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Clinical assessment of dehydration in older people admitted to hospital What are the strongest indicators?

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Abstract

Due to an absence of published primary data, this study explores dehydration prevalence and the change in physiological parameters frequently used to assess dehydration (fluid deficit) in older hospitalized people, as no standard measurement method exists. This observational longitudinal cohort study recruited 43 people aged 60 years or over, voluntarily admitted to a tertiary teaching hospital's Geriatric and Rehabilitation Unit (GARU). Over 40 clinical, hematological and urinary biochemical parameters employed by medical officers during dehydration assessment, identified through literature, interviews and focus group were investigated. Short-term weight changes, intra- and inter-rater repeatability of dehydration assessments were completed to assess validation and precision of the clinician's clinical dehydration assessment. Systolic blood pressure drop on standing, sternal skin turgor, tongue dryness and body mass index (BMI) were associated with hydration status; demonstrated clinically meaningful differences between groups. BMI negatively confounded the association between dehydration and systolic blood pressure drop on standing. Physical, rather than biochemical, parameters more often identified mild dehydration. The findings challenge common expectations of hematological and physiological measurement

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changes occurring in older people clinically assessed as dehydrated and emphasize the need to adjust for potential confounders during exploration of the associations of clinical parameters with dehydration status.

Keywords: Dehydration of elderly patients; Clinical assessment of hypovolemia; Hospital dehydration prevalence; Adjusting for potential confounders; Fluid deficit

1. Introduction

No working clinical definition of dehydration exists (Weinberg and Minaker, 1995). Dehydration is not a homogenous condition and does not manifest in a single form, contributing to difficulties with assessment (Sarhill et al., 2001; Thomas et al., 2003). The term ''dehydration'' is used to encompass several conditions associated with fluid deficit (Mange et al., 1997; Sarhill et al., 2001). The terms ''fluid deficit'', ''hypovolemia'', ''volume depletion'' and ''dehydration'' were originally defined in the 1930s and 1940s (Mange et al., 1997; Sarhill et al., 2001) to better understand treatments for fatal diarrhea (Holt et al., 1915) and survival of shipwrecked sailors and downed aviators (Adolph, 1947; Gamble, 1947).

The lack of standardized or validated methods for clinical assessment of fluid deficit (dehydration or volume depletion) is a major limitation to study in clinical settings and is worthy of being addressed. Clinical studies often explore dehydration by clinical assessments based upon combinations of parameters selected, without reference, as indicators of dehydration including urea, creatinine, sodium, osmolality and urine specific gravity (SG) (Himmelstein et al., 1983; Weinberg and Minaker, 1995; Molaschi et al., 1997; Wakefield et al., 2002). Others do not make explicit, or minimally describe, their procedures for deciding hydration status (Beaujean et al., 1997; Collins and Myatt, 2000), and inter-rater repeatability is not reported.

The most accepted process for confirming dehydration is an assessment of body fluid loss by weight change as a percentage of total body weight (Weinberg and Minaker, 1995; Murphy, 1998). Assessing dehydration by short-term weight change after imposing exercise and/or fluid restrictions has been frequently undertaken in healthy young athletic or military populations (Gopinathan et al., 1988; Mudambo et al., 1997; Shirreffs and Maughan, 1998; Kovacs et al., 1999). Any such studies conducted with older people have involved healthy volunteers (Phillips et al., 1984; Takamata et al., 1999) rather than those hospitalized for medical care, where imposed dehydration would not be ethical. Results from healthy volunteers cannot be extrapolated to the older hospitalized person due to disease states that may affect dehydration status (Gennari and Kassirer, 1974; Spira et al., 1997), physiological changes with age such as declining renal function (Fried and Palevsky, 1997; Miller, 1997) and reduced thirst response (Phillips et al., 1993; Warren et al., 1994). In clinical practice, assessing dehydration by the conventional means of weight change has limitations, as measurements taken over two time points preclude immediate assessment. Other means to assess dehydration in the clinical setting are required.

