0 [0.0, 0.07]

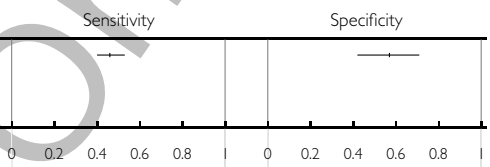


Test 49. Skin turgor, anterior forearm 295, ≥3 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 49 Skin turgor, anterior forearm 295, ≥3 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	115	22	134	29	0.46 [0.40, 0.53]	0.57 [0.42, 0.71]

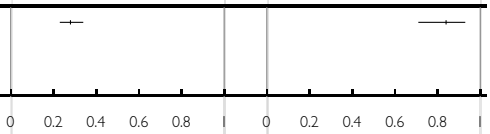


Test 50. Skin turgor, anterior thigh 295, ≥3 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 50 Skin turgor, anterior thigh 295, ≥3 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	71	8	179	43	0.28 [0.23, 0.34]	0.84 [0.71, 0.93]

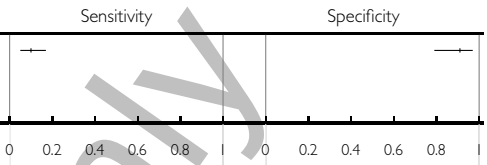


Test 51. Skin turgor, anterior thigh 295, abnormal.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 51 Skin turgor, anterior thigh 295, abnormal

Study	TP	FP	FN	TN	Sensitivity	Specificity
Source Study 2001	11	5	98	48	0.10 [0.05, 0.17]	0.91 [0.79, 0.97]

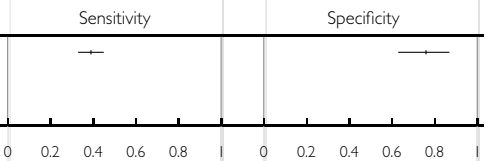


Test 52. Skin turgor, subclavicular 295, ≥3 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 52 Skin turgor, subclavicular 295, ≥3 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	99	12	154	39	0.39 [0.33, 0.45]	0.76 [0.63, 0.87]

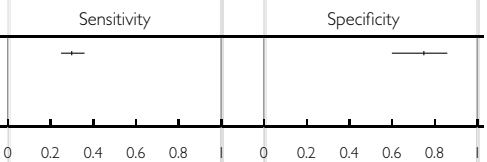


Test 53. Skin turgor, sternum 295, ≥3 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 53 Skin turgor, sternum 295, ≥3 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	76	13	175	38	0.30 [0.25, 0.36]	0.75 [0.60, 0.86]

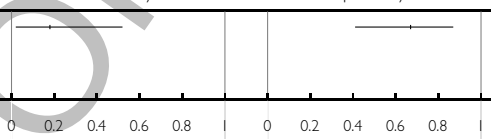


Test 54. Skin turgor, anterior chest 295, slow.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 54 Skin turgor, anterior chest 295, slow

Study	TP	FP	FN	TN	Sensitivity	Specificity
Shimizu 2012	2	6	9	12	0.18 [0.02, 0.52]	0.67 [0.41, 0.87]

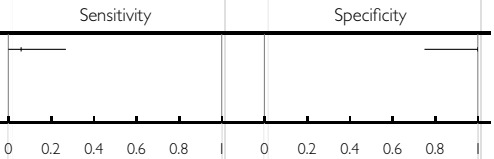


Test 55. Skin turgor, hand 295, ≥4 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 55 Skin turgor, hand 295, ≥4 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	1	0	17	13	0.06 [0.00, 0.27]	1.00 [0.75, 1.00]

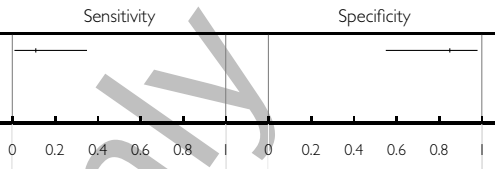


Test 56. Skin turgor, hand 295, ≥3 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 56 Skin turgor, hand 295, ≥3 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	2	2	16	11	0.11 [0.01, 0.35]	0.85 [0.55, 0.98]



Test 57. Skin turgor, hand 295, ≥1 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 57 Skin turgor, hand 295, ≥1 sec

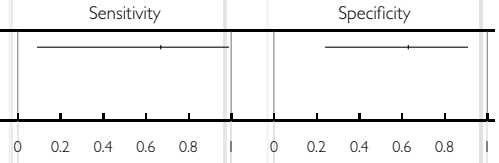
Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	17	13	1	0	0.94 [0.73, 1.00]	0.0 [0.0, 0.25]

Test 58. Skin turgor, hand 295, abnormal.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 58 Skin turgor, hand 295, abnormal

Study	TP	FP	FN	TN	Sensitivity	Specificity
McGarvey 2010	2	3	1	5	0.67 [0.09, 0.99]	0.63 [0.24, 0.91]

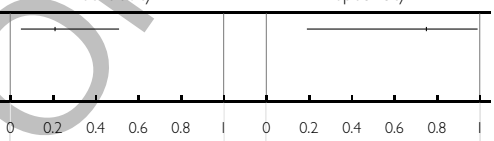


Test 59. Skin turgor, site unspecified 295, abnormal.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 59 Skin turgor, site unspecified 295, abnormal

Study	TP	FP	FN	TN	Sensitivity	Specificity
Rowat 2011	3	1	11	3	0.21 [0.05, 0.51]	0.75 [0.19, 0.99]

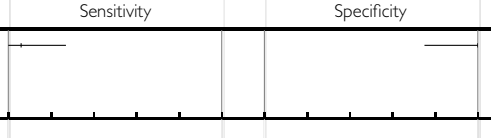


Test 60. Capillary refill 295, ≥4 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 60 Capillary refill 295, ≥4 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	1	0	17	13	0.06 [0.00, 0.27]	1.00 [0.75, 1.00]

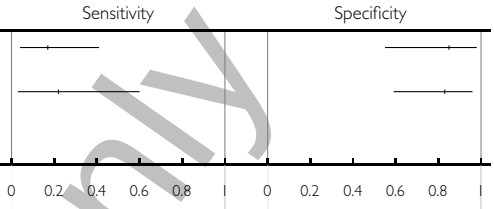


Test 61. Capillary refill 295, ≥3 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 61 Capillary refill 295, ≥3 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	3	2	15	11	0.17 [0.04, 0.41]	0.85 [0.55, 0.98]
Shimizu 2012	2	3	7	15	0.22 [0.03, 0.60]	0.83 [0.59, 0.96]

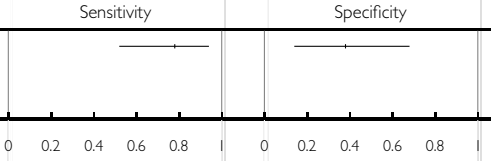


Test 62. Capillary refill 295, ≥2 sec.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 62 Capillary refill 295, ≥2 sec

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	14	8	4	5	0.78 [0.52, 0.94]	0.38 [0.14, 0.68]

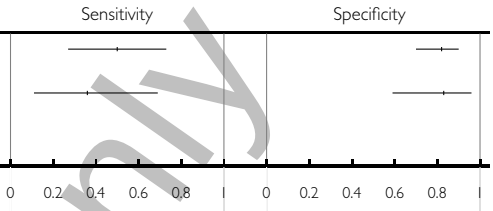


Test 63. Dry axilla by touch 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 63 Dry axilla by touch 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Eaton 1994	10	12	10	54	0.50 [0.27, 0.73]	0.82 [0.70, 0.90]
Shimizu 2012	4	3	7	15	0.36 [0.11, 0.69]	0.83 [0.59, 0.96]

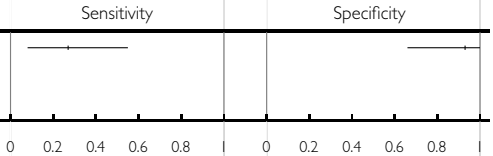


Test 64. Dry axilla by meter 295, <32%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 64 Dry axilla by meter 295, <32%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Shimizu 2012	4	1	11	13	0.27 [0.08, 0.55]	0.93 [0.66, 1.00]

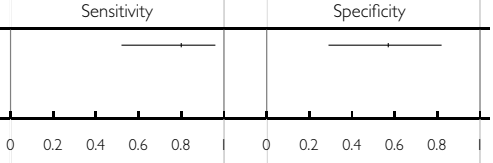


Test 65. Dry axilla by meter 295, <37%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 65 Dry axilla by meter 295, <37%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Shimizu 2012	12	6	3	8	0.80 [0.52, 0.96]	0.57 [0.29, 0.82]

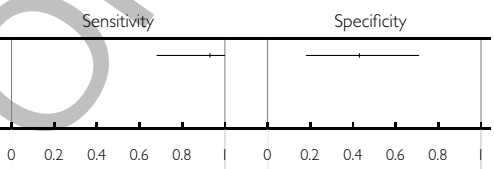


Test 66. Dry axilla by meter 295, <42%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 66 Dry axilla by meter 295, <42%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Shimizu 2012	14	8	1	6	0.93 [0.68, 1.00]	0.43 [0.18, 0.71]

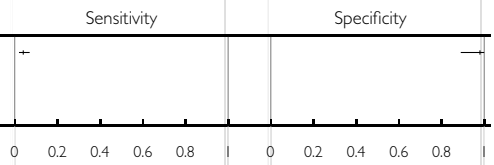


Test 67. Consciousness level 295, ≥coma.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 67 Consciousness level 295, ≥coma

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	9	1	246	47	0.04 [0.02, 0.07]	0.98 [0.89, 1.00]

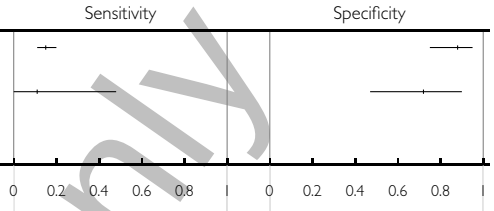


Test 68. Consciousness level 295, ≥stupor.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 68 Consciousness level 295, ≥stupor

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	39	6	216	42	0.15 [0.11, 0.20]	0.88 [0.75, 0.95]
Shimizu 2012	1	5	8	13	0.11 [0.00, 0.48]	0.72 [0.47, 0.90]

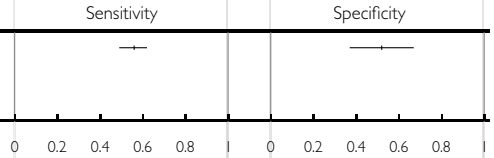


Test 69. Consciousness level 295, ≥obsessed.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 69 Consciousness level 295, ≥obsessed

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	142	23	113	25	0.56 [0.49, 0.62]	0.52 [0.37, 0.67]

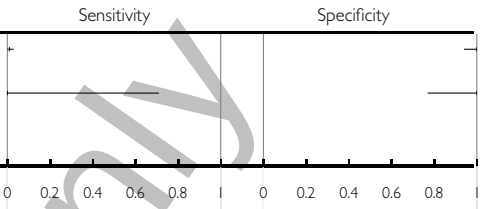


Test 70. MMSE 295 <10.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 70 MMSE 295 <10

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	2	0	243	63	0.01 [0.00, 0.03]	1.00 [0.94, 1.00]
Gaspar Acute % LTC 2011	0	0	3	14	0.0 [0.0, 0.71]	1.00 [0.77, 1.00]

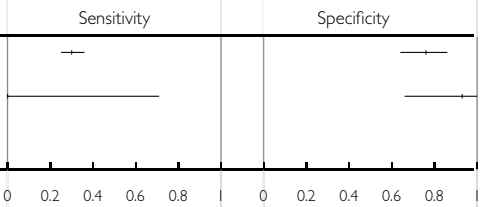


Test 71. MMSE 295 <20.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 71 MMSE 295 <20

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	74	15	171	48	0.30 [0.25, 0.36]	0.76 [0.64, 0.86]
Gaspar Acute % LTC 2011	0	1	3	13	0.0 [0.0, 0.71]	0.93 [0.66, 1.00]

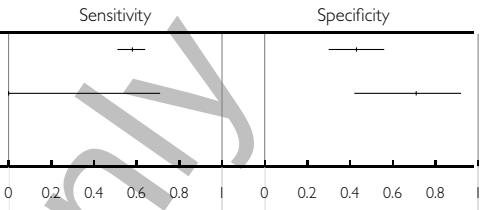


Test 72. MMSE 295 <25.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 72 MMSE 295 <25

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	141	36	104	27	0.58 [0.51, 0.64]	0.43 [0.30, 0.56]
Gaspar Acute % LTC 2011	0	4	3	10	0.0 [0.0, 0.71]	0.71 [0.42, 0.92]

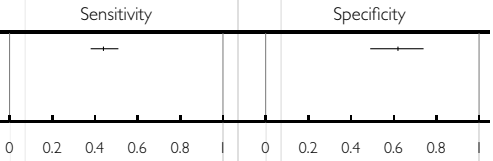


Test 73. Neecham 295 <27.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 73 Neecham 295 <27

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	108	24	137	39	0.44 [0.38, 0.51]	0.62 [0.49, 0.74]

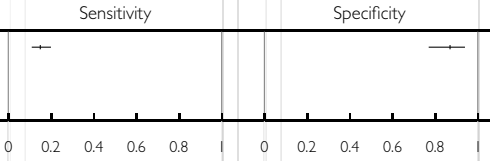


Test 74. Neecham 295, ≤24.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 74 Neecham 295, ≤24

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	36	8	209	55	0.15 [0.11, 0.20]	0.87 [0.77, 0.94]

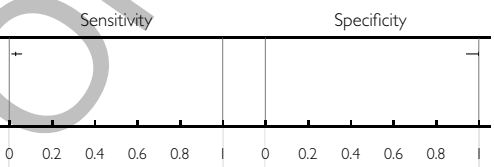


Test 75. Neecham 295, <20.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 75 Neecham 295, <20

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	7	0	238	63	0.03 [0.01, 0.06]	1.00 [0.94, 1.00]

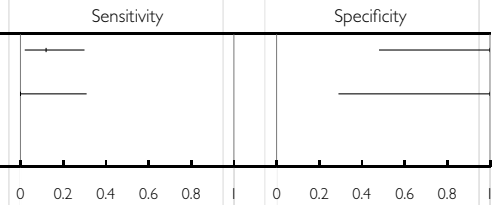


Test 76. Tiredness 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 76 Tiredness 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	3	0	23	5	0.12 [0.02, 0.30]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

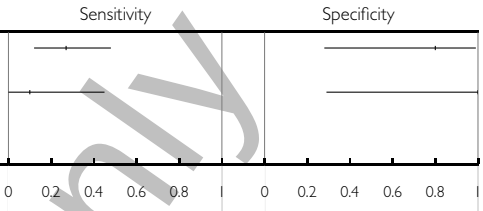


Test 77. Tiredness 295, moderate or severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 77 Tiredness 295, moderate or severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	7	1	19	4	0.27 [0.12, 0.48]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	1	0	9	3	0.10 [0.00, 0.45]	1.00 [0.29, 1.00]

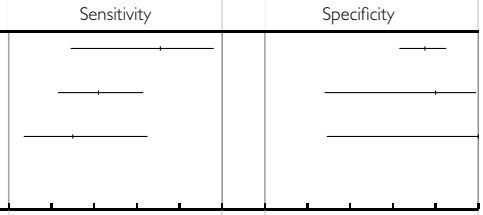


Test 78. Fatigue 295, any.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 78 Fatigue 295, any

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	5	16	2	48	0.71 [0.29, 0.96]	0.75 [0.63, 0.85]
Sjöstrand ED 2013	11	1	15	4	0.42 [0.23, 0.63]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	3	0	7	3	0.30 [0.07, 0.65]	1.00 [0.29, 1.00]

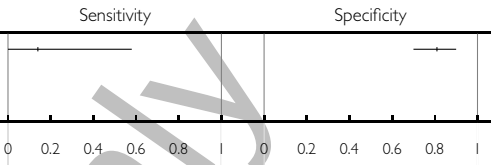


Test 79. Lassitude 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 79 Lassitude 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	1	12	6	52	0.14 [0.00, 0.58]	0.81 [0.70, 0.90]

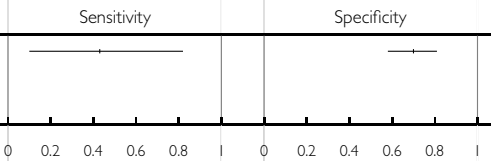


Test 80. Feels dull 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 80 Feels dull 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	3	19	4	45	0.43 [0.10, 0.82]	0.70 [0.58, 0.81]

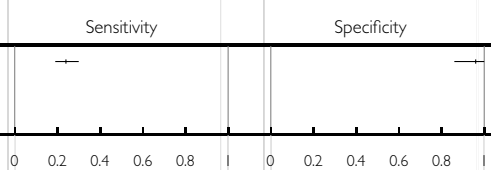


Test 81. Dry oral mucosa 295, cheek.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 81 Dry oral mucosa 295, cheek

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	59	2	182	47	0.24 [0.19, 0.30]	0.96 [0.86, 1.00]

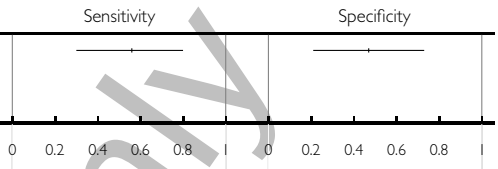


Test 82. Tongue furrows 295, ≥mild.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 82 Tongue furrows 295, ≥mild

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	9	8	7	7	0.56 [0.30, 0.80]	0.47 [0.21, 0.73]

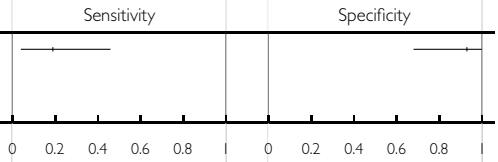


Test 83. Tongue furrows 295, ≥moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 83 Tongue furrows 295, ≥moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	3	1	13	14	0.19 [0.04, 0.46]	0.93 [0.68, 1.00]

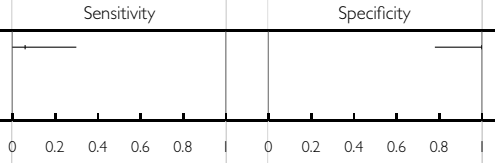


Test 84. Tongue furrows 295, ≥severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 84 Tongue furrows 295, ≥severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	1	0	15	15	0.06 [0.00, 0.30]	1.00 [0.78, 1.00]

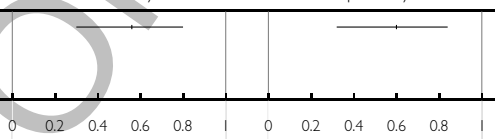


Test 85. Tongue dry 295, ≥mild.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 85 Tongue dry 295, ≥mild

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	9	6	7	9	0.56 [0.30, 0.80]	0.60 [0.32, 0.84]

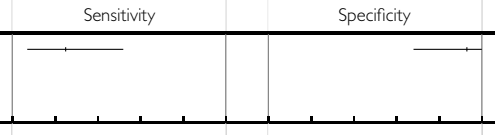


Test 86. Tongue dry 295, ≥moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 86 Tongue dry 295, ≥moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	4	1	12	14	0.25 [0.07, 0.52]	0.93 [0.68, 1.00]

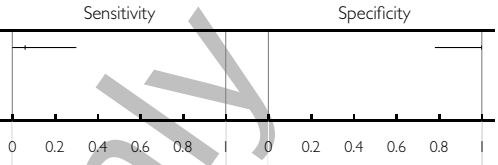


Test 87. Tongue dry 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 87 Tongue dry 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	1	0	15	15	0.06 [0.00, 0.30]	1.00 [0.78, 1.00]

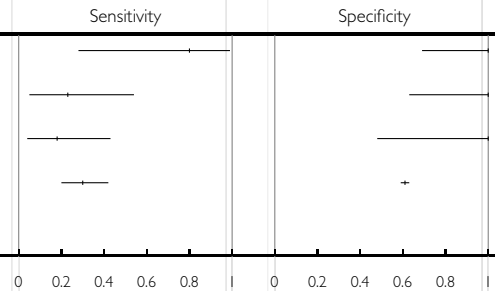


Test 88. BIA Resistance 50kHz 295, ≥550 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 88 BIA Resistance 50kHz 295, ≥550 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Allison 2005	4	0	1	10	0.80 [0.28, 0.99]	1.00 [0.69, 1.00]
Kafri 2012	3	0	10	8	0.23 [0.05, 0.54]	1.00 [0.63, 1.00]
Powers 2012	3	0	14	5	0.18 [0.04, 0.43]	1.00 [0.48, 1.00]
Stookey 2005	21	727	49	1150	0.30 [0.20, 0.42]	0.61 [0.59, 0.63]

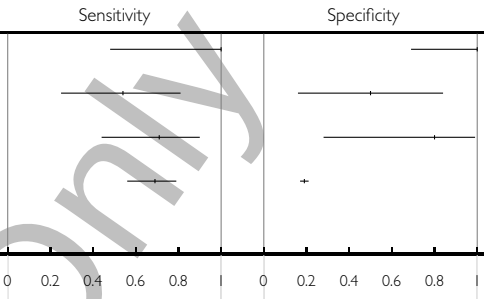


Test 89. BIA Resistance 50kHz 295, ≥450 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 89 BIA Resistance 50kHz 295, ≥450 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Allison 2005	5	0	0	10	1.00 [0.48, 1.00]	1.00 [0.69, 1.00]
Kafri 2012	7	4	6	4	0.54 [0.25, 0.81]	0.50 [0.16, 0.84]
Powers 2012	12	1	5	4	0.71 [0.44, 0.90]	0.80 [0.28, 0.99]
Stookey 2005	48	1518	22	359	0.69 [0.56, 0.79]	0.19 [0.17, 0.21]

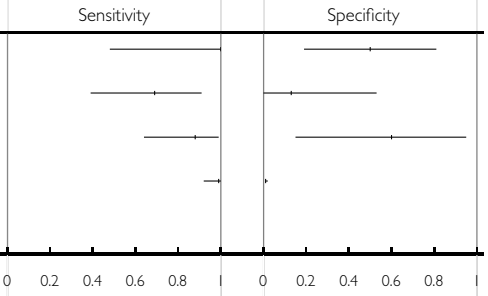


Test 90. BIA Resistance 50kHz 295, ≥350 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 90 BIA Resistance 50kHz 295, ≥350 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Allison 2005	5	5	0	5	1.00 [0.48, 1.00]	0.50 [0.19, 0.81]
Kafri 2012	9	7	4	1	0.69 [0.39, 0.91]	0.13 [0.00, 0.53]
Powers 2012	15	2	2	3	0.88 [0.64, 0.99]	0.60 [0.15, 0.95]
Stookey 2005	69	1859	1	18	0.99 [0.92, 1.00]	0.01 [0.01, 0.02]

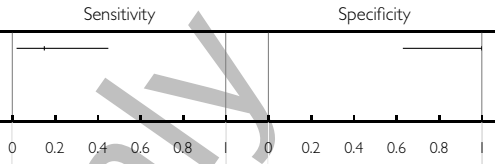


Test 91. BIA Resistance 100kHz 295, ≥550 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 91 BIA Resistance 100kHz 295, ≥550 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	2	0	11	8	0.15 [0.02, 0.45]	1.00 [0.63, 1.00]

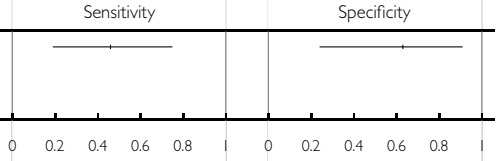


Test 92. BIA Resistance 100kHz 295, ≥450 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 92 BIA Resistance 100kHz 295, ≥450 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	6	3	7	5	0.46 [0.19, 0.75]	0.63 [0.24, 0.91]

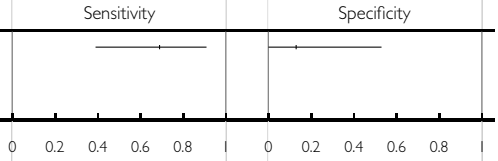


Test 93. BIA Resistance 100kHz 295, ≥350 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 93 BIA Resistance 100kHz 295, ≥350 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	9	7	4	1	0.69 [0.39, 0.91]	0.13 [0.00, 0.53]

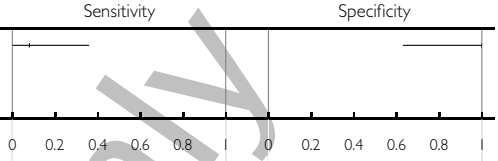


Test 94. BIA Resistance 200kHz 295, ≥550 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 94 BIA Resistance 200kHz 295, ≥550 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	1	0	12	8	0.08 [0.00, 0.36]	1.00 [0.63, 1.00]

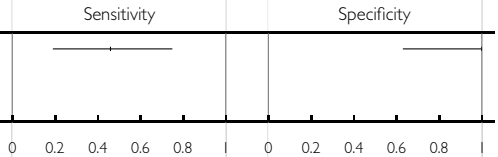


Test 95. BIA Resistance 200kHz 295, ≥450 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 95 BIA Resistance 200kHz 295, ≥450 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	6	0	7	8	0.46 [0.19, 0.75]	1.00 [0.63, 1.00]

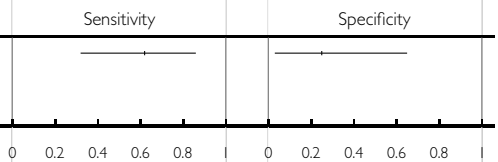


Test 96. BIA Resistance 200kHz 295, ≥350 ohms.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 96 BIA Resistance 200kHz 295, ≥350 ohms

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kafri 2012	8	6	5	2	0.62 [0.32, 0.86]	0.25 [0.03, 0.65]

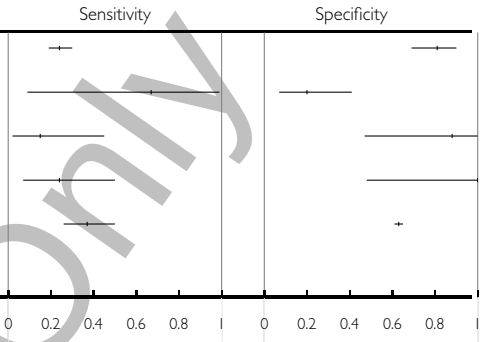


Test 97. BIA TBW% 295, <45%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 97 BIA TBW% 295, <45%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	59	12	186	51	0.24 [0.19, 0.30]	0.81 [0.69, 0.90]
Gaspar Acute % LTC 2011	2	20	1	5	0.67 [0.09, 0.99]	0.20 [0.07, 0.41]
Kafri 2012	2	1	11	7	0.15 [0.02, 0.45]	0.88 [0.47, 1.00]
Powers 2012	4	0	13	5	0.24 [0.07, 0.50]	1.00 [0.48, 1.00]
Stookey 2005	26	692	44	1184	0.37 [0.26, 0.50]	0.63 [0.61, 0.65]

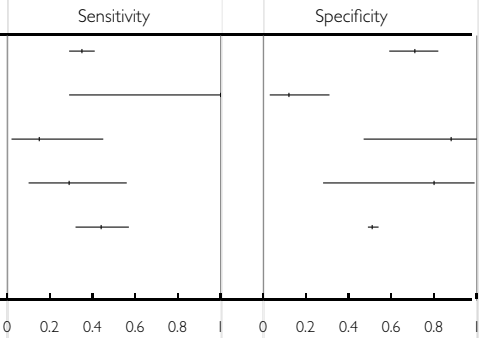


Test 98. BIA TBW% 295, <47%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 98 BIA TBW% 295, <47%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	85	18	160	45	0.35 [0.29, 0.41]	0.71 [0.59, 0.82]
Gaspar Acute % LTC 2011	3	22	0	3	1.00 [0.29, 1.00]	0.12 [0.03, 0.31]
Kafri 2012	2	1	11	7	0.15 [0.02, 0.45]	0.88 [0.47, 1.00]
Powers 2012	5	1	12	4	0.29 [0.10, 0.56]	0.80 [0.28, 0.99]
Stookey 2005	31	914	39	962	0.44 [0.32, 0.57]	0.51 [0.49, 0.54]

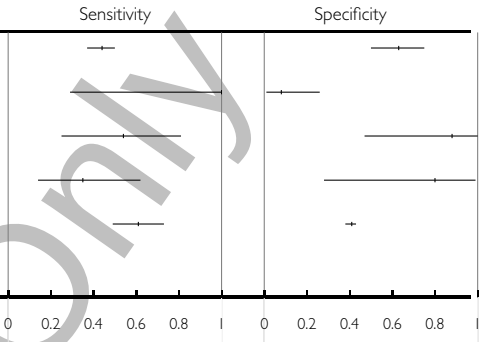


Test 99. BIA TBW% 295, <49%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 99 BIA TBW% 295, <49%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	107	23	138	40	0.44 [0.37, 0.50]	0.63 [0.50, 0.75]
Gaspar Acute % LTC 2011	3	23	0	2	1.00 [0.29, 1.00]	0.08 [0.01, 0.26]
Kafri 2012	7	1	6	7	0.54 [0.25, 0.81]	0.88 [0.47, 1.00]
Powers 2012	6	1	11	4	0.35 [0.14, 0.62]	0.80 [0.28, 0.99]
Stookey 2005	43	1112	27	764	0.61 [0.49, 0.73]	0.41 [0.38, 0.43]

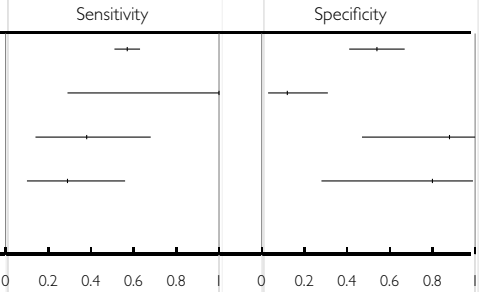


Test 100. BIA ICW% 295, <25%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 100 BIA ICW% 295, <25%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	140	29	105	34	0.57 [0.51, 0.63]	0.54 [0.41, 0.67]
Gaspar Acute % LTC 2011	3	22	0	3	1.00 [0.29, 1.00]	0.12 [0.03, 0.31]
Kafri 2012	5	1	8	7	0.38 [0.14, 0.68]	0.88 [0.47, 1.00]
Powers 2012	5	1	12	4	0.29 [0.10, 0.56]	0.80 [0.28, 0.99]

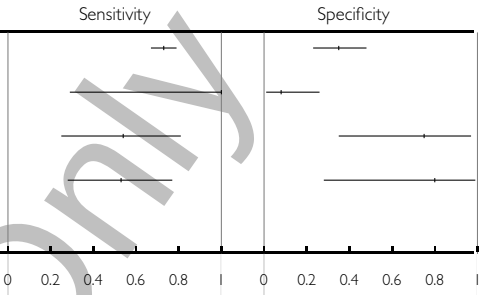


Test 101. BIA ICW% 295, <27%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 101 BIA ICW% 295, <27%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	180	41	65	22	0.73 [0.67, 0.79]	0.35 [0.23, 0.48]
Gaspar Acute % LTC 2011	3	23	0	2	1.00 [0.29, 1.00]	0.08 [0.01, 0.26]
Kafri 2012	7	2	6	6	0.54 [0.25, 0.81]	0.75 [0.35, 0.97]
Powers 2012	9	1	8	4	0.53 [0.28, 0.77]	0.80 [0.28, 0.99]

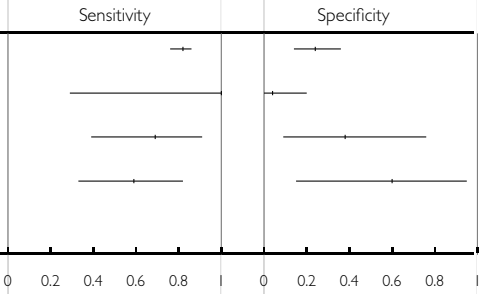


Test 102. BIA ICW% 295, <29%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 102 BIA ICW% 295, <29%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	200	48	45	15	0.82 [0.76, 0.86]	0.24 [0.14, 0.36]
Gaspar Acute % LTC 2011	3	24	0	1	1.00 [0.29, 1.00]	0.04 [0.00, 0.20]
Kafri 2012	9	5	4	3	0.69 [0.39, 0.91]	0.38 [0.09, 0.76]
Powers 2012	10	2	7	3	0.59 [0.33, 0.82]	0.60 [0.15, 0.95]

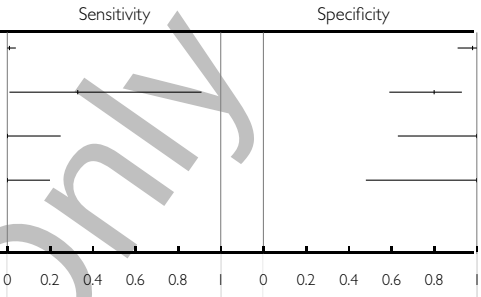


Test 103. BIA ECW% 295, <18%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 103 BIA ECW% 295, <18%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	3	1	242	62	0.01 [0.00, 0.04]	0.98 [0.91, 1.00]
Gaspar Acute % LTC 2011	1	5	2	20	0.33 [0.01, 0.91]	0.80 [0.59, 0.93]
Kafri 2012	0	0	13	8	0.0 [0.0, 0.25]	1.00 [0.63, 1.00]
Powers 2012	0	0	17	5	0.0 [0.0, 0.20]	1.00 [0.48, 1.00]

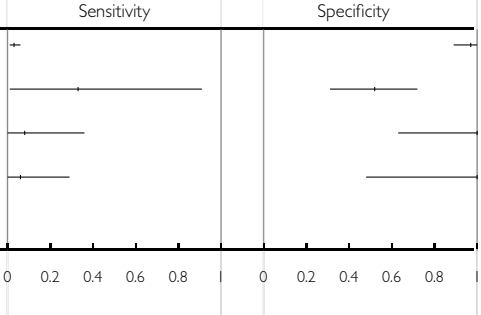


Test 104. BIA ECW% 295, <20%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 104 BIA ECW% 295, <20%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	8	2	237	61	0.03 [0.01, 0.06]	0.97 [0.89, 1.00]
Gaspar Acute % LTC 2011	1	12	2	13	0.33 [0.01, 0.91]	0.52 [0.31, 0.72]
Kafri 2012	1	0	12	8	0.08 [0.00, 0.36]	1.00 [0.63, 1.00]
Powers 2012	1	0	16	5	0.06 [0.00, 0.29]	1.00 [0.48, 1.00]