A diagnosis of dehydration during hospital admission has been associated with increased morbidity and mortality (Warren et al., 1994), yet no prevalence data or standardized and validated approach to clinically assessing dehydration is currently reported in the literature. No studies of older people admitted to hospital have attempted to validate the diagnosis of clinically assessed dehydration, against the percentage of total body water lost as assessed by weight gain after recovery, which is currently the most accepted method for confirming dehydration (Weinberg and Minaker, 1995; Murphy, 1998). Given the paucity of descriptive information, this study was undertaken to explore both the prevalence of subjective clinically assessed dehydration, and its association with a range of parameters indicative of dehydration, amongst older people admitted to hospital.

2. Methods

2.1. Study design

An observational longitudinal cohort study was conducted. Weight measurements and clinical dehydration assessments were undertaken initially and 1 week later. Clinical dehydration assessments were compared to the short-term weight changes in order to validate dehydration verification, given that no standard clinical dehydration assessment exists. The term dehydration was used to encompass all types of fluid deficit as they appear in the clinical setting.

Ethics approval was granted and signed informed consent obtained. Individuals were excluded if involuntarily admitted, fitted with a pacemaker (both due to contraindications with another study component) or younger than 60 years.

2.2. Study sampling frame and target population

New admissions between May and December 2002 to the GARU of a tertiary teaching hospital were recruited ($n = 43$) to reflect the older hospitalized patient. Due to the study's descriptive nature, the age and gender of study participants and the totality of those admitted to GARU were compared with the hospital population to assess representativeness.

2.3. Dehydration indicator parameters

Interviews with medical officers and a review of the literature revealed that no standard process for dehydration assessment exists and that individual professional judgment, using a range of parameters, forms part of the decision process. The clinical assessment of dehydration was categorized as nil, mild, moderate or severe based upon individual professional judgment of one clinician, which included medical and surgical history, physical examination, fluid intake, urine output and weight changes. Parameters for investigation of their individual association with this clinical assessment were identified through (i) an extensive search of the literature, (ii) semi-structured interviews and (iii) focus groups with consultants.

Interviews involved medical officers and consultants from a range of medical disciplines ($n = 9$). Responses to the open question ''How do you assess dehydration?'' were verified and confirmed at the interview's completion. The focus group consisted of an expert panel of eight consultants, each with 20 years or more experience from internal medicine, nephrology, cardiology, emergency and geriatrics. Subsequent to the focus group, the consultants graded their perceived importance of the parameters raised during the focus group. The parameters identified as ''important'' in assessing the presence of dehydration in older people were further explored in this study and are outlined below.

2.4. Demographic and dehydration information

Age and gender data for GARU and the remaining hospital-wide discharges aged 60 years and over were obtained from the hospital's Health Information Management Department. The number of discharges with the dehydration code ''E86'' (a collective code for volume depletion or depletion of the volume of plasma or extracellular fluid or dehydration) according to the International Classification of Diseases 10th edition, Australian Modification (ICD-10-AM) (National Centre for Classification in Health, 2002) as a principal or secondary diagnosis were completed for GARU patients and the remaining hospital population.

2.5. Data collection

On admission, height was measured to the nearest 0.5 cm using a portable stadiometer (Fisco Videoflex, England). On admission and a week later, weight was recorded in kilograms to the nearest 0.1 kg, weighed in light clothing on chair scales (Model 211CHD, Mercury Scale Company, South Australia).

2.6. Clinical examination and medical history

The parameters assessed on admission included: recent fluid intake, recent vomiting and diarrhea (past 3 days), fever (past 3 days), changes in functional level, environmental risks (e.g., hot weather, recent exercise), medication, alcohol, medical history, surgical history, blood pressure, heart rate, postural change in blood pressure and heart rate on standing, respiratory rate, elevated body temperature, jugular venous pressure (JVP), tissue turgor, BMI, reported thirst, inspection of the oral mucous membranes for dryness, inspection of the tongue for dryness and longitudinal furrows, urine volume and confusion as measured by the mental status questionnaire (MSQ) developed and validated for the older hospitalized population (Kahn et al., 1960). The measured weight change (over 1 week) was assessed. Heart rate and blood pressure were both measured supine and after standing for 2 min. Tissue turgor was measured by pinching tissue on the dorsum of the hand and over the sternum and recording the seconds elapsed for tissue fold to return to normal.