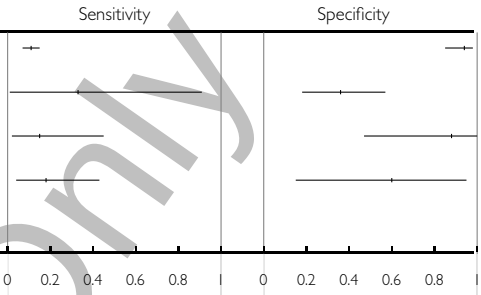


Test 105. BIA ECW% 295, <22%.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 105 BIA ECW% 295, <22%

Study	TP	FP	FN	TN	Sensitivity	Specificity
Culp 2003	26	4	219	59	0.11 [0.07, 0.15]	0.94 [0.85, 0.98]
Gaspar Acute % LTC 2011	1	16	2	9	0.33 [0.01, 0.91]	0.36 [0.18, 0.57]
Kafri 2012	2	1	11	7	0.15 [0.02, 0.45]	0.88 [0.47, 1.00]
Powers 2012	3	2	14	3	0.18 [0.04, 0.43]	0.60 [0.15, 0.95]

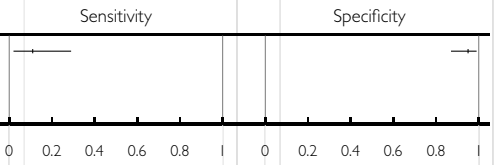


Test 106. Insufficient tears 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 106 Insufficient tears 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	3	4	24	74	0.11 [0.02, 0.29]	0.95 [0.87, 0.99]



Test 107. Insufficient tears or not tolerated 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 107 Insufficient tears or not tolerated 295

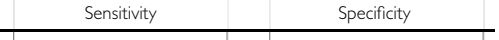
Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Walsh 2012	7	9	20	69	0.26 [0.11, 0.46]	0.88 [0.79, 0.95]		

Test 108. Oral thickener used 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 108 Oral thickener used 295

Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Stotts 2009	6	5	24	13	0.20 [0.08, 0.39]	0.72 [0.47, 0.90]		



Test 109. Oral fluid without thickener 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 109 Oral fluid without thickener 295

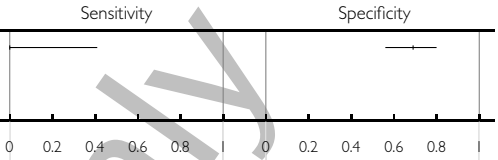
Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Stotts 2009	17	8	13	10	0.57 [0.37, 0.75]	0.56 [0.31, 0.78]		

Test 110. Lips dry 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 110 Lips dry 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	0	20	7	44	0.0 [0.0, 0.41]	0.69 [0.56, 0.80]

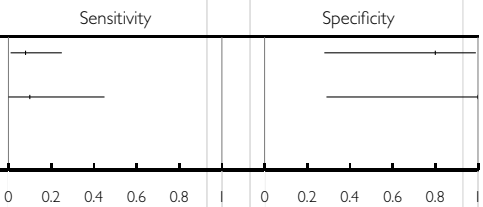


Test 111. Dry mouth 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 111 Dry mouth 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	2	1	24	4	0.08 [0.01, 0.25]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	1	0	9	3	0.10 [0.00, 0.45]	1.00 [0.29, 1.00]

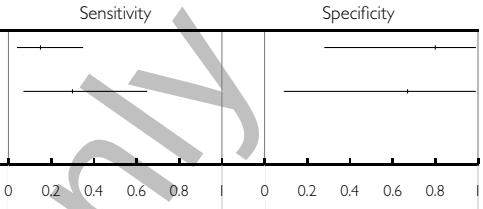


Test 112. Dry mouth 295, moderate or severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 112 Dry mouth 295, moderate or severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	4	1	22	4	0.15 [0.04, 0.35]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	3	1	7	2	0.30 [0.07, 0.65]	0.67 [0.09, 0.99]

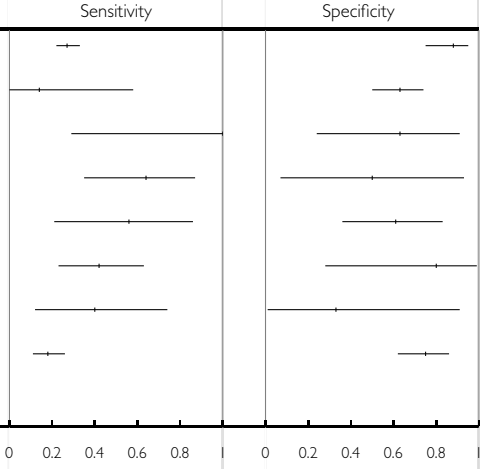


Test 113. Dry mouth 295, any.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 113 Dry mouth 295, any

Study	TP	FP	FN	TN	Sensitivity	Specificity
Chassagne 2006	65	6	174	43	0.27 [0.22, 0.33]	0.88 [0.75, 0.95]
Kajii 2006	1	24	6	40	0.14 [0.00, 0.58]	0.63 [0.50, 0.74]
McGarvey 2010	3	3	0	5	1.00 [0.29, 1.00]	0.63 [0.24, 0.91]
Rowat 2011	9	2	5	2	0.64 [0.35, 0.87]	0.50 [0.07, 0.93]
Shimizu 2012	5	7	4	11	0.56 [0.21, 0.86]	0.61 [0.36, 0.83]
Sjöstrand ED 2013	11	1	15	4	0.42 [0.23, 0.63]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	4	2	6	1	0.40 [0.12, 0.74]	0.33 [0.01, 0.91]
Source Study 2001	20	13	91	40	0.18 [0.11, 0.26]	0.75 [0.62, 0.86]

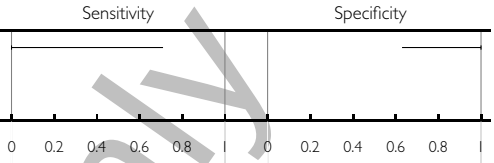


Test 114. Unable to spit 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 114 Unable to spit 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
McGarvey 2010	0	0	3	8	0.0 [0.0, 0.71]	1.00 [0.63, 1.00]

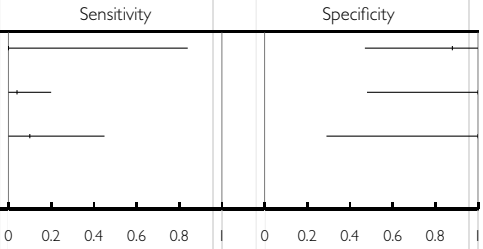


Test 115. Thirst VAS rating 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 115 Thirst VAS rating 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Mack 1994	0	1	2	7	0.0 [0.0, 0.84]	0.88 [0.47, 1.00]
Sjöstrand ED 2013	1	0	25	5	0.04 [0.00, 0.20]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	1	0	9	3	0.10 [0.00, 0.45]	1.00 [0.29, 1.00]

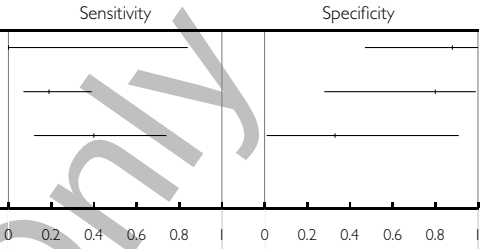


Test 116. Thirst VAS rating 295, moderate plus.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 116 Thirst VAS rating 295, moderate plus

Study	TP	FP	FN	TN	Sensitivity	Specificity
Mack 1994	0	1	2	7	0.0 [0.0, 0.84]	0.88 [0.47, 1.00]
Sjöstrand ED 2013	5	1	21	4	0.19 [0.07, 0.39]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	4	2	6	1	0.40 [0.12, 0.74]	0.33 [0.01, 0.91]

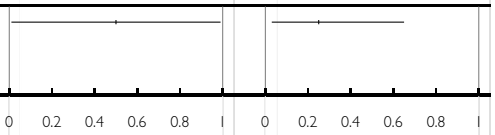


Test 117. Thirst VAS rating 295, mild plus.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 117 Thirst VAS rating 295, mild plus

Study	TP	FP	FN	TN	Sensitivity	Specificity
Mack 1994	1	6	1	2	0.50 [0.01, 0.99]	0.25 [0.03, 0.65]

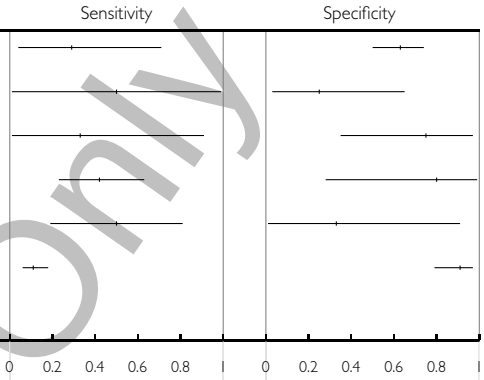


Test 118. Thirsty 295, any degree.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 118 Thirsty 295, any degree

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	2	24	5	40	0.29 [0.04, 0.71]	0.63 [0.50, 0.74]
Mack 1994	1	6	1	2	0.50 [0.01, 0.99]	0.25 [0.03, 0.65]
McGarvey 2010	1	2	2	6	0.33 [0.01, 0.91]	0.75 [0.35, 0.97]
Sjöstrand ED 2013	11	1	15	4	0.42 [0.23, 0.63]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	5	2	5	1	0.50 [0.19, 0.81]	0.33 [0.01, 0.91]
Source Study 2001	12	5	99	48	0.11 [0.06, 0.18]	0.91 [0.79, 0.97]

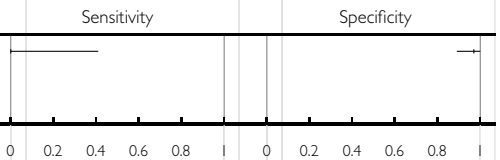


Test 119. Tongue smarts 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 119 Tongue smarts 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	0	2	7	62	0.0 [0.0, 0.41]	0.97 [0.89, 1.00]

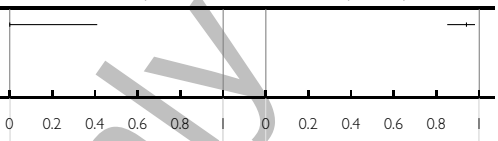


Test 120. Mouth smarts 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 120 Mouth smarts 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	0	4	7	60	0.0 [0.0, 0.41]	0.94 [0.85, 0.98]

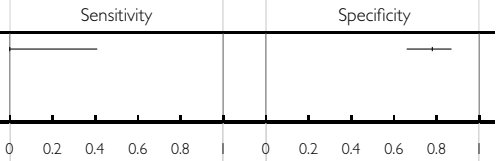


Test 121. Sticky saliva 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 121 Sticky saliva 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	0	14	7	50	0.0 [0.0, 0.41]	0.78 [0.66, 0.87]

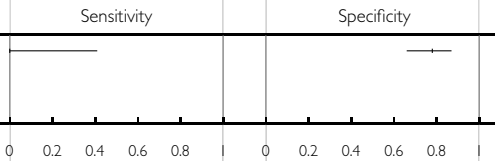


Test 122. Sticky mouth 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 122 Sticky mouth 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	0	14	7	50	0.0 [0.0, 0.41]	0.78 [0.66, 0.87]

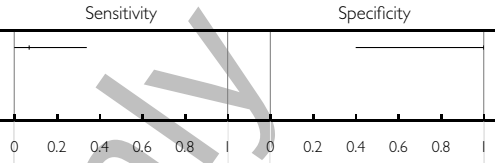


Test 123. Blue lips 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 123 Blue lips 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Rowat 2011	1	0	13	4	0.07 [0.00, 0.34]	1.00 [0.40, 1.00]

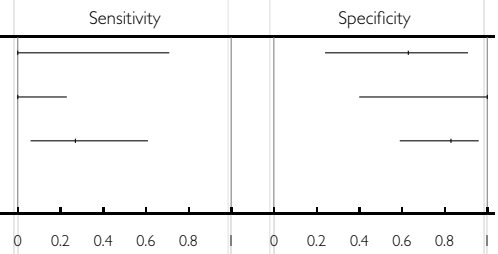


Test 124. Sunken eyes 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 124 Sunken eyes 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
McGarvey 2010	0	3	3	5	0.0 [0.0, 0.71]	0.63 [0.24, 0.91]
Rowat 2011	0	0	14	4	0.0 [0.0, 0.23]	1.00 [0.40, 1.00]
Shimizu 2012	3	3	8	15	0.27 [0.06, 0.61]	0.83 [0.59, 0.96]

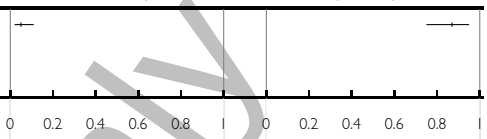


Test 125. Bed sores 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 125 Bed sores 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Source Study 2001	6	7	105	46	0.05 [0.02, 0.11]	0.87 [0.75, 0.95]

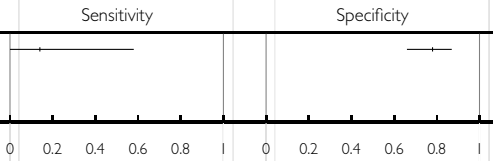


Test 126. Swallowing problems 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 126 Swallowing problems 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	1	14	6	50	0.14 [0.00, 0.58]	0.78 [0.66, 0.87]

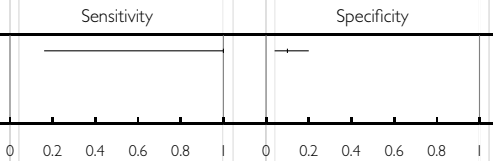


Test 127. Enjoyment of food 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 127 Enjoyment of food 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	2	62	0	7	1.00 [0.16, 1.00]	0.10 [0.04, 0.20]

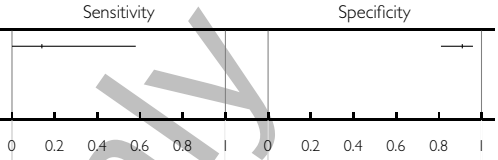


Test 128. Appetite 295.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 128 Appetite 295

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	1	6	6	58	0.14 [0.00, 0.58]	0.91 [0.81, 0.96]

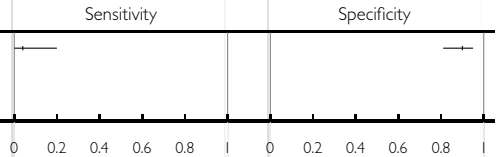


Test 129. Dry eye severity by DEQ-5 295, >12.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 129 Dry eye severity by DEQ-5 295, >12

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	1	8	25	70	0.04 [0.00, 0.20]	0.90 [0.81, 0.95]

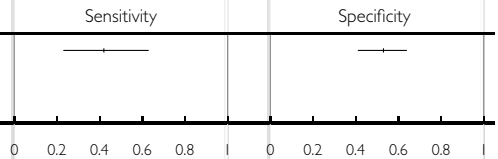


Test 130. Dry eye severity by DEQ-5 295, >6.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 130 Dry eye severity by DEQ-5 295, >6

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	11	37	15	41	0.42 [0.23, 0.63]	0.53 [0.41, 0.64]

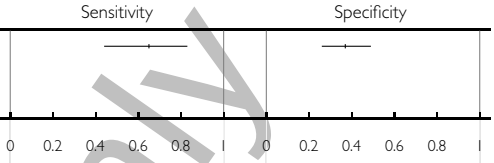


Test 131. Dry eye severity by DEQ-5 295, >3.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 131 Dry eye severity by DEQ-5 295, >3

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	17	49	9	29	0.65 [0.44, 0.83]	0.37 [0.26, 0.49]

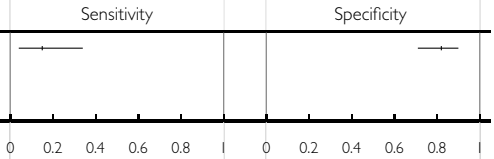


Test 132. Dry eye severity by VAS 295, >5.0 cm.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 132 Dry eye severity by VAS 295, >5.0 cm

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	4	14	23	63	0.15 [0.04, 0.34]	0.82 [0.71, 0.90]

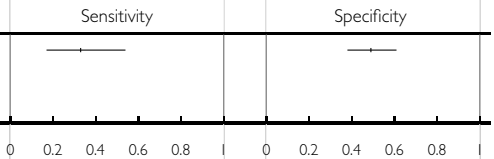


Test 133. Dry eye severity by VAS 295, >1.1 cm.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 133 Dry eye severity by VAS 295, >1.1 cm

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	9	39	18	38	0.33 [0.17, 0.54]	0.49 [0.38, 0.61]