2.7. Hematological biochemistry

The medical officer or qualified staff member collected a non-fasting blood sample. Electrolyte and liver function tests were performed at the hospital laboratory under

standard conditions. The information collected included albumin, sodium, chloride, urea, creatinine, osmolality, urate, urea/creatinine ratio; hematocrit and hemoglobin levels. Hematocrit was assessed after stabilizing participants in a sitting or lying position for 15 min.

2.8. Urinary biochemistry

A urine sample was collected at time of consent. Urinary ketones were assessed at ward level using urine dipsticks (Multistix 8 by Bayer Diagnostics Australia) prior to sending urine tests for laboratory analysis of osmolality, chloride, urea and creatinine.

2.9. Repeatability

To eliminate inter-rater variability, one person collected all data for any one parameter. One medical officer conducted all clinical dehydration measures and performed the clinical assessment of all participants. The hydration assessment was made by the study medical officer in person, and the same officer completed a blinded re-assessment of a sub-sample ($n = 12$), 6 months later by reviewing the measurements documented on paper. Intra-rater and inter-rater repeatability using the kappa statistic were estimated to determine the agreement of assessments completed by the consultants of the geriatric unit and the study's medical officer, using the same documentation. Intra-rater repeatability of height and weight measurements was completed and confirmed in a separate sample of older people to the study (mean differences, $n = 9$; 0.23 cm, 95% CI −0.2 to 0.7 cm and 0.02 kg, 95% CI −0.1 to 0.1 kg, respectively).

2.10. Data analysis

Means ± S.D. summarized the normally distributed biochemical parameters of urine SG and blood biochemistry (sodium, chlorine, osmolality, creatinine, urea/creatinine ratio, urate, albumin, hemoglobin, hematocrit). Medians and ranges summarized the biochemical parameters that were not normally distributed including blood and urine biochemistry (blood urea, urinary urea, urinary creatinine, urinary sodium, urinary chlorine and urinary SG). The presence of urinary ketones were reported as counts and presented as the percentages of total participants. Crude odd ratios of four or more were selected as they provided the clearest distinction between the responses of the dehydrated and well-hydrated groups given the sample size.

Clinical significance was used for decisions regarding the relevance of any demographic associations and importance of magnitude of parameter changes. The opinion on changes in parameters considered to be clinically significant was sought from the consultant expert panel ($n = 8$), individually, by questionnaire. Changes required for the consultant to, firstly ''consider'', and secondly, ''be more confident'' of a diagnosis of dehydration, were elucidated while cognizant that parameters are not used in isolation. The minimum change was selected to indicate a clinically significant change between groups reflecting their hydration status. A clinically significant difference in

BMI was selected as 5.0 kg/m^2, which is consistent with the risk category change used in practice (English, 1987) and a 10% relative difference in weight based on the average 70 kg man (Stratton et al., 2003).

Clinically significant variables were included in multivariable modeling and potential confounders (age, gender, BMI) of the relationships between each parameter and clinical hydration status were individually assessed. Age (60–79 years, 80 years or over) and BMI (less than 20, 20 and more) were grouped if the odds ratios of the continuous variables categorized into quintiles were not linearly related to outcome. Confounding was judged considerable if the adjusted odds ratios differed from the unadjusted estimates by more than 10% relatively. Logistic regression and general linear modeling using forward entry of variables was completed to adjust for the effect of another parameter during model exploration. Analyses were performed using Statistical Package for the Social Sciences (Release 11, SPSS Inc., Chicago, II, 2003).

3. Results

3.1. Prevalence of dehydration

Of 82 GARU admissions approached, 18 were ineligible, 43 fulfilled the inclusion criteria and consented, and 21 declined or withdrew. The dehydration prevalence of participants on admission was 16.3% (95% CI: 5.3–27.3%, 7/43). This was significantly higher than the annual ICD-coded dehydration figures for GARU (5.3%, 95% CI: 3.9–6.7%, $n = 963$) and the ICD-coded dehydration figures for the remainder of the hospital (2.0%, 95% CI: 1.8–2.2%, $n = 28{,}308$) amongst those aged 60 years and over. All clinically assessed dehydration was deemed to be mild.