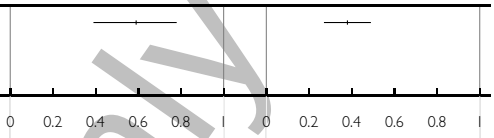


Test 134. Dry eye severity by VAS 295, >0.6 cm.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 134 Dry eye severity by VAS 295, >0.6 cm

Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Walsh 2012	16	48	11	29	0.59 [0.39, 0.78]	0.38 [0.27, 0.49]		

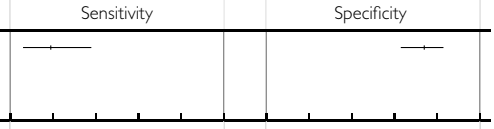


Test 135. NITBUT 295 <6 secs.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 135 NITBUT 295 <6 secs

Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Walsh 2012	5	20	22	57	0.19 [0.06, 0.38]	0.74 [0.63, 0.83]		

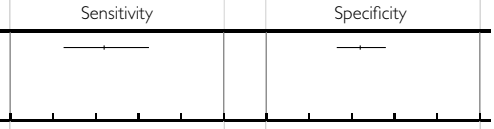


Test 136. NITBUT 295 <10 secs.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 136 NITBUT 295 <10 secs

Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Walsh 2012	12	43	15	34	0.44 [0.25, 0.65]	0.44 [0.33, 0.56]		

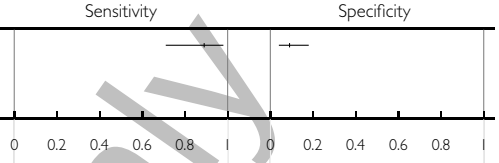


Test 137. NITBUT 295 <27 secs.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 137 NITBUT 295 <27 secs

Study	TP	FP	FN	TN	Sensitivity	Specificity
Walsh 2012	24	70	3	7	0.89 [0.71, 0.98]	0.09 [0.04, 0.18]

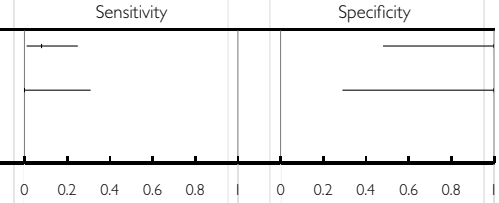


Test 138. Balance 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 138 Balance 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	2	0	24	5	0.08 [0.01, 0.25]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

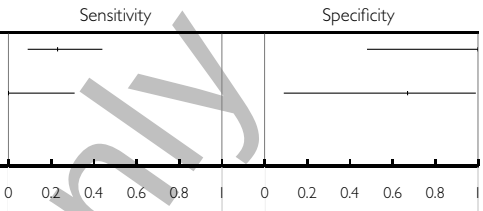


Test 139. Balance 295, ≥moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 139 Balance 295, ≥moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	6	0	20	5	0.23 [0.09, 0.44]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	1	10	2	0.0 [0.0, 0.31]	0.67 [0.09, 0.99]

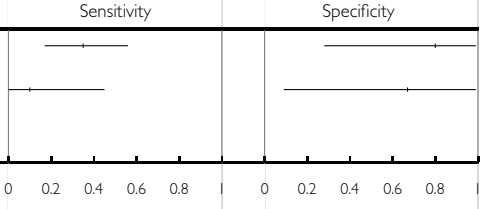


Test 140. Balance 295, any degree.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 140 Balance 295, any degree

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	9	1	17	4	0.35 [0.17, 0.56]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	1	1	9	2	0.10 [0.00, 0.45]	0.67 [0.09, 0.99]

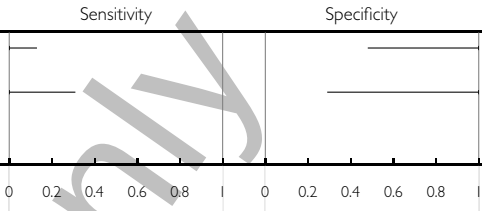


Test 141. Headache 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 141 Headache 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	0	0	26	5	0.0 [0.0, 0.13]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

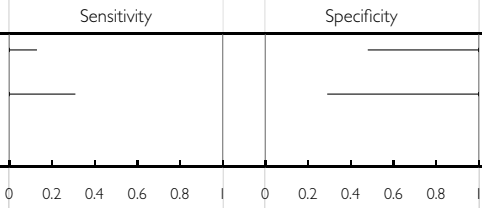


Test 142. Headache 295, moderate+.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 142 Headache 295, moderate+

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	0	0	26	5	0.0 [0.0, 0.13]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

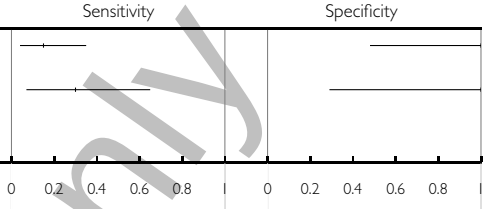


Test 143. Headache 295, any degree.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 143 Headache 295, any degree

Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Sjöstrand ED 2013	4	0	22	5	0.15 [0.04, 0.35]	1.00 [0.48, 1.00]		
Sjöstrand Healthy 2013	3	0	7	3	0.30 [0.07, 0.65]	1.00 [0.29, 1.00]		

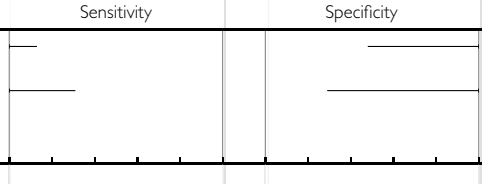


Test 144. Nausea 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 144 Nausea 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity	Sensitivity	Specificity
Sjöstrand ED 2013	0	0	26	5	0.0 [0.0, 0.13]	1.00 [0.48, 1.00]		
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]		

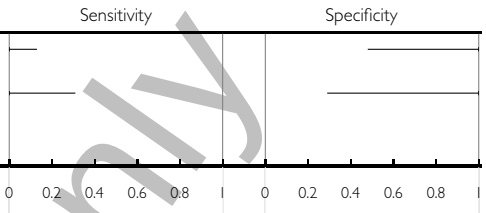


Test 145. Nausea 295, ≥moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 145 Nausea 295, ≥moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	0	0	26	5	0.0 [0.0, 0.13]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

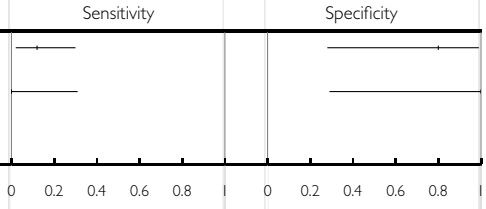


Test 146. Nausea 295, any degree.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 146 Nausea 295, any degree

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	3	1	23	4	0.12 [0.02, 0.30]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

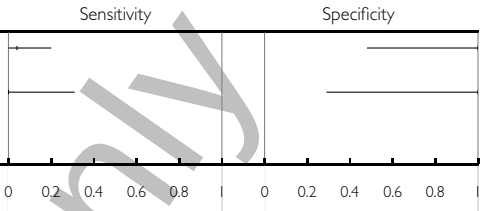


Test 147. Muscle weakness 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 147 Muscle weakness 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	1	0	25	5	0.04 [0.00, 0.20]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

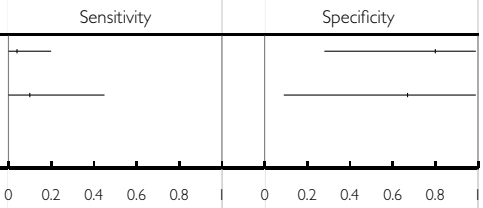


Test 148. Muscle weakness 295, ≥moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 148 Muscle weakness 295, ≥moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	1	1	25	4	0.04 [0.00, 0.20]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	1	1	9	2	0.10 [0.00, 0.45]	0.67 [0.09, 0.99]

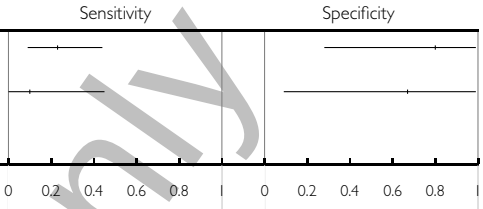


Test 149. Muscle weakness 295, any degree.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 149 Muscle weakness 295, any degree

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	6	1	20	4	0.23 [0.09, 0.44]	0.80 [0.28, 0.99]
Sjöstrand Healthy 2013	1	1	9	2	0.10 [0.00, 0.45]	0.67 [0.09, 0.99]

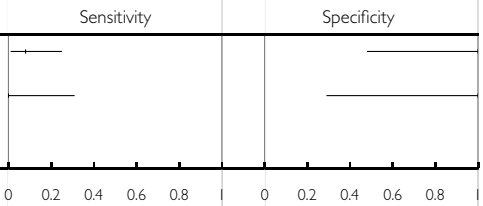


Test 150. Dizziness 295, severe.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 150 Dizziness 295, severe

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	2	0	24	5	0.08 [0.01, 0.25]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	0	0	10	3	0.0 [0.0, 0.31]	1.00 [0.29, 1.00]

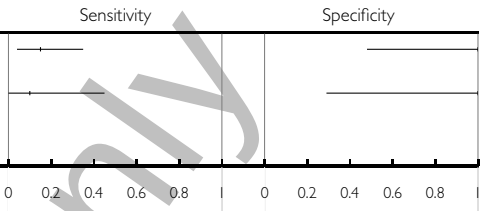


Test 151. Dizziness 295, ≥moderate.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 151 Dizziness 295, ≥moderate

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	4	0	22	5	0.15 [0.04, 0.35]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	1	0	9	3	0.10 [0.00, 0.45]	1.00 [0.29, 1.00]

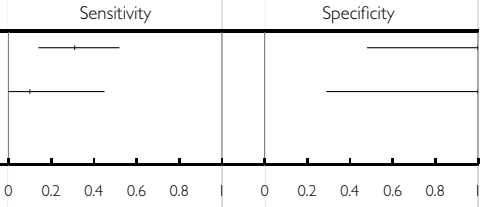


Test 152. Dizziness 295, any degree.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 152 Dizziness 295, any degree

Study	TP	FP	FN	TN	Sensitivity	Specificity
Sjöstrand ED 2013	8	0	18	5	0.31 [0.14, 0.52]	1.00 [0.48, 1.00]
Sjöstrand Healthy 2013	1	0	9	3	0.10 [0.00, 0.45]	1.00 [0.29, 1.00]

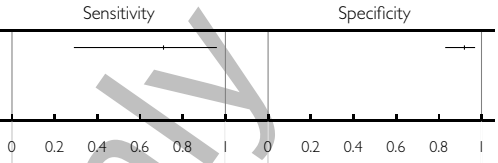


Test 153. Combined drinks AND fatigue.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 153 Combined drinks AND fatigue

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	5	5	2	59	0.71 [0.29, 0.96]	0.92 [0.83, 0.97]

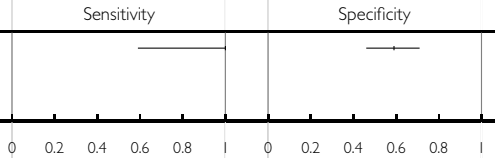


Test 154. Combined, drinks OR fatigue.

Review: Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people

Test: 154 Combined, drinks OR fatigue

Study	TP	FP	FN	TN	Sensitivity	Specificity
Kajii 2006	7	26	0	38	1.00 [0.59, 1.00]	0.59 [0.46, 0.71]



ADDITIONAL TABLES

Table 1. Table explaining cut off values

Test	Description & detail	Cut off reasoning
1 Drinks intake, very low 2 Drinks intake, low 3 Drinks intake, moderate	Ad lib water intake (including water in water, tea and coffee) or all drinks combined, very low vs low and moderate and high • Very low: <1.4L/d in men, <1.0L/d in women • Low: 1.4 to <2.2L/d in men, 1.0 to <1.6L/d in women • Moderate: 2.2 to <3.0L/d in men, 1.6 to <2.2L/d in women	European guidance, EFSA 2010, suggests that men need 2.5L/d of fluid (overall, from food and drinks) while women need 2.0L/d. As they assume that 20% of fluid comes from food, this suggests a drinks intake need of 2.0L/d in men and 1.6L/d in women. The US Panel on Dietary Reference Intakes 2004 suggests that men should drink 3.0L/d and women 2.2L/d.

Table 1. Table explaining cut off values (*Continued*)

	• High: 3.0+L/d in men, 2.2+L in women	We set cut offs to reflect the range of drinks intakes above and below these levels
4 Drinks intake, standard	Drinks intake <1.5L/d in men and women	Taken from evidence that drinks intakes in instititutionalised adults should be at least 1500ml/d (Chidester & Spangler 1997, McGee 1999).
5 Fluid intake, very low 6 Fluid intake, low 7 Fluid intake, moderate	Fluid intake (fluid from food and drinks) - very low vs. low+ • Very low: <1.7l in men, <1.3L in women • Low: 1.7 to <2.7L in men, 1.3 to <2.0L in women • Moderate: 2.7 to <3.7L in men, 2.0 to <2.7L in women • High: 3.7+L in men, 2.7+L in women	European guidance, EFSA 2010, suggests that men need 2.5L/d of fluid (overall, from food and drinks), and that women need 2.0L/d. The US Panel on Dietary Reference Intakes 2004 suggests that men need 3.7L/d and women 2.7L/d of fluid from all sources. We set cut offs to reflect the range of fluid intakes above and below these levels
8 Misses drinks between meals	Participant reports missing drinks between meals	Participant answered "0" to at least one question about how many drinks were taken between meals (defined by primary study, Kajii 2006)
9 Misses drinks at meals	Participant reports missing some drinks at meals	Participant answered "0" to at least one question about how many drinks were taken at breakfast, lunch and evening meal (defined by primary study, Kajii 2006)
10 Urine vol, - <300 mL/d 11 Urine vol, <500 mL/d 12 Urine vol, <800 mL/d 13 Urine vol, fluid recs	Urine volume in ml/d: • <300 ml/d vs 300+ ml/d • <500 ml/d vs 500+ ml/d • <800 ml/d vs 800+ ml/d • <1700ml/d in men or <1300ml/d in women vs 1700+ml/d in men or 1300+ml/d in women	Oliguria is defined as less than 300-500ml/d in adults and normal urine output 800-2000ml/d. Cut-offs set at 300ml/d, 500ml/d, 800ml/d and the lowest fluid intake cut-offs (1.3L/d in women, 1.7L/d in men). A review co-author later commented that the cut-off traditionally used in the USA is 400ml/24 hours - we kept the 300 and 500 ml cut offs as these fall either side of 400ml/24 hours
14 Urine vol daytime, <900 mL 15 Urine vol daytime, <1420 mL 16 Urine vol daytime, <1940 mL	Urinary volume <900ml vs. 900+ml from 7am to 11pm	Cut-offs decided on the basis of the median (1417ml) and outlying values (900, 1940ml) in Johnson 2003
17 Urine vol night, >450 mL/night 18 Urine vol night, >860 mL/night 19 Urine vol night, >1270 mL/night	Urinary volume 450+ml/night vs. <450ml/night from 11pm to 7am	Cut-offs decided by median (863ml) and outlyers (450, 1270ml) in Johnson 2003

Table 1. Table explaining cut off values (*Continued*)

20 Urine voids daytime, ≥11/day 21 Urine voids daytime, ≥7/day 22 Urine voids daytime, ≥4/day	Number of urinary voids during daytime, 7am-11pm	Cut-offs chosen by median (7.0) and outliers (4, 11) in Johnson 2003
23 Urine voids night, ≥1.5/night 24 Urine voids night, ≥2.6/night 25 Urine voids night, ≥4.1/night	Number of urinary voids during night, 11pm to 7am	Cut-offs chosen by median (2.6) and outliers (1.5, 4.1) in Johnson 2003
26 Nocturnal polyuria	Self-reported nocturnal polyuria (reported as yes or no)	
27 Fluid balance, <-180 mL/d 28 Fluid balance, <+180 mL/d 29 Fluid balance, <+1700 mL/d	Fluid balance - fluid from foods and drinks minus urine volume (both over 24 hours), <-180ml/d vs. -180+ml/d	Cut-offs defined by medians from the first 3 datasets analysed (Bossingham 2005; Lindner 2009; Monahan 2006)
30 USG ≥1.035 31 USG ≥1.028 32 USG ≥1.020	• Urine Specific Gravity (USG) - 1.035+ • Urine Specific Gravity (USG) - 1.028+ • Urine Specific Gravity (USG) - 1.020+	Various normal ranges for USG are suggested including 1.006 to 1.020 (Bossingham 2005) and Armstrong has suggested that >1.035 is consistent with frank dehydration (Armstrong 1998), so cut-offs chosen at 1.020, 1.028 and 1.035.
33 Urine colour >6 34 Urine colour >4 35 Urine colour >2	Urine colour as assessed on the Armstrong colour chart, cut-off over 6	Urine colour as assessed on the Armstrong colour chart, score from 1 to 8, 1 is palest, 8 darkest (Armstrong 1998), so cut-offs chosen at 2, 4 and 6.
36 Urine osmolality >1000 mOsm/kg 37 Urine osmolality >800 mOsm/kg 38 Urine osmolality >600 mOsm/kg	• Urine osmolality - >1000 mOsm/kg • Urine osmolality - >800 mOsm/kg • Urine osmolality - >600 mOsm/kg	Cut-offs taken from EFSA 2010 'Dietary Reference Values for water'. They suggest usual urinary osmolarity ranges from 50-1200mOsm/L with up to 500mOsm/L indicating normal hydration. Cut-offs set at 600, 800 and 1000mOsm/L
39 Tear osmolarity >324 mOsm/L 40 Tear osmolarity >316 mOsm/L 41 Tear osmolarity >310 mOsm/L	Tear osmolarity by TearLab system	Literature driven cut-offs (for dry-eye disease, not for dehydration), referenced by Walsh 2012.
42 Heart rate ≥120 bpm 43 Heart rate ≥100 bpm 44 Heart rate ≥80 bpm		Heart rates below 60beats/min are called bradycardia, and over 100 beats/min tachycardia. As higher heart rate is associated with dehydration cut-offs were chosen at 80 beats/min (the upper end of normal), 100 beats/min (onset of tachycardia) and 120 beats/min (a step above 100)
45 Orthostatic hypotension	Orthostatic hypotension - blood pressure falls by at least 20mmHg systolic	Defined by Freeman 2011.