3.2. Representativeness of study participants

The gender distribution of study participants ($n = 43$; males 35%), was not clinically different from that of total GARU discharges ($n = 963$; males 47%) or the remaining hospitalized population ($n = 28{,}308$; males 50%) aged 60 years or more. The proportion of males was considered greater than the published levels evident in nursing home and long-term care facilities (12–27% male) (Siebens et al., 1986; Blaum et al., 1995; Chidester and Spangler, 1997; Cacchione et al., 2003) but comparable with the published levels evident with older hospitalized populations (39%, 42% male) (Inouye et al., 1999; Thomas et al., 2003).

The gender of those who declined participation (4/10, 40% male), withdrew or had incomplete data (6/11, 54% male) did not differ at a clinically significant level from the GARU study participants. Those who declined participation (78.9 $\pm$ 8.3 years), withdrew (80.0 $\pm$ 7.7 years) or had incomplete data (81.6 $\pm$ 8.0 years), were similar in age to the study participants (78.3 $\pm$ 8.3) and the total GARU discharges (77.2 $\pm$ 9.1). Although a little older than the remaining hospitalized population aged 60 years or more (71.7 $\pm$ 7.8 years), participants were not aged 80 years or over, which is considered to be clinically older (WHO Expert Committee, 1987).

3.3. Repeatability of clinical dehydration assessment

The medical officer's assessments of clinical dehydration status were completely consistent, whether completed in person or when assessing results documented on paper ($n = 12$, $\kappa = 1.0$). Good inter-rater repeatability (Harris and Taylor, 2004) of dehydration assessments ($n = 23$) against the study's medical officer was confirmed, with three consultants achieving 83–87% (19–20/23) crude agreement ($\kappa = 0.7$) and one consultant achieving 78% (18/23) crude agreement ($\kappa = 0.5$) via the clinical assessment information documented on paper.

The clinical assessment of dehydration was additionally validated by repeated weight measurement and clinically assessed hydration status, both completed for five participants. No weight change (over the week) was evident for one participant. Four of the five showed weight changes and changes in the percentage of total body weight in a direction consistent with the change in hydration status (−1.7 kg, 3.5%; −0.8 kg, 1.2%; −0.6 kg, 1% weight loss for three whose clinical hydration assessment declined, +2.6 kg, 5.8% weight gain for one whose clinical hydration assessment improved).

3.4. Age, gender and hydration status

There were similar proportions of dehydrated females (5/28, 17.9%, 95% CI: 3.7–32.1%) and males (2/15, 13.3%, 95% CI: 0.0–30.5%). Dehydrated study participants (78.5 ± 8.6 years, $n = 7$) were not clinically different in age from those assessed as well hydrated (77.1 ± 6.8 years, $n = 36$).

3.5. Comparison of individual clinical indicators to clinical assessment of dehydration

Parameters were individually tested against the clinical assessment of dehydration to determine which correlated with global clinical assessment of dehydration amongst hospitalized older people.

3.5.1. Hematological and urinary biochemistry

There was no difference in blood or urinary biochemistry levels between patients who were and who were not considered clinically dehydrated (Tables 1 and 2). Due to collection difficulties in this population, a high proportion of urinary data was missing (Table 2).

The mean urinary SG if either mildly dehydrated (SG 1.018 ± 0.005, 95% CI: 1.013–1.028, $n = 4$) or well hydrated (SG 1.015 ± 0.007, 95% CI: 1.012–1.018, $n = 16$) did not reach the level of SG 1.020 considered clinically significant for dehydration. Urinary ketones were not present with mild dehydration (0/4, 0.0%) although evident in one participant assessed as well hydrated (1/16, 6.3%).