Table 1. Table explaining cut off values (*Continued*)

	or 10mmHg diastolic at 30sec, 1 min or 3mins after moving from lying to standing or sitting	
46 Body temperature ≥38.2ºC 47 Body temperature ≥36.8ºC 48 Body temperature ≥33.2ºC	Body temperature, degrees centigrade • 38.2+ vs. <38.2 • 36.8+ vs. <36.8 • 33.2+ vs. <33.2	The typical under-tongue body temperature is 36.8 °C, with the normal range 33.2-38.2 °C (Sund-Levander 2002), so cut-offs were chosen at 33.2, 36.8 and 38.2 °C.
49 Skin turgor, anterior forearm, ≥3 sec 50 Skin turgor, anterior thigh, ≥3 sec 51 Skin turgor, anterior thigh, abnormal 52 Skin turgor, subclavicular, ≥3 sec 53 Skin turgor, sternum, ≥3 sec 54 Skin turgor, anterior chest, slow	Skin turgor is defined by the number of seconds taken for skin to return to normal after being pinched • Skin turgor at anterior forearm - 3+ seconds vs. 0-2 seconds • Skin turgor at anterior thigh - 3+ seconds vs. 0-2 seconds • Skin turgor at anterior thigh - abnormal vs. normal • Skin turgor at subclavicular - 3+ seconds vs. 0-2 seconds • Skin turgor, sternum - 3seconds vs. 0-seconds • Anterior chest skin turgor assessed as slow to return to normal position by internal medicine residents	Defined by primary study authors (Chassagne 2006; Shimizu 2012; Source Study 2001)
55 Skin turgor, hand, ≥4 sec 56 Skin turgor, hand, ≥3 sec 57 Skin turgor, hand, ≥1 sec	Skin turgor assessed on back of hand, taking 4+ sec vs. <4 sec to return to normal after pinching	3+ seconds is a commonly chosen cut-off in skin turgor studies, so we used this as a cut-off and added data driven cut-offs (median 1sec, min 0 sec, max 4 sec, Kafri 2012) - 1+, 3+, 4+ pragmatically.
58 Skin turgor, hand, abnormal	Skin turgor on back of hand was considered abnormal (no definition)	Defined by primary study authors (McGarvey 2010)
59 Skin turgor, site unspecified, abnormal	The only instructions on form (there was no other specific information as to site etc and considered to be a judgement): "Doesn't bounce back if pinched"	Defined by primary study authors (Rowat 2011)
60 Capillary refill, ≥4 sec 61 Capillary refill, ≥3 sec 62 Capillary refill, ≥2 sec	• Capillary refill time, 4+sec vs. 0-3sec • Capillary refill time, 3+sec vs. 0-2sec (Kafri), capillary refill of middle finger at heart height >2 seconds (Tokuda) • Capillary refill time, 2+ sec vs. 0-1 sec	Cut-offs data driven, defined by Shimizu 2012 data set (>2 seconds vs. 0-2 seconds) and by Kafri 2012 (median 2 seconds, min 1 second, max 4 seconds). Cut-offs 2+ seconds, 3+ seconds and 4+ seconds
63 Dry axilla by touch	Axilla (underarm) was dry to the feel (as opposed to moist)	Feel of axilla - dry or moist. Defined by primary study authors (Eaton 1994; Shimizu

Table 1. Table explaining cut off values (*Continued*)

		2012)
64 Dry axilla by meter, <32% 65 Dry axilla by meter, <37% 66 Dry axilla by meter, <42%	• Dry axilla assessed by skin moisture meter, as <32% • Dry axilla assessed by skin moisture metre, as <37% • Dry axilla assessed by skin moisture metre, as <42%	Mean axillary moisture in the primary research was 37%, with a mean of 33% in the dehydrated group and 42% in the hydrated group, so cut-offs were chosen at 37%, 32% and 42% (Shimizu 2012).
67 Consciousness level, ≥coma 68 Consciousness level, ≥stupor 69 Consciousness level, ≥obsessed	• Consciousness level - coma vs. other • Consciousness level - coma or stupor vs. other (Chassagne 2006) or decreased consciousness (Shimizu 2012) • Consciousness level - coma or stupor or obsessed vs. alert	Cut-offs provided by levels chosen by primary researcher - coma, stupor, obsessed, alert (Chassagne 2006). We also included data presented in Tokuda (Shimizu 2012) , as decreased consciousness vs not decreased.
70 MMSE <10 71 MMSE <20 72 MMSE <25	Mini-mental State Exam, a measure of cognitive health, scores from 0 to 30, higher scores suggest better cognitive health	Cut-offs chosen according to standards for the MMSE, with a score of 24 or less indicating presence of dementia, 20-24 indicating mild dementia, 10-19 moderate dementia and <10 severe dementia (O'Bryant 2008; Simard 1998). Cut-offs were chosen at <25, <20 and <10.
73 Neecham <27 74 Neecham ≤24 75 Neecham <20	Neecham confusion scale, a 9-item instrument for assessing confusion, range 0 to 30. Scores of 24 or less suggest delirium, other cut-offs chosen at 20 and 27	
76 Tiredness, severe 77 Tiredness, moderate or severe	Do you have any symptoms of tiredness? 0= no, if yes graded on 1-100 VAS for severity. Severe tiredness equated to 67+, Moderate tiredness to 34+, fatigue (tiredness of any degree) to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)
78 Fatigue, any	Participant reported fatigue. Participant answered "yes" to question of whether had felt fatigue over past 3 days (Kajii 2006) or answered "yes" to feeling symptoms of tiredeness (any number >0 on 0-100 VAS) (Sjöstrand Healthy 2013)	
79 Lassitude	Participant answered "yes" to question of whether had felt lassitude over past 3 days	Set by primary researcher (Kajii 2006)
80 Feels dull	Participant answered "yes" to question of whether had felt dull over past 3 days	Set by primary researcher (Kajii 2006)

Table 1. Table explaining cut off values (*Continued*)

81 Dry oral mucosa, cheek	Dry oral mucosa, assessed on the inside of the cheek - dry vs wet	Defined by researchers (Chassagne 2006).
82 Tongue furrows, ≥mild 83 Tongue furrows, ≥moderate 84 Tongue furrows, ≥severe	• Tongue furrows, mild, moderate or severe vs. none • Tongue furrows, moderate or severe vs. none or mild • Tongue furrows, severe vs. none, mild or moderate	Severity categories as defined by study author (Kafri 2012)
85 Tongue dry, ≥mild 86 Tongue dry, ≥moderate 87 Tongue dry, severe	• Tongue dry, mild, moderate or severe vs. damp • Tongue dry, moderate or severe vs. mild or damp • Tongue dry, severe vs. mild, moderate or damp	Severity categories as defined by study author (Kafri 2012)
88 BIA Resistance 50kHz, ≥550 ohms 89 BIA Resistance 50kHz, ≥450 ohms 90 BIA Resistance 50kHz, ≥350 ohms	Resistance at 50kHz from bioimpedance analysis (BIA) • dichotomised at 550ohms • dichotomised at 450ohms • dichotomised at 350ohms	Cut-off proposed at 550ohms by Allison 2005 (with values of at least 550 suggesting hypovolaemia). Other cut-offs chosen at 350 and 450 pragmatically
91 BIA Resistance 100kHz, ≥550 ohms 92 BIA Resistance 100kHz, ≥450 ohms 93 BIA Resistance 100kHz, ≥350 ohms	Resistance at 100kHz from bioimpedance analysis (BIA) • dichotomised at 550ohms • dichotomised at 450ohms • dichotomised at 350ohms	Cut-off proposed at 550ohms by Allison 2005 (with values of at least 550 suggesting hypovolaemia). Other cut-offs chosen at 350 and 450ohms pragmatically
94 BIA Resistance 200kHz, ≥550 ohms 95 BIA Resistance 200kHz, ≥450 ohms 96 BIA Resistance 200kHz, ≥350 ohms	Resistance at 200kHz from bioimpedance analysis (BIA) • dichotomised at 550ohms • dichotomised at 450ohms • dichotomised at 350ohms	Cut-off proposed at 550ohms by Allison 2005 (with values of at least 550 suggesting hypovolaemia). Other cut-offs chosen at 350 and 450ohms pragmatically
97 BIA TBW% <45% 98 BIA TBW% <47% 99 BIA TBW% <49%	Total body water as a percentage of body weight by BIA • <45% vs. 45%+ • <47% vs. 47%+ • <49% vs. 49%+	Cut-offs chosen based on data published in Kafri 2012, best TBW% diagnostic accuracy at 47%, outliers 45%, 49%.
100 BIA ICW% <25% 101 BIA ICW% <27% 102 BIA ICW% <29%	Intracellular water as a percentage of total body weight by BIA • <25% vs. 25%+ • <27% vs. 27%+ • <29% vs. 29%+	Cut-offs chosen based on data published in Kafri 2012, best ICW% diagnostic accuracy at 27%, outliers 25%, 29%.

Table 1. Table explaining cut off values (*Continued*)

103 BIA ECW% <18% 104 BIA ECW% <20% 105 BIA ECW% <22%	Extracellular water as a percentage of total body weight by BIA • <18% vs. 18%+ • <20% vs. 20%+ • <22% vs. 22%+	Cut-offs chosen based on data published in Kafri 2012, best ECW% diagnostic accuracy at 20%, outliers 18%, 22%.
106 Insufficient tears	Insufficient tear sample for osmolality analysis (<50nL)	Assessed as in Walsh 2012
107 Insufficient tears or not tolerated	Insufficient tear sample for osmolality analysis (<50nL) or participant could not tolerate tear collection	Assessed as in Walsh 2012
108 Oral thickener used	Participants taking fluid orally with a thickener vs. those with oral intake and no thickener or nasogastric feeds	Categories chosen by study author (Stotts 2009)
109 Oral fluid without thickener	Participants taking fluid orally without thickener vs. those with oral intake and thickener or nasogastric feeds	Categories chosen by study author (Stotts 2009)
110 Lips dry	Participant reports lips have felt dry during past 3 days	Categorised by study authors (Kajii 2006)
111 Dry mouth, severe 112 Dry mouth, moderate or severe	Do you have any symptoms of dry mouth? 0=no, if yes graded on 1-100 VAS for severity. Severe dry mouth equated to 67+, Moderate tiredness to 34+, fatigue (tiredness of any degree) to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)
113 Dry mouth, any	Participant reports dry mouth of any degree	• Participant reports mouth has been dry over the past 3 days (Kajii 2006) or • Reports abnormal dryness (Source Study 2001 - unclear who assessed, and Rowat 2011 - assessed by staff), • Researchers found both tongue & oral mucosa to be dry (Shimizu 2012), • Researchers found dry oral mucosa, assessed at the linguo-maxillary sulcus (Chassagne 2006), • Oral mucous membranes found to be dry by the examiner (McGarvey 2010), • Participants reported they had some symptoms of dry mouth (Sjöstrand ED 2013; Sjöstrand Healthy 2013).
114 Unable to spit	Participant unable to spit into a cup	

Table 1. Table explaining cut off values (*Continued*)

115 Thirst VAS rating, severe 116 Thirst VAS rating, moderate plus 117 Thirst VAS rating, mild plus	• Severe: Thirst VAS rating >125mm of 180mm scale (0 equates to "not thirsty at all", 125 equates to "extremely thirsty") or 67+ on a 100mm scale. • Moderate: Thirst VAS rating >80mm of 180mm scale • Mild: Thirst VAS rating >40mm of 180mm scale	Thirst VAS rating >125mm of 180mm scale, 0 equates to "not thirsty at all", 125 equates to "extremely thirsty" (Mack 1994) . As the median of this small data set was 51mm (min 0, max 130mm) one cut-off was chosen below the median, at 40mm, and one intermediate (at 80mm). For Sjostrand severe thirst was assumed as a score of equated to 67+, Moderate to 34+, mild to 1+ (Sjöstrand Healthy 2013)
118 Thirsty, any degree	Participant feels thirsty (any degree)	Participant reports they have felt thirst over past 3 days (Kajii 2006) or thirst (no description how assessed, Source Study 2001) , or participant says whether or not they feel thirsty at present (McGarvey 2010), or stated that did or did not have symptoms of thirst (0=no, if yes graded on 1-100 VAS for severity) (Sjöstrand Healthy 2013).
119 Tongue smarts	Participant answers "yes" to question of whether tongue has been smarting over past 3 days	
120 Mouth smarts	Participant answered "yes" to question of whether anywhere other than their tongue has been smarting over past 3 days	
121 Sticky saliva	Participant answered "yes" to question of whether saliva has been sticky over the past 3 days	
122 Sticky mouth	Participant answered "yes" to question of whether mouth has felt sticky over past 3 days	
123 Blue lips	Blue lips (assessed as blue or not, by staff)	
124 Sunken eyes	Sunken eyes (assessed as sunken or not, by staff)	
125 Bed sores	Presence of bed sores (assessed as present or not by staff)	
126 Swallowing problems	Participant answered "yes" to question of whether had had swallowing problems over past 3 days	

Table 1. Table explaining cut off values (*Continued*)

127 Enjoyment of food	Participant reported lack of enjoyment of food, by answering "no" to question of whether had felt enjoyment of food over past 3 days	
128 Appetite	Participant reported lack of appetite, by answering "no" to question of whether had felt good appetite over past 3 days	
129 Dry eye severity by DEQ-5 >12 130 Dry eye severity by DEQ-5 >6 131 Dry eye severity by DEQ-5 >3	Dry eye questionnaire (DEQ-5)	Dry eye questionnaire (DEQ-5) - range 0-20, higher scores indicate more frequent or severe dry eyes. Cut-off of >6 suggested by literature review of Walsh 2012, others data driven (median 6, min 0, max 18) at 3, 6, 12.
132 Dry eye severity by VAS >5.0 cm 133 Dry eye severity by VAS >1.1 cm 134 Dry eye severity by VAS >0.6 cm	VAS of 10cm in reply to "How dry do your eyes feel right now" with 0 meaning "not at all dry" and 10 meaning "very dry"	Cut-offs data driven (median 1.1cm, min 0, max 9) at 0.6, 1.1 and 5.0cm (Walsh 2012)
135 NITBUT <6 secs 136 NITBUT <10 secs 137 NITBUT <27 secs	Non-invasive tear film breakup time (NITBUT), seconds.	Cut-off of <10seconds suggested as result of literature review by Walsh 2012, others data driven (median 8.9, min 2.5, max 44.7seconds) - at <6, <10 and <27 seconds)
138 Balance, severe 139 Balance, ≥moderate 140 Balance, any degree	Do you have any symptoms of balance problems? 0=no, if yes graded on 1-100 VAS for severity. Severe balance problems equated to 67+, Moderate to 34+, mild to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)
141 Headache, severe 142 Headache, moderate+ 143 Headache, any degree	Do you have any symptoms of headache? 0=no, if yes graded on 1-100 VAS for severity. Severe headache equated to 67+, Moderate to 34+, mild to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)
144 Nausea, severe 145 Nausea, ≥moderate 146 Nausea, any degree	Do you have any symptoms of nausea? 0=no, if yes graded on 1-100 VAS for severity. Severe nausea equated to 67+, Moderate to 34+, mild to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)
147 Muscle weakness, severe 148 Muscle weakness, ≥moderate 149 Muscle weakness, any degree	Do you have any symptoms of muscle weakness? 0=no, if yes graded on 1-100 VAS for severity. Severe muscle weakness equated to 67+, Moderate to 34+, mild to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)

Table 1. Table explaining cut off values (*Continued*)

150 Dizziness, severe 151 Dizziness, ≥moderate 152 Dizziness, any degree	Do you have any symptoms of dizziness? 0= no, if yes graded on 1-100 VAS for severity. Severe dizziness equated to 67+, Moderate to 34+, mild to 1+	VAS scale split into thirds (Sjöstrand ED 2013; Sjöstrand Healthy 2013)
153 Combined drinks AND fatigue	Combined measure, scored where an individual participant BOTH missed some drinks between meals AND reported fatigue	
154 Combined, drinks OR fatigue	Combined measure, scored where an individual participant EITHER missed some drinks between meals OR reported fatigue (or both)	