3.5.2. Clinical examination

Clinically important and statistically significant differences in clinical examination parameters between the study groups included a greater reduction in systolic blood

Table 1
Comparison of individual blood biochemical tests amongst those with or without clinically assessed dehydration

	No dehydration ($n = 36$)		Mild dehydration ($n = 7$)		Clinically significant value*
	Mean	±S.D.	Mean	±S.D.	
Sodium (mmol/l)	134.97	4.17	135.29	6.16	>145 [148]
Chlorine (mmol/l)	101.33	4.53	100.71	5.41	>110 [115]
Osmolality (mmol/kg)	275.69	9.80	273.71	13.01	>290 [300]
Creatinine (mmol/l)	0.10	0.04	0.07	0.02	>0.11 [0.15]
Urea/creatinine ratio	87.56	30.76	88.71	27.82	>100 [110]
Urate (mmol/l)	0.36	0.14	0.28	0.09	>0.5
Albumin (g/l)	34.00	3.87	34.43	6.45	>45.00
Hemoglobin (g/l)	123.69	18.68	127.71	18.44	>150 [170]
Hematocrit (l/l)	0.38	0.05	0.40	0.06	>0.50

* Change required in the parameter for the consultant to consider [or be more confident of] dehydration.

pressure upon standing if dehydrated (20.14 ± 20.86 mm Hg) compared with no dehydration (2.12 ± 19.06 mm Hg, $p = 0.03$) and a lower BMI (20.00 ± 3.03) if clinically assessed as dehydrated compared to not (27.50 ± 6.27, $p = 0.03$) (Table 3). Those assessed with mild dehydration (median 46.7 kg, range 39.0–68.8 kg, $n = 4$) and the well hydrated (median 71.5 kg, range 39.0–142.8, $n = 25$) showed a clinically and statistically significant weight difference ($p = 0.04$).

Those assessed with mild dehydration had greater odds of dry tongue, tongue furrows and dry oral mucous membranes relative to the well hydrated (Table 4). Those with mild dehydration demonstrated greater odds of reduced sternal tissue turgor after pinching compared with the well hydrated (Table 4). These clinically relevant associations, however, did not have adequate statistical power to attain statistical significance.

3.5.3. Medical history

A similar number of medical conditions was evident amongst those clinically assessed as dehydrated ($n = 7$, median 4, range 1–8) compared with the well hydrated ($n = 35$, median 3, range 0–11). The number of prescribed medications (7.8 ± 3.4 versus 9.6 ± 4.3), diuretic use (OR 0.5, 95% CI: 0.05–4.8) or antidepressant medication (OR 0.9, 95% CI: 0.2–5.3) were not different between those clinically assessed as dehydrated ($n = 7$,

Table 2
Comparison of individual clinical examination, blood and urinary biochemical tests amongst those with or without clinically assessed dehydration

	No dehydration			Mild dehydration			Clinically significant value*
	n	Median	Range	*n*	Median	Range	
JVP (cm)	33	0	0–3	7	0	0–4	0 (not visible)
Blood urea (mmol/l)	36	7.3	3.9–21.5	7	6.3	3.6–77	>10 [15]
Urinary urea (mmol/l)	27	197.0	63–465	7	193.0	63–513	A change
Urinary creatinine (mmol/l)	27	6.3	1.7–20.3	7	7.4	3.7–20.8	An increase
Urinary sodium (mmol/l)	27	47.0	9–129	7	97.0	10–142	<40
Urinary chlorine (mmol/l)	17	69.0	21–128	5	81.0	15–163	<20

* Value required in the parameter for the consultant to consider [or be more confident of] dehydration.

Table 3
Comparison of individual clinical examination parameters amongst those with or without clinically assessed dehydration

	No dehydration			Mild dehydration			Clinically significant value*
	n	Mean	±S.D.	*n*	Mean	±S.D.	
Lying heart rate	36	78.06	11.63	7	84.00	12.00	>100 [120]
Lying systolic BP	36	130.78	21.58	7	142.86	35.22	>80 [<80]
Lying diastolic BP	36	72.67	13.10	7	75.71	18.80	>50 [50]
Respiratory rate	36	19.89	5.19	7	18.86	4.14	>20
Maximum body temperature	35	36.58	0.54	6	36.60	0.52	>38 °C
MSQ	34	8.20	2.40	7	9.29	0.76	<7
Standing heart rate	26	83.77	13.31	7	86.57	19.55	
Standing systolic BP	26	132.62	22.44	7	122.71	29.47	
Standing diastolic BP	25	78.80	16.79	7	80.00	18.93	
Diastolic BP drop on standing	26	5.54	9.25	7	4.29	9.76	Decrease 5 [decrease 10]
Heart rate increase on standing	26	5.69	13.81	7	2.57	10.31	An increase [>0]
Systolic BP drop on standing**	26	2.12	19.06	7	20.14	20.86	A decrease [>0]
BMI (kg/m^2)**	17	27.50	6.27	4	20.00	3.03	5 unit difference

BP, blood pressure (mm Hg).
* Value required in parameter for the consultant to consider [or be more confident of] dehydration.
** $p = 0.03$.

5, 7) or well hydrated ($n = 35, 29, 32$, respectively). No patient assessed as dehydrated had been currently or recently prescribed antibiotics, compared with 22% (7/32) of the well hydrated.

The potential influence of medical history on dehydration risk was explored. No participant had undergone recent surgery (within the last year). None of the dehydrated had experienced vomiting, diarrhea or fever during the previous 3 days. Other explored conditions without statistical significance are outlined in Table 5. For a range of other conditions, there were no occurrences amongst the dehydrated and consequently no informative analysis beyond this statement could be performed (Table 5).

Table 4
Comparison of oral and physical clinical examination parameters amongst those with or without clinically assessed dehydration

	No dehydration, number of $n = 36$, *n* (%)	Mild dehydration, number of $n = 7$, *n* (%)	OR* (unadjusted)	95% CI
Presence of	Yes	Yes		
Dry tongue	13 (36.1)	5 (71.4)	4.42	0.75–26.10
Tongue furrows	11 (30.6)	4 (57.1)	3.03	0.58–15.88
Dry oral mucous membranes	13 (36.1)	4 (57.1)	2.36	0.46–12.21
Tissue turgor (>2 seconds**)				
Hand	25 (69.4)	6 (88.7)	2.64	0.28–24.62
Sternal	1 (2.8)	1 (14.3)	5.83	0.32–106.44

* An OR over 1 indicates increased odds of dehydration when the parameter is present relative to the odds of dehydration in its absence.
** Value required in the parameter for the consultant to consider dehydration.

Table 5
Unadjusted odds of mild dehydration given medical history of statistically not significant parameters ($n = 43$)

Increased odds of dehydration	
Unadjusted odds ratio	
>4	Depression, Menière's disease
3.1–4	Nil
2.1–3	Renal calculi or gout, reported changes in functional level
1.1–2	Diabetes mellitus, hypertension, ischemic heart disease, peripheral vascular disease, weight loss, osteoarthritis
Reduced odds of dehydration	
Unadjusted odds ratio	
0–1	Previous stroke, heart failure, chronic obstructive airways disease, asthma, constipation, been in air conditioning, reported thirst
Uninformative[a]	Bronchiectasis, cataract, goiter, syncope, pulmonary embolism or diarrhea, atrial fibrillation, hypercholesterolemia, urinary tract infection, psychiatric illness, varicose veins, renal failure, subdural hematoma, peptic ulcer, urinary incontinence, gastroesophageal reflux, aortic valve replacement, vomiting, dementia, hypoparathyroidism

[a]Odds ratio unable to be calculated as nil events occurred in one or other of the study groups.

Although the confidence intervals were wide and estimates were not statistically significant, higher odds of mild dehydration was suggested amongst those with a medical history ($n = 5$, 2, 3, 3, 30 cases, respectively) of depression (OR 4.4, 95% CI: 0.6–33.2), Menière's disease (OR 5.8, 95% CI: 0.3–106.4), renal calculi or gout (both OR 2.8, 95% CI: 0.2–36.4) and reported changes in functional level (OR 2.3, 95% CI: 0.24–21.38) (Table 5).