Table 2. Meta-analysis results for water-loss dehydration - cut-off at 295 mOsm/kg$

Test	Cut-off	Number of studies	Number of participants	Sensitivity (95% CI)	Specificity (95% CI)	PLR (95% CI)	NLR (95% CI)	DOR (95% CI)
Fluid intake	Very low	4	130	0.17 (0.09 to 0.28)	0.91 (0.55 to 0.99)	1.80 (1.83 to 13.21)	0.92 (0.73 to 1.15)	1.96 (0.22 to 17.92)
	Low	4	130	0.32 (0.06 to 0.77)	0.71 (0.27 to 0.94)	1.09 (0.43 to 2.79)	0.96 (0.63 to 1.46)	1.14 (0.29 to 4.38)
	Moderate	4	130	0.62 (0.33 to 0.84)	0.35 (0.14 to 0.63)	0.95 (0.67 to 1.33)	1.10 (0.61 to 1.97)	0.86 (0.34 to 2.17)
Urine volume	< 300 mL/d	6	150	0.02 (0.00 to 0.58)	0.99 (0.67 to 1.00)	1.79 (0.01 to 456.93)	0.99 (0.89 to 1.10)	1.81 (0.01 to 513.00)
	< 500 mL/d	6	150	0.02 (0.00 to 0.68)	0.92 (0.64 to 0.99)	0.21 (0.00 to 29.68)	1.07 (0.91 to 1.26)	0.20 (0.00 to 31.35)
	< 800 mL/d*	6	150	0.17 (0.03 to 0.60)	0.87 (0.13 to 1.00)	1.40 (0.14 to 14.26)	0.94 (0.70 to 1.28)	1.48 (0.11 to 20.14)
	< fluid recommendations	6	150	0.38 (0.13 to 0.73)	0.62 (0.29 to 0.86)	1.01 (0.56 to 1.80)	1.00 (0.69 to 1.43)	1.01 (0.40 to 2.59)
Fluid balance	<-180 mL/d (less than a deficit of 180mL/d)	4	92	0.09 (0.03 to 0.27)	0.97 (0.00 to 1.00)	3.62 (0.00 to 1880531)	0.93 (0.67 to 1.29)	3.89 (0.00 to 2771562)

Table 2. Meta-analysis results for water-loss dehydration - cut-off at 295 mOsm/kg$ (*Continued*)

	<+180 mL/d (less than a surplus of 180mL/d)	4	92	0.24 (0.12 to 0.43)	0.53 (0.11 to 0.92)	0.51 (0.17 to 1.60)	1.43 (0.53 to 3.88)	0.36 (0.04 to 2.92)
	<+1700 mL/d (less than a surplus of 1700mL/d)	4	92	0.62 (0.38 to 0.82)	0.01 (0.00 to 0.90)	0.63 (0.43 to 0.91)	50.42 (0.05 to 47624.47)	0.01 (0.00 to 11.41)
USG	≥ 1.035	4	358	0.00 (0.00 to 0.70)	1.00 (0.06 to 1.00)	0.90 (0.00 to 9538.29)	1.00 (0.99 to 1.01)	0.90 (0.00 to 9653.24)
	≥ 1.028	4	358	0.03 (0.00 to 0.22)	0.94 (0.73 to 0.99)	0.45 (0.12 to 1.67)	1.04 (0.97 to 1.11)	0.43 (0.11 to 1.66)
	≥ 1.020	4	358	0.22 (0.11 to 0.40)	0.78 (0.39 to 0.95)	1.01 (0.43 to 2.40)	1.00 (0.78 to 1.27)	1.01 (0.34 to 3.06)
Urine colour	> 6*	4	78	0.14 (0.01 to 0.72)	0.95 (0.29 to 1.00)	2.64 (0.17 to 40.97)	0.91 (0.67 to 1.23)	2.91 (0.16 to 53.59)
	> 4*	4	78	0.32 (0.06 to 0.79)	0.88 (0.09 to 1.00)	2.70 (0.14 to 51.59)	0.77 (0.48 to 1.24)	3.51 (0.15 to 84.09)
	>2	4	78	0.68 (0.24 to 0.93)	0.43 (0.14 to 0.77)	1.18 (0.71 to 1.95)	0.76 (0.30 to 1.91)	1.56 (0.39 to 6.23)
Urine osmolality	> 1000 mOsm/kg	6	158	Meta-analysis would not run				
	> 800 mOsm/kg*	6	158	0.10 (0.04 to 0.23)	0.97 (0.81 to 1.00)	3.86 (0.48 to 31.16)	0.92 (0.83 to 1.02)	4.18 (0.48 to 36.28)
	> 600 mOsm/kg	6	158	0.43 (0.29 to 0.58)	0.73 (0.58 to 0.84)	1.59 (0.96 to 2.64)	0.78 (0.60 to 1.02)	2.04 (0.96 to 4.33)
Heart rate	≥ 120 BPM	4	373	Meta-analysis would not run				
	≥ 100 BPM**	4	373	0.09 (0.03 to 0.26)	0.87 (0.59 to 0.97)	0.75 (0.34 to 1.65)	1.04 (0.92 to 1.17)	0.73 (0.30 to 1.79)
	≥ 80 BPM	4	373	0.45 (0.31 to 0.60)	0.56 (0.15 to 0.90)	1.03 (0.45 to 2.38)	0.98 (0.52 to 1.84)	1.06 (0.24 to 4.58)
BIA resist 50 kHz	≥ 550 Ω	4	2005	0.29 (0.19 to 0.42)	0.98 (0.22 to 1.00)	16.29 (0.10 to 2772.02)	0.72 (0.60 to 0.87)	22.56 (0.12 to 4224.63)

Table 2. Meta-analysis results for water-loss dehydration - cut-off at 295 mOsm/kg$ (*Continued*)

	≥ 450 Ω	4	2005	0.73 (0.57 to 0.84)	0.70 (0.18 to 0.96)	2.43 (0.43 to 13.65)	0.39 (0.14 to 1.07)	6.20 (0.42 to 90.95)
	≥ 350 Ω	4	2005	0.92 (0.71 to 0.98)	0.16 (0.02 to 0.61)	1.10 (0.81 to 1.48)	0.50 (0.10 to 2.59)	2.20 (0.32 to 15.02)
TBW as % body weight	< 45%	5	2325	0.31 (0.18 to 0.47)	0.72 (0.42 to 0.90)	1.08 (0.65 to 1.79)	0.97 (0.80 to 1.17)	1.11 (0.55 to 2.23)
	< 47%	5	2325	0.40 (0.23 to 0.60)	0.60 (0.30 to 0.85)	1.01 (0.70 to 1.47)	0.99 (0.78 to 1.26)	1.02 (0.55 to 1.89)
	< 49%	5	2325	0.54 (0.35 to 0.72)	0.50 (0.24 to 0.77)	1.09 (0.80 to 1.49)	0.91 (0.69 to 1.19)	1.20 (0.67 to 2.15)
ICW as % body weight	< 25%	4	379	0.54 (0.31 to 0.76)	0.59 (0.22 to 0.88)	1.31 (0.74 to 2.32)	0.78 (0.60 to 1.03)	1.67 (0.73 to 3.81)
	< 27%	4	379	0.69 (0.52 to 0.83)	0.45 (0.14 to 0.80)	1.26 (0.74 to 2.13)	0.68 (0.42 to 1.12)	1.84 (0.67 to 5.04)
	< 29%	4	379	0.80 (0.63 to 0.90)	0.26 (0.09 to 0.55)	1.07 (0.87 to 1.31)	0.80 (0.47 to 1.34)	1.34 (0.66 to 2.75)
ECW as % body weight	< 18%	4	379	0.02 (0.00 to 0.18)	0.97 (0.77 to 1.00)	0.68 (0.11 to 4.35)	1.01 (0.96 to 1.06)	0.67 (0.10 to 4.49)
	< 20%	4	379	0.06 (0.02 to 0.19)	0.93 (0.62 to 0.99)	0.81 (0.20 to 3.35)	1.02 (0.91 to 1.14)	0.80 (0.17 to 3.70)
	<2 2%	4	379	0.15 (0.08 to 0.27)	0.76 (0.42 to 0.93)	0.62 (0.23 to 1.72)	1.12 (0.81 to 1.55)	0.55 (0.15 to 2.09)
Dry mouth		8	623	0.39 (0.26 to 0.54)	0.68 (0.56 to 0.78)	1.24 (0.83 to 1.85)	0.89 (0.70 to 1.12)	1.39 (0.74 to 2.62)
Thirsty**		6	300	0.34 (0.18 to 0.54)	0.64 (0.42 to 0.82)	0.94 (0.56 to 1.57)	1.03 (0.78 to 1.36)	0.91 (0.41 to 2.01)

* and **: these meta-analyses did not run using the metandi command as usual, but those marked * ran using nip(7), those marked ** did not run with nip(7), but did run with nip(8)

Abbreviations: BPM beats per minute; USG urine specific gravity, BIA bioelectrical impedance analysis, TBW total body water, ICW intracellular water, ECW extracellular water.

$ Water-loss dehydration includes those with impending (serum osmolality 295 to 300 mOsm/kg) and current (serum osmolality >300 mOsm/kg) dehydration.

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $

Test	Studies	TP	FP	FN	TN	Sensitivity	Specificity	PPV	NPV	PLR	NLR	Pre-test probability	Post-test probability given T+	Post-test probability given T-
1 Drinks intake, very low	Bossingham 2005	0	1	4	16	0.00 [0.00, 0.60]	0.94 [0.71, 1.00]	0	0.80	0	1.06	0.19	0	0.20
	Kajii 2006	3	2	4	62	0.43 [0.10, 0.82]	0.97 [0.89, 1.00]	0.6	0.94	13.71	0.59	0.10	0.6	0.06
2 Drinks intake, low	Bossingham 2005	3	11	1	6	0.75 [0.19, 0.99]	0.35 [0.14, 0.62]	0.21	0.86	1.16	0.71	0.19	0.21	0.14
	Kajii 2006	5	20	2	44	0.71 [0.29, 0.96]	0.69 [0.56, 0.80]	0.2	0.96	2.29	0.42	0.10	0.2	0.04
3 Drinks intake, moderate	Bossingham 2005	4	17	0	0	1.00 [0.40, 1.00]	0.00 [0.00, 0.20]	0.19	#	1	#	0.19	0.19	#
	Kajii 2006	7	49	0	15	1.00 [0.59, 1.00]	0.23 [0.14, 0.36]	0.13	1	1.31	0	0.10	0.13	0
4 Drinks intake, standard	Bossingham 2005	0	5	4	12	0.00 [0.00, 0.60]	0.71 [0.44, 0.90]	0	0.75	0	1.42	0.19	0	0.25

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

	Kajii 2006	4	14	3	50	0.57 [0.18, 0.90]	0.78 [0.66, 0.87]	0.22	0.94	2.61	0.55	0.10	0.22	0.06
5 Fluid intake, very low	Bossingham 2005	0	0	4	17	0.00 [0.00, 0.60]	1.00 [0.80, 1.00]	#	0.81	#	1	0.19	#	0.19
	Lindner 2009	5	0	21	8	0.19 [0.07, 0.39]	1.00 [0.63, 1.00]	1	0.28	#	0.81	0.76	1	0.72
	Perren 2011	0	7	6	14	0.00 [0.00, 0.46]	0.67 [0.43, 0.85]	0	0.70	0	1.5	0.22	0	0.30
	Stotts 2009	6	4	24	14	0.20 [0.08, 0.39]	0.78 [0.52, 0.94]	0.6	0.37	0.9	1.03	0.63	0.6	0.63
6 Fluid intake, low	Stotts 2009	22	12	8	6	0.73 [0.54, 0.88]	0.33 [0.13, 0.59]	0.65	0.43	1.1	0.8	0.63	0.65	0.57
	Bossingham 2005	0	0	4	17	0.00 [0.00, 0.60]	1.00 [0.80, 1.00]	#	0.81	#	1	0.19	#	0.19
	Lindner 2009	10	3	16	5	0.38 [0.20, 0.59]	0.63 [0.24, 0.91]	0.77	0.24	1.03	0.98	0.76	0.77	0.76
	Perren 2011	2	10	4	11	0.33 [0.04, 0.78]	0.52 [0.30, 0.74]	0.17	0.73	0.7	1.27	0.22	0.17	0.27

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

7 Fluid intake, moderate	Bossingham 2005	1	7	3	10	0.25 [0.01, 0.81]	0.59 [0.33, 0.82]	0.13	0.77	0.61	1.28	0.19	0.13	0.23
	Lindner 2009	14	4	12	4	0.54 [0.33, 0.73]	0.50 [0.16, 0.84]	0.78	0.25	1.08	0.92	0.76	0.78	0.75
	Perren 2011	3	12	3	9	0.50 [0.12, 0.88]	0.43 [0.22, 0.66]	0.2	0.75	0.88	1.17	0.22	0.2	0.25
	Stotts 2009	27	17	3	1	0.90 [0.73, 0.98]	0.06 [0.00, 0.27]	0.61	0.25	0.95	1.8	0.63	0.61	0.75
8 Misses drinks between meals	Kajii 2006	7	15	0	49	1.00 [0.59, 1.00]	0.77 [0.64, 0.86]	0.32	1	4.27	0	0.10	0.32	0
9 Misses drinks at meals	Kajii 2006	0	3	7	61	0.00 [0.00, 0.41]	0.95 [0.87, 0.99]	0	0.90	0	1.05	0.10	0	0.10
10 Urine vol, < 300 mL/d	Bossingham 2005	0	0	4	17	0.00 [0.00, 0.60]	1.00 [0.80, 1.00]	#	0.81	#	1	0.19	#	0.19
	Fletcher 1999	0	0	4	11	0.00 [0.00, 0.60]	1.00 [0.72, 1.00]	#	0.73	#	1	0.27	#	0.27
	Johnson 2003	0	0	15	28	0.00 [0.00, 0.	1.00 [0.88, 1.	#	0.65	#	1	0.35	#	0.35

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

						22]	00]							
	Lindner 2009	4	0	22	8	0.15 [0.04, 0.35]	1.00 [0.63, 1.00]	1	0.27	#	0.85	0.76	1	0.73
	Mack 1994	0	1	2	7	0.00 [0.00, 0.84]	0.88 [0.47, 1.00]	0	0.78	0	1.14	0.2	0	0.22
	Perren 2011	0	9	6	12	0.00 [0.00, 0.46]	0.57 [0.34, 0.78]	0	0.67	0	1.75	0.22	0	0.33
11 Urine vol, < 500 mL/d	Bossingham 2005	0	0	4	17	0.00 [0.00, 0.60]	1.00 [0.80, 1.00]	#	0.81	#	1	0.19	#	0.19
	Fletcher 1999	0	1	4	10	0.00 [0.00, 0.60]	0.91 [0.59, 1.00]	0	0.71	0	1.1	0.27	0	0.29
	Johnson 2003	0	0	15	28	0.00 [0.00, 0.22]	1.00 [0.88, 1.00]	#	0.65	#	1	0.35	#	0.35
	Lindner 2009	6	1	20	7	0.23 [0.09, 0.44]	0.88 [0.47, 1.00]	0.86	0.26	1.85	0.88	0.76	0.86	0.74
	Mack 1994	0	2	2	6	0.00 [0.00, 0.84]	0.75 [0.35, 0.97]	0	0.75	0	1.33	0.2	0	0.25
	Perren 2011	0	12	6	9	0.00 [0.00, 0.46]	0.43 [0.22, 0.66]	0	0.60	0	2.33	0.22	0	0.40

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

12 Urine vol, < 800 mL/d	Bossingham 2005	0	0	4	17	0.00 [0.00, 0.60]	1.00 [0.80, 1.00]	#	0.81	#	1	0.19	#	0.19
	Fletcher 1999	0	2	4	9	0.00 [0.00, 0.60]	0.82 [0.48, 0.98]	0	0.69	0	1.22	0.27	0	0.31
	Johnson 2003	0	0	15	28	0.00 [0.00, 0.22]	1.00 [0.88, 1.00]	#	0.65	#	1	0.35	#	0.35
	Lindner 2009	10	3	16	5	0.38 [0.20, 0.59]	0.63 [0.24, 0.91]	0.77	0.24	1.03	0.98	0.76	0.77	0.76
	Mack 1994	1	4	1	4	0.50 [0.01, 0.99]	0.50 [0.16, 0.84]	0.2	0.8	1	1	0.2	0.2	0.2
	Perren 2011	4	21	2	0	0.67 [0.22, 0.96]	0.00 [0.00, 0.16]	0.16	0.00	0.67	#	0.22	0.16	1.00
13 Urine vol - fluid recommendations (alt)	Bossingham 2005	0	1	4	16	0.00 [0.00, 0.60]	0.94 [0.71, 1.00]	0	0.80	0	1.06	0.19	0	0.20
	Fletcher 1999	2	8	2	3	0.50 [0.07, 0.93]	0.27 [0.06, 0.61]	0.2	0.6	0.69	1.83	0.27	0.2	0.4