3.6. Multivariable analysis

Associations between each of the clinically significant assessment parameters and dehydration status were adjusted for the effects of age group, gender and BMI, one at a time. Gender and age group did not confound associations between hydration status and any of the clinically significant assessment parameters. BMI group (less than 20, 20 or more) did not confound associations between hydration status and tongue dryness. Regression coefficients ($n = 33$) showed that the mean decrease in systolic blood pressure with dehydration was more pronounced after adjusting for BMI groups (-38.3 mm Hg, 95% CI: -74.3 to -2.2 mm Hg) compared with the unadjusted value (-18.0 mm Hg, 95% CI: -34.9 to -1.2 mm Hg). Cautiously, it could be speculated that BMI group may confound the association between the drop in systolic blood pressure and dehydration.

4. Discussion

4.1. Dehydration prevalence

Dehydration prevalence on admission was higher than identified through hospital coding, with mild dehydration being predominant. The limited medical chart

documentation and subsequent coding indicates dehydration is under-recognized amongst hospitalized older people. Consequently, officially coded figures of dehydration in health care institutions as documented from medical record entries by clinicians, are likely to be underestimates.

4.2. Clinically significant dehydration assessment parameters

A wide variety of factors considered in the diagnosis of dehydration were explored to provide an evidence-base for practice. Interestingly, physical rather than biochemical parameters were more favorable indicators of mild hydration on the basis of both practicality and clinical significance of the noted differences between the groups based on hydration status. The systolic blood pressure drop on standing, sternal skin turgor, tongue dryness and BMI differed at clinically significant levels with changes in hydration status. The proportion of missing data for urinary parameters demonstrated that they were a poor practical option for clinical dehydration assessment amongst older people admitted to hospital.

As long ago as 1965, laboratory data were ''reported'' to be of little value in determining the presence of dehydration, particularly when the patient first appears for examination in a state of dehydration'' (Lapides et al., 1965). Physical signs were concluded to be preferable, as biochemical values did not substantially change after restricting daily fluid to 360 ml over 5 days in seven healthy males aged 33–69 years (Lapides et al., 1965). The current findings support the contention that there is limited value in biochemical indicators for less severe dehydration and that physical signs may hold more promise as clinical indicators.

Of particular note, although frequently used as confirmation of dehydration in the literature, our study data showed that elevated serum sodium and osmolality were not sensitive dehydration indicators for mild dehydration (Himmelstein et al., 1983; Weinberg and Minaker, 1995; Molaschi et al., 1997; Wakefield et al., 2002). Amongst older people admitted with a dehydration diagnosis code, wide ranges existed for both serum sodium (range 120–178 mmol/l) and osmolality (range 256–307 mOsm/kg), with only 11 and 17% respectively having higher values than the usual normal physiological range's maximum of 145 mmol/l sodium and 295 mOsm/kg (Thomas et al., 2003). Clinically assessed dehydration can occur therefore without major elevations of serum sodium or osmolality.

4.3. Dehydration, volume depletion and fluid deficit

In contrast to dehydration, volume depletion may be accompanied by increased, decreased or normal serum sodium (Sarhill et al., 2001). The terms ''dehydration'' and ''volume depletion'' have been used interchangeably in practice to describe fluid deficits. Most presentations of fluid deficit and most people referred to as ''dehydrated'' in the hospital setting are probably volume depleted (McGee et al., 1999; Thomas et al., 2003). In this study, serum sodium was normal despite a clinical assessment of dehydration, suggesting volume depletion rather than intracellular dehydration.

Over one-third of those with hospital-coded dehydration have no biochemistry to support the diagnosis and the lack of aggressive therapy supports the proposition that

volume depletion rather than true intracellular dehydration is in fact present (Thomas et al., 2003). USA hospital information management organizations have recently recommended the development of separate codes for volume depletion and dehydration to enable discrimination between the different fluid deficit conditions in preference to current collective coding practices (AHIMA, 2005). The presence of two distinct conditions of fluid deficit in the clinical setting adds to the difficulty of validating optimal parameters for the assessment of what is commonly referred to as ''dehydration''.