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

	Johnson 2003	1	3	14	25	0.07 [0.00, 0.32]	0.89 [0.72, 0.98]	0.25	0.64	0.62	1.05	0.35	0.25	0.36
	Lindner 2009	19	5	7	3	0.73 [0.52, 0.88]	0.38 [0.09, 0.76]	0.79	0.3	1.17	0.72	0.76	0.79	0.7
	Mack 1994	1	7	1	1	0.50 [0.01, 0.99]	0.13 [0.00, 0.53]	0.13	0.5	0.57	4	0.2	0.13	0.5
	Perren 2011	3	6	3	15	0.50 [0.12, 0.88]	0.71 [0.48, 0.89]	0.33	0.83	1.75	0.7	0.22	0.33	0.17
14 Urine vol daytime, >900 mL	Johnson 2003	3	3	12	25	0.20 [0.04, 0.48]	0.89 [0.72, 0.98]	0.5	0.68	1.87	0.90	0.35	0.5	0.32
15 Urine vol daytime, >1420 mL	Johnson 2003	7	15	8	13	0.47 [0.21, 0.73]	0.46 [0.28, 0.66]	0.32	0.62	0.87	1.15	0.35	0.32	0.38
16 Urine vol daytime, >1940 mL	Johnson 2003	12	22	3	6	0.80 [0.52, 0.96]	0.21 [0.08, 0.41]	0.35	0.67	1.02	0.93	0.35	0.35	0.33
17 Urine vol nighttime,	Johnson 2003	1	2	14	26	0.07 [0.00, 0.32]	0.93 [0.76, 0.99]	0.33	0.65	0.93	1.01	0.35	0.33	0.35

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

> 450 mL														
18 Urine vol night-time, > 860 mL	Johnson 2003	8	13	7	15	0.53 [0.27, 0.79]	0.54 [0.34, 0.72]	0.38	0.68	1.15	0.87	0.35	0.38	0.32
19 Urine vol night-time, > 1270 mL	Johnson 2003	12	26	3	2	0.80 [0.52, 0.96]	0.07 [0.01, 0.24]	0.32	0.40	0.86	2.8	0.35	0.32	0.60
20 Urine voids day-time, ≥ 11/day	Johnson 2003	0	1	2	40	0.00 [0.00, 0.84]	0.98 [0.87, 1.00]	0	0.95	0	1.03	0.05	0	0.05
21 Urine voids day-time, ≥ 7/day	Johnson 2003	2	20	0	21	1.00 [0.16, 1.00]	0.51 [0.35, 0.67]	0.09	1.00	2.05	0	0.05	0.09	0
22 Urine voids day-time, ≥ 4/day	Johnson 2003	2	38	0	3	1.00 [0.16, 1.00]	0.07 [0.02, 0.20]	0.05	1.00	1.08	0	0.05	0.05	0
23 Urine voids night, ≥ 1.5/night	Johnson 2003	0	4	15	24	0.00 [0.00, 0.22]	0.86 [0.67, 0.96]	0	0.62	0	1.17	0.35	0	0.39

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

24 Urine voids night, ≥ 2.6/ night	Johnson 2003	8	14	7	14	0. 53 [0. 27, 0. 79]	0. 50 [0. 31, 0. 69]	0.36	0.67	1.07	0.93	0.35	0.36	0.33
25 Urine voids night, ≥ 4.1/ night	Johnson 2003	13	24	2	4	0. 87 [0. 60, 0. 98]	0. 14 [0. 04, 0. 33]	0.35	0.67	1.01	0.93	0.35	0.35	0.33
26 Nocturnal polyuri	Johnson 2003	8	16	7	12	0. 53 [0. 27, 0. 79]	0. 43 [0. 24, 0. 63]	0.33	0.63	0.93	1.09	0.35	0.33	0.37
27 Fluid balance, <-180 mL/d (less than a fluid deficit of 180ml/ d)	Bossingham 2005	0	0	4	17	0. 00 [0. 00, 0. 60]	1. 00 [0. 80, 1. 00]	#	0.81	#	1	0.19	#	0.19
	Lindner 2009	2	0	24	8	0. 08 [0. 01, 0. 25]	1. 00 [0. 63, 1. 00]	1	0.25	#	0.92	0.76	1	0.75
	Monahan 2006	2	3	5	0	0. 29 [0. 04, 0. 71]	0. 00 [0. 00, 0. 71]	0.4	0	0.29	#	0.7	0.4	1
	Perren 2011	0	9	6	12	0. 00 [0. 00, 0. 46]	0. 57 [0. 34, 0. 78]	0	0.67	0	1.75	0.22	0	0.33

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

28 Fluid balance, <+180 mL/d (less than a fluid excess of 180ml/d)	Bossingham 2005	2	8	2	9	0.50 [0.07, 0.93]	0.53 [0.28, 0.77]	0.2	0.82	1.06	0.94	0.19	0.2	0.18
	Lindner 2009	4	0	22	8	0.15 [0.04, 0.35]	1.00 [0.63, 1.00]	1	0.27	#	0.85	0.76	1	0.73
	Monahan 2006	3	3	4	0	0.43 [0.10, 0.82]	0.00 [0.00, 0.71]	0.5	0	0.43	#	0.7	0.5	1
	Perren 2011	0	12	6	9	0.00 [0.00, 0.46]	0.43 [0.22, 0.66]	0	0.60	0	2.33	0.22	0	0.40
29 Fluid balance, <+1700 mL/d (less than a fluid excess of 1700 ml/d)	Bossingham 2005	4	17	0	0	1.00 [0.40, 1.00]	0.00 [0.00, 0.20]	0.19	#	1	#	0.19	0.19	#
	Lindner 2009	12	4	14	4	0.46 [0.27, 0.67]	0.50 [0.16, 0.84]	0.75	0.22	0.92	1.08	0.76	0.75	0.78

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

	Monahan 2006	3	3	4	0	0.43 [0.10, 0.82]	0.00 [0.00, 0.71]	0.5	0	0.43	#	0.7	0.5	1
	Perren 2011	4	21	2	0	0.67 [0.22, 0.96]	0.00 [0.00, 0.16]	0.16	0.00	0.67	#	0.22	0.16	1.00
30 Urine specific gravity (USG), ≥ 1.035	Bossingham 2005 Bossingham 2005	0	0	2	19	0.00 [0.00, 0.84]	1.00 [0.82, 1.00]	#	0.810	#	1	0.190	#	0.190
	Culp 2003	0	0	245	63	0.00 [0.00, 0.01]	1.00 [0.94, 1.00]	#	0.205	#	1	0.795	#	0.795
	Rowat 2011	2	1	11	3	0.15 [0.02, 0.45]	0.75 [0.19, 0.99]	0.67	0.21	0.62	1.13	0.77	0.67	0.79
	Sjöstran Healthy 2013	0	0	9	3	0.00 [0.00, 0.34]	1.00 [0.29, 1.00]	#	0.25	#	1.00	0.75	#	0.75
31 Urine specific gravity (USG), ≥ 1.028	Bossingham 2005	0	0	2	19	0.00 [0.00, 0.84]	1.00 [0.82, 1.00]	#	0.810	#	1	0.190	#	0.190
	Culp 2003	7	5	238	58	0.03 [0.01, 0.06]	0.92 [0.82, 0.97]	0.58	0.20	0.36	1.06	0.80	0.58	0.80

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

	Rowat 2011	3	1	10	3	0.23 [0.05, 0.54]	0.75 [0.19, 0.99]	0.75	0.23	0.92	1.03	0.77	0.75	0.77
	Sjöstran Healthy 2013	0	0	9	3	0.00 [0.00, 0.34]	1.00 [0.29, 1.00]	#	0.25	#	1.00	0.75	#	0.75
32 Urine specific gravity (USG), ≥ 1.020	Bossingham 2005 Bossingham 2005	0	0	2	19	0.00 [0.00, 0.84]	1.00 [0.82, 1.00]	#	0.81	#	1	0.19	#	0.19
	Culp 2003	58	18	187	45	0.24 [0.18, 0.30]	0.71 [0.59, 0.82]	0.76	0.19	0.83	1.07	0.80	0.76	0.81
	Rowat 2011	6	2	7	2	0.46 [0.19, 0.75]	0.50 [0.07, 0.93]	0.75	0.22	0.92	1.08	0.77	0.75	0.78
	Sjöstran Healthy 2013	3	1	6	2	0.33 [0.07, 0.70]	0.67 [0.09, 0.99]	0.75	0.25	1.00	1.00	0.75	0.75	0.75
33 Urine colour, > 6	Fletcher 1999	1	1	3	10	0.25 [0.01, 0.81]	0.91 [0.59, 1.00]	0.5	0.77	2.75	0.83	0.27	0.5	0.23
	Rowat 2011	11	3	2	1	0.85 [0.55, 0.98]	0.25 [0.01, 0.81]	0.79	0.333	1.13	0.62	0.77	0.79	0.67
	Sjöstran ED 2013	1	0	28	7	0.03 [0.00, 0.18]	1.00 [0.59, 1.00]	1.00	0.20	#	0.97	0.81	1.00	0.80

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

	Sjöstran Healthy 2013	0	0	7	3	0.00 [0.00, 0.41]	1.00 [0.29, 1.00]	#	0.30	#	1.00	0.70	#	0.70
34 Urine colour, > 4	Fletcher 1999	3	9	1	2	0.75 [0.19, 0.99]	0.18 [0.02, 0.52]	0.25	0.67	0.92	1.38	0.27	0.25	0.33
	Rowat 2011	9	2	4	2	0.69 [0.39, 0.91]	0.50 [0.07, 0.93]	0.82	0.33	1.38	0.62	0.77	0.82	0.67
	Sjöstran ED 2013	4	0	25	7	0.14 [0.04, 0.32]	1.00 [0.59, 1.00]	1.00	0.22	#	0.86	0.81	1.00	0.78
	Sjöstran Healthy 2013	0	0	7	3	0.00 [0.00, 0.41]	1.00 [0.29, 1.00]	#	0.30	#	1.00	0.70	#	0.70
35 Urine colour, > 2	Fletcher 1999	4	10	0	1	1.00 [0.40, 1.00]	0.09 [0.00, 0.41]	0.29	1	1.1	0	0.27	0.29	0
	Rowat 2011	2	1	11	3	0.15 [0.02, 0.45]	0.75 [0.19, 0.99]	0.67	0.21	0.62	1.13	0.77	0.67	0.79
	Sjöstran ED 2013	20	4	9	3	0.69 [0.49, 0.85]	0.43 [0.10, 0.82]	0.83	0.25	1.21	0.72	0.81	0.83	0.75
	Sjöstran Healthy 2013	5	1	2	2	0.71 [0.29, 0.96]	0.67 [0.09, 0.99]	0.83	0.50	2.14	0.43	0.70	0.83	0.50
36 Urine osmo-lality,	Fletcher 1999	0	0	4	11	0.00 [0.00, 0.	1.00 [0.72, 1.	#	0.73	#	1	0.27	#	0.27

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

> 1000 mOsm/kg						60]	00]							
	Johnson 2003	0	0	15	28	0.00 [0.00, 0.22]	1.00 [0.88, 1.00]	#	0.65	#	1	0.35	#	0.35
	Lindner 2009	0	0	19	8	0.00 [0.00, 0.18]	1.00 [0.63, 1.00]	#	0.30	#	1	0.70	#	0.70
	Powers 2012	1	0	16	5	0.06 [0.00, 0.29]	1.00 [0.48, 1.00]	1	0.24	#	0.94	0.77	1	0.76
	Sjöstran ED 2013	0	0	31	7	0.00 [0.00, 0.11]	1.00 [0.59, 1.00]	#	0.18	#	1.00	0.82	#	0.82
	Sjöstran Healthy 2013	0	0	10	3	0.00 [0.00, 0.31]	1.00 [0.29, 1.00]	#	0.23	#	1.00	0.77	#	0.77
37 Urine osmolality > 800 mOsm/kg	Fletcher 1999	1	1	3	10	0.25 [0.01, 0.81]	0.91 [0.59, 1.00]	0.5	0.77	2.75	0.83	0.27	0.5	0.23
	Johnson 2003	0	0	15	28	0.00 [0.00, 0.22]	1.00 [0.88, 1.00]	#	0.65	#	1	0.35	#	0.35
	Lindner 2009	0	0	19	8	0.00 [0.00, 0.18]	1.00 [0.63, 1.00]	#	0.30	#	1	0.70	#	0.70

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

	Powers 2012	3	1	14	4	0.18 [0.04, 0.43]	0.80 [0.28, 0.99]	0.75	0.22	0.88	1.03	0.77	0.75	0.78
	Sjöstran ED 2013	5	0	26	7	0.16 [0.05, 0.34]	1.00 [0.59, 1.00]	1.00	0.21	#	0.84	0.82	1.00	0.79
	Sjöstran Healthy 2013	2	0	8	3	0.20 [0.03, 0.56]	1.00 [0.29, 1.00]	1.00	0.27	#	0.80	0.77	1.00	0.73
38 Urine osmolality, > 600 mOsm/kg	Fletcher 1999	1	6	3	5	0.25 [0.01, 0.81]	0.45 [0.17, 0.77]	0.14	0.63	0.46	1.65	0.27	0.14	0.38
	Johnson 2003	5	6	10	22	0.33 [0.12, 0.62]	0.79 [0.59, 0.92]	0.45	0.69	1.56	0.85	0.35	0.45	0.31
	Lindner 2009	4	1	15	7	0.21 [0.06, 0.46]	0.88 [0.47, 1.00]	0.8	0.32	1.68	0.90	0.70	0.8	0.68
	Powers 2012	7	1	10	4	0.41 [0.18, 0.67]	0.80 [0.28, 0.99]	0.88	0.29	2.06	0.74	0.77	0.88	0.71
	Sjöstran ED 2013	15	1	16	6	0.48 [0.30, 0.67]	0.86 [0.42, 1.00]	0.94	0.27	3.39	0.60	0.82	0.94	0.73
	Sjöstran Healthy 2013	8	1	2	2	0.80 [0.44, 0.97]	0.67 [0.09, 0.99]	0.89	0.50	2.40	0.30	0.77	0.89	0.50

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

39 Tear osmolarity, > 324 mOsm/L	Walsh 2012	8	28	12	41	0.40 [0.19, 0.64]	0.59 [0.47, 0.71]	0.22	0.77	0.99	1.01	0.23	0.22	0.23
40 Tear osmolarity, > 316 mOsm/L	Walsh 2012	10	37	10	32	0.50 [0.27, 0.73]	0.46 [0.34, 0.59]	0.21	0.76	0.93	1.08	0.23	0.21	0.24
41 Tear osmolarity, > 310 mOsm/L	Walsh 2012	11	49	9	20	0.55 [0.32, 0.77]	0.29 [0.19, 0.41]	0.18	0.69	0.77	1.55	0.23	0.18	0.31
42 Heart rate, ≥ 120 BPM	Chassagne 2006	6	1	246	51	0.02 [0.01, 0.05]	0.98 [0.90, 1.00]	0.86	0.17	1.24	1.00	0.83	0.86	0.83
	Lindner 2009	2	1	24	7	0.08 [0.01, 0.25]	0.88 [0.47, 1.00]	0.67	0.23	0.62	1.05	0.76	0.67	0.77
	Powers 2012	0	0	17	5	0.00 [0.00, 0.20]	1.00 [0.48, 1.00]	#	0.23	#	1	0.77	#	0.77
	Sjöstran Healthy 2013	0	0	10	3	0.00 [0.00, 0.31]	1.00 [0.29, 1.00]	#	0.23	#	1.00	0.77	#	0.77
43 Heart rate ≥ 100	Chassagne 2006	23	5	229	47	0.09 [0.06, 0.13]	0.90 [0.79, 0.97]	0.82	0.17	0.95	1.01	0.83	0.82	0.83

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

BPM														
	Lindner 2009	8	4	18	4	0.31 [0.14, 0.52]	0.50 [0.16, 0.84]	0.67	0.18	0.62	1.38	0.76	0.67	0.82
	Powers 2012	0	1	17	4	0.00 [0.00, 0.20]	0.80 [0.28, 0.99]	0	0.19	0	1.25	0.77	0	0.81
	Sjöstran Healthy 2013	0	0	10	3	0.00 [0.00, 0.31]	1.00 [0.29, 1.00]	#	0.23	#	1.00	0.77	#	0.77
44 Heart rate ≥ 80 BPM	Chassagne 2006	118	22	134	30	0.47 [0.41, 0.53]	0.58 [0.43, 0.71]	0.84	0.18	1.11	0.92	0.83	0.84	0.82
	Lindner 2009	16	8	10	0	0.62 [0.41, 0.80]	0.00 [0.00, 0.37]	0.67	0	0.62	#	0.76	0.67	1
	Powers 2012	2	2	15	3	0.12 [0.01, 0.36]	0.60 [0.15, 0.95]	0.5	0.17	0.29	1.47	0.77	0.5	0.83
	Sjöstran Healthy 2013	4	0	6	3	0.40 [0.12, 0.74]	1.00 [0.29, 1.00]	1.00	0.33	#	0.60	0.77	1.00	0.67
45 Orthostatic hypotension	Chassagne 2006	19	4	100	20	0.16 [0.10, 0.24]	0.83 [0.63, 0.95]	0.83	0.17	0.96	1.01	0.83	0.83	0.83
46 Body tempera-	Chassagne 2006	21	1	224	49	0.09 [0.05, 0.	0.98 [0.89, 1.	0.95	0.18	4.29	0.93	0.83	0.95	0.82

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

ture ≥ 38.2 °C						13]	00]							
47 Body temperature ≥ 36.8 °C	Chassagne 2006	210	39	35	11	0.86 [0.81, 0.90]	0.22 [0.12, 0.36]	0.84	0.24	1.10	0.65	0.83	0.84	0.76
48 Body temperature ≥33.2 °C	Chassagne 2006	244	50	1	0	1.00 [0.98, 1.00]	0.00 [0.00, 0.07]	0.83	0	1.00	#	0.83	0.83	1
49 Skin turgor, anterior forearm ≥ 3 seconds	Chassagne 2006	115	22	134	29	0.46 [0.40, 0.53]	0.57 [0.42, 0.71]	0.84	0.18	1.07	0.95	0.83	0.84	0.82
50 Skin turgor, anterior thigh ≥ 3 seconds	Chassagne 2006	71	8	179	43	0.28 [0.23, 0.34]	0.84 [0.71, 0.93]	0.90	0.19	1.81	0.85	0.83	0.90	0.81
51 Skin turgor, anterior thigh, ab-	Source Study 2001	11	5	98	48	0.10 [0.05, 0.17]	0.91 [0.79, 0.97]	0.6875	0.3287671	1.07	0.992737	0.6728395	0.6875	0.67123288

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

normal														
52 Skin turgor, subclavicular ≥3 seconds	Chassagne 2006	99	12	154	39	0.39 [0.33, 0.45]	0.76 [0.63, 0.87]	0.89	0.20	1.66	0.80	0.839	0.89	0.80
53 Skin turgor, sternum ≥ 3 seconds	Chassagne 2006	76	13	175	38	0.30 [0.25, 0.36]	0.75 [0.60, 0.86]	0.85	0.18	1.19	0.94	0.83	0.85	0.82
54 Skin turgor, anterior chest, slow	Shimizu 2012	2	6	9	12	0.18 [0.02, 0.52]	0.67 [0.41, 0.87]	0.25	0.57	0.55	1.23	0.38	0.25	0.43
55 Skin turgor, hand, ≥ 4 seconds	Kafri 2012	1	0	17	13	0.06 [0.00, 0.27]	1.00 [0.75, 1.00]	1	0.43	#	0.94	0.58	1	0.57
56 Skin turgor, hand, ≥ 3 seconds	Kafri 2012	1	3	15	12	0.06 [0.00, 0.30]	0.80 [0.52, 0.96]	0.25	0.44	0.31	1.17	0.52	0.06	0.8

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

57 Skin turgor, hand, ≥ 1 seconds	Kafri 2012	17	13	1	0	0.94 [0.73, 1.00]	0.00 [0.00, 0.25]	0.57	0	0.94	#	0.58	0.57	1
58 Skin turgor, hand, abnormal	McGarvey 2010	2	3	1	5	0.67 [0.09, 0.99]	0.63 [0.24, 0.91]	0.4	0.83	1.78	0.53	0.27	0.4	0.17
59 Skin turgor, site unspecified, abnormal	Rowat 2011	3	1	11	3	0.21 [0.05, 0.51]	0.75 [0.19, 0.99]	0.75	0.21	0.86	1.05	0.78	0.75	0.79
60 Capillary refill, ≥ 4 seconds	Kafri 2012	1	0	17	13	0.06 [0.00, 0.27]	1.00 [0.75, 1.00]	1	0.43	#	0.94	0.58	1	0.57
61 Capillary refill, ≥ 3 seconds	Kafri 2012	3	2	15	11	0.17 [0.04, 0.41]	0.85 [0.55, 0.98]	0.6	0.42	1.08	0.98	0.58	0.6	0.58
	Shimizu 2012	2	3	7	15	0.22 [0.03, 0.	0.83 [0.59, 0.	0.4	0.68	1.33	0.93	0.33	0.4	0.32

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

						60]	96]							
62 Capillary refill, ≥ 2 seconds	Kafri 2012	14	8	4	5	0.78 [0.52, 0.94]	0.38 [0.14, 0.68]	0.64	0.56	1.26	0.58	0.58	0.64	0.44
63 Dry axilla by touch	Eaton 1994	10	12	10	54	0.50 [0.27, 0.73]	0.82 [0.70, 0.90]	0.45	0.84	2.75	0.61	0.23	0.45	0.16
	Shimizu 2012	4	3	7	15	0.36 [0.11, 0.69]	0.83 [0.59, 0.96]	0.57	0.68	2.18	0.76	0.38	0.57	0.32
64 Dry axilla by metre, < 32%	Shimizu 2012	4	1	11	13	0.27 [0.08, 0.55]	0.93 [0.66, 1.00]	0.8	0.54	3.73	0.79	0.52	0.8	0.46
65 Dry axilla by metre < 37%	Shimizu 2012	12	6	3	8	0.80 [0.52, 0.96]	0.57 [0.29, 0.82]	0.67	0.73	1.87	0.35	0.52	0.67	0.27
66 Dry axilla by metre < 42%	Shimizu 2012	14	8	1	6	0.93 [0.68, 1.00]	0.43 [0.18, 0.71]	0.64	0.86	1.63	0.16	0.52	0.64	0.14
67 Consciousness level	Chassagne 2006	9	1	246	47	0.04 [0.02, 0.07]	0.98 [0.89, 1.00]	0.9	0.16	1.69	0.99	0.84	0.9	0.84

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

≥ coma														
68 Consciousness level ≥ stupor	Chassagne 2006	39	6	216	42	0.15 [0.11, 0.20]	0.88 [0.75, 0.95]	0.87	0.16	1.22	0.97	0.84	0.87	0.84
	Shimizu 2012	1	5	8	13	0.11 [0.00, 0.48]	0.72 [0.47, 0.90]	0.17	0.62	0.4	1.23	0.33	0.17	0.38
69 Consciousness level ≥ obsessed	Chassagne 2006	142	23	113	25	0.56 [0.49, 0.62]	0.52 [0.37, 0.67]	0.86	0.18	1.16	0.85	0.84	0.86	0.82
70 MMSE < 10	Culp 2003	2	0	243	63	0.01 [0.00, 0.03]	1.00 [0.94, 1.00]	1	0.21	#	0.99	0.80	1	0.79
	Gaspar Acute & LTC 2011	0	0	3	14	0.00 [0.00, 0.71]	1.00 [0.77, 1.00]	#	0.82	#	1	0.18	#	0.18
71 MMSE, < 20	Culp 2003	74	15	171	48	0.30 [0.25, 0.36]	0.76 [0.64, 0.86]	0.83	0.22	1.27	0.92	0.80	0.83	0.78
	Gaspar Acute & LTC 2011	0	1	3	13	0.00 [0.00, 0.71]	0.93 [0.66, 1.00]	0	0.81	0	1.08	0.18	0	0.19

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

72 MMSE, < 25	Culp 2003	141	36	104	27	0.58 [0.51, 0.64]	0.43 [0.30, 0.56]	0.80	0.21	1.01	0.99	0.80	0.80	0.79
	Gaspar Acute & LTC 2011	0	4	3	10	0.00 [0.00, 0.71]	0.71 [0.42, 0.92]	0	0.77	0	1.4	0.18	0	0.23
73 Neecha < 20	Culp 2003	7	0	238	63	0.03 [0.01, 0.06]	1.00 [0.94, 1.00]	1	0.21	#	0.97	0.80	1	0.79
74 Neecha ≤ 24	Culp 2003	36	8	209	55	0.15 [0.11, 0.20]	0.87 [0.77, 0.94]	0.82	0.21	1.16	0.98	0.80	0.82	0.79
75 Neecha < 27	Culp 2003	108	24	137	39	0.44 [0.38, 0.51]	0.62 [0.49, 0.74]	0.82	0.22	1.16	0.90	0.80	0.82	0.78
76 Tiredness, severe	Sjöstran Healthy 2013	0	0	10	3	0.00 [0.00, 0.31]	1.00 [0.29, 1.00]	#	0.23	#	1.00	0.77	#	0.77
	Sjöstran ED 2013	3	0	23	5	0.12 [0.02, 0.30]	1.00 [0.48, 1.00]	1.00	0.18	#	0.88	0.84	1.00	0.82
77 Tiredness, moderate or severe	Sjöstran Healthy 2013	1	0	9	3	0.10 [0.00, 0.45]	1.00 [0.29, 1.00]	1.00	0.25	#	0.90	0.77	1.00	0.75
	Sjöstran ED 2013	7	1	19	4	0.27 [0.12, 0.48]	0.80 [0.28, 0.99]	0.88	0.17	1.35	0.91	0.84	0.88	0.83

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

78 Fatigue	Kajii 2006	5	16	2	48	0.71 [0.29, 0.96]	0.75 [0.63, 0.85]	0.24	0.96	2.86	0.38	0.10	0.24	0.04
	Sjöstran ED 2013	11	1	15	4	0.42 [0.23, 0.63]	0.80 [0.28, 0.99]	0.92	0.21	2.12	0.72	0.84	0.92	0.79
	Sjöstran Healthy 2013	3	0	7	3	0.30 [0.07, 0.65]	1.00 [0.29, 1.00]	1.00	0.30	#	0.7	0.77	1.00	0.70
79 Lassitude	Kajii 2006	1	12	6	52	0.14 [0.00, 0.58]	0.81 [0.70, 0.90]	0.08	0.90	0.76	1.05	0.10	0.08	0.10
80 Feels dull	Kajii 2006	3	19	4	45	0.43 [0.10, 0.82]	0.70 [0.58, 0.81]	0.14	0.92	1.44	0.81	0.10	0.14	0.08
81 Dry oral mucosa, cheek	Chassagne 2006	59	2	182	47	0.24 [0.19, 0.30]	0.96 [0.86, 1.00]	0.97	0.21	6.00	0.79	0.83	0.97	0.79
82 Tongue furrows, ≥ mild	Kafri 2012	9	8	7	7	0.56 [0.30, 0.80]	0.47 [0.21, 0.73]	0.53	0.5	1.05	0.94	0.52	0.53	0.5
83 Tongue furrows, ≥ moderate	Kafri 2012	3	1	13	14	0.19 [0.04, 0.46]	0.93 [0.68, 1.00]	0.75	0.52	2.81	0.87	0.52	0.75	0.48

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

84 Tongue furrows, ≥ severe	Kafri 2012	1	0	15	15	0.06 [0.00, 0.30]	1.00 [0.78, 1.00]	1	0.5	#	0.94	0.52	1	0.5
85 Tongue dry, ≥ mild	Kafri 2012	9	6	7	9	0.56 [0.30, 0.80]	0.60 [0.32, 0.84]	0.6	0.56	1.41	0.73	0.52	0.6	0.44
86 Tongue dry, ≥mode	Kafri 2012	4	1	12	14	0.25 [0.07, 0.52]	0.93 [0.68, 1.00]	0.8	0.54	3.75	0.80	0.52	0.8	0.46
87 Tongue dry, severe	Kafri 2012	1	0	15	15	0.06 [0.00, 0.30]	1.00 [0.78, 1.00]	1	0.5	#	0.94	0.52	1	0.5
88 BIA Resistance 50 kHz, ≥ 550 Ω	Allison 2005	4	0	1	10	0.80 [0.28, 0.99]	1.00 [0.69, 1.00]	1	0.909	#	0.2	0.333	1	0.090
	Kafri 2012	3	0	10	8	0.23 [0.05, 0.54]	1.00 [0.63, 1.00]	1.00	0.44	#	0.77	0.62	1.00	0.56
	Powers 2012	3	0	14	5	0.18 [0.04, 0.43]	1.00 [0.48, 1.00]	1.00	0.26	#	0.82	0.77	1.00	0.74
	Stookey 2005	21	727	49	1150	0.30 [0.20, 0.42]	0.61 [0.59, 0.63]	0.03	0.96	0.77	1.14	0.04	0.03	0.04
89 BIA resis-	Allison 2005	5	0	0	10	1.00 [0.48, 1.	1.00 [0.69, 1.	1	1	#	0	0.33	1	0

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

tance 50 kHz, ≥ 450 Ω						00]	00]							
	Kafri 2012	7	4	6	4	0. 54 [0. 25, 0. 81]	0. 50 [0. 16, 0. 84]	0.64	0.40	1.08	0.92	0.62	0.64	0.60
	Powers 2012	12	1	5	4	0. 71 [0. 44, 0. 90]	0. 80 [0. 28, 0. 99]	0.92	0.44	3.53	0.37	0.77	0.92	0.56
	Stookey 2005	48	1518	22	359	0. 69 [0. 56, 0. 79]	0. 19 [0. 17, 0. 21]	0.03	0.94	0.85	1.64	0.04	0.03	0.06
90 BIA resistance 50 kHz, ≥ 350 Ω	Allison 2005	5	5	0	5	1. 00 [0. 48, 1. 00]	0. 50 [0. 19, 0. 81]	0.5	1	2	0	0.33	0.5	0
	Kafri 2012	9	7	4	1	0. 69 [0. 39, 0. 91]	0. 13 [0. 00, 0. 53]	0.56	0.20	0.79	2.46	0.62	0.56	0.80
	Powers 2012	15	2	2	3	0. 88 [0. 64, 0. 99]	0. 60 [0. 15, 0. 95]	0.88	0.60	2.21	0.20	0.77	0.88	0.40
	Stookey 2005	69	1859	1	18	0. 99 [0. 92, 1. 00]	0. 01 [0. 01, 0. 02]	0.04	0.95	1.00	1.49	0.04	0.04	0.05
91 BIA resistance 100	Kafri 2012	2	0	11	8	0. 15 [0. 02, 0. 45]	1. 00 [0. 63, 1. 00]	1.00	0.42	#	0.85	0.62	1.00	0.58

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

kHz, ≥ 550 Ω														
92 BIA resistance 100 kHz, ≥ 450 Ω	Kafri 2012	6	3	7	5	0.46 [0.19, 0.75]	0.63 [0.24, 0.91]	0.67	0.42	1.23	0.86	0.62	0.67	0.58
93 BIA resistance 100 kHz, ≥ 350 Ω	Kafri 2012	9	7	4	1	0.69 [0.39, 0.91]	0.13 [0.00, 0.53]	0.56	0.20	0.79	2.46	0.62	0.56	0.80
94 BIA resistance 200 kHz, ≥550 Ω	Kafri 2012	1	0	12	8	0.08 [0.00, 0.36]	1.00 [0.63, 1.00]	1.00	0.40	#	0.92	0.62	1.00	0.60
95 BIA resistance 200 kHz, ≥450 Ω	Kafri 2012	6	0	7	8	0.46 [0.19, 0.75]	1.00 [0.63, 1.00]	1.00	0.53	#	0.54	0.62	1.00	0.47
96 BIA resistance 200 kHz, ≥ 350 Ω	Kafri 2012	8	6	5	2	0.62 [0.32, 0.86]	0.25 [0.03, 0.65]	0.57	0.29	0.82	1.54	0.62	0.57	0.71

Table 3. Diagnostic accuracy of tests for water-loss dehydration: 295 mOsm/kg cut-off $ (*Continued*)

97 BIA TBW %, < 45%	Culp 2003	59	12	186	51	0.24 [0.19, 0.30]	0.81 [0.69, 0.90]	0.83	0.22	1.26	0.94	0.80	0.83	0.79
	Gaspar Acute & LTC 2011	2	20	1	5	0.67 [0.09, 0.99]	0.20 [0.07, 0.41]	0.09	0.83	0.83	1.67	0.11	0.09	0.17
	Kafri 2012	2	1	11	7	0.15 [0.02, 0.45]	0.88 [0.47, 1.00]	0.67	0.39	1.23	0.97	0.62	0.67	0.61
	Powers 2012	4	0	13	5	0.24 [0.07, 0.50]	1.00 [0.48, 1.00]	1.00	0.28	#	0.77	0.77	1.00	0.72
	Stookey 2005	26	692	44	1184	0.37 [0.26, 0.50]	0.63 [0.61, 0.65]	0.04	0.96	1.01	1.00	0.04	0.04	0.04
98 BIA TBW %, < 47%	Culp 2003	85	18	160	45	0.35 [0.29, 0.41]	0.71 [0.59, 0.82]	0.83	0.22	1.21	0.91	0.80	0.83	0.78
	Gaspar Acute & LTC 2011	3	22	0	3	1.00 [0.29, 1.00]	0.12 [0.03, 0.31]	0.12	1	1.14	0	0.11	0.12	0
	Kafri 2012	2	1	11	7	0.15 [0.02, 0.45]	0.88 [0.47, 1.00]	0.67	0.39	1.23	0.97	0.62	0.67	0.61
	Powers 2012	5	1	12	4	0.29 [0.10, 0.	0.80 [0.28, 0.	0.83	0.25	1.47	0.88	0.77	0.83	0.75