4.4. The validation measure

Previously, other clinical studies had not independently verified the judgment of clinical dehydration assessment in the clinical setting by short-term weight change or assessed inter-rater repeatability. The clinical dehydration assessment completed a week apart with a subset of participants was consistent with body fluid loss assessed by weight change as a percentage of total body weight, which is the most accepted process for the confirmation of dehydration (Weinberg and Minaker, 1995; Murphy, 1998).

Good agreement of clinical dehydration assessment was confirmed between the study's medical officer and GARU consultants. A level of agreement around 80% or better compares well with other studies where clinical judgment was involved (Baker et al., 1982; Eaton et al., 1994). Despite the lack of an established and optimal combination of dehydration identification parameters for the older person, consistent clinical judgment was confirmed amongst the consultants practicing geriatric medicine.

The fluid deficits induced in well older people by exercise or restricted fluid intakes cannot be assumed to represent the same condition evident amongst older people admitted to hospital. Different conditions may be represented, as many precipitants for volume depletion are evident amongst older people admitted to hospital, including water losses though fever or disease, blood loss, fasting or ascites and diuretics (Weinberg and Minaker, 1995; Fried and Palevsky, 1997; O'Brien et al., 1999; Sarhill et al., 2001; Oppliger and Bartok, 2002; Thomas et al., 2003). Consequently, until the parameters best associated with fluid deficit in clinical populations are established, clinical judgment substantiated by short-term weight change, appears to be an acceptable means of assessing the hydration status of older people admitted to hospital.

4.5. Confounders of dehydration status

There was a scarcity of studies adjusting for confounders of the associations between hydration status and biochemistry (Burge, 1993), clinical history or physical assessment parameters. Confounding of the association of dehydration and serum osmolality by weight or disease is possible as solutes such as creatinine increase with muscle (Forbes, 1987; Bowker et al., 1992; Chumlea et al., 1996) while diseases that affect major serum solutes such as electrolytes, glucose or urea can also impact serum osmolality (Gennari, 1984). In addition to male gender, serum creatinine concentrations are elevated by medical conditions including renal function, diabetic ketoacidosis, gastrointestinal bleeding, cardiac failure and septicemia (Bowker et al., 1992). Increased serum osmolality is apparent with greater age and male gender (McLean et al., 1992). Changes in physiology,

medications and the presence of conditions such as uncontrolled diabetes or inappropriate secretion of antidiuretic hormone increase water excretion and lower urine osmolality (Kleinfeld et al., 1979; Miller et al., 1995; Ship and Fischer, 1997; Spira et al., 1997). In addition to dehydration, dry oral mucosa has been associated with aging, a range of medications (diuretics, anticholinergics), diseases (diabetes mellitus, thyroid dysfunction, nephritis) and treatments (radiation therapy) (Greenspan, 1996; Astor et al., 1999).

Our study established that the association between hydration status and the systolic blood pressure drop on standing was confounded by BMI. This demonstrates that adjusting for potential confounders is important for the future development of validated and standardized dehydration assessment parameters suitable for use in clinical practice.

4.6. Limitations with clinical dehydration studies

All dehydration in this study was rated as mild. Whether dehydrated older people in care show more pronounced differences in biochemistry, clinical examination or physical parameters if more severely dehydrated (being 6–30% of those assessed as dehydrated) remains unexplored (Lavizzo Mourey et al., 1988; Gross et al., 1992; Ooi et al., 1997). One study in a clinical setting attempted to correlate assessment variables with clinically assessed dehydration severity (Gross et al., 1992). However, this approach may be limited, as correlations assumed normally distributed variables (which were not confirmed for all variables in our study and hence unlikely in other's studies) and a linear relationship between variables, which may not reflect physiological response (Lavizzo Mourey et al., 1988). Regardless, mild dehydration, in contrast to more pronounced dehydration, has been most commonly assessed in this study and others and is worthy of further investigation in its own right.

With the lack of an objective gold standard and the subsequent use of clinical assessment of dehydration, it is possible that the parameters identified as being associated with dehydration are simply a reflection of those employed by the medical officer during clinical dehydration assessments. The fact that a range of different measures were employed during dehydration assessments by medical officers, that dehydration assessments by the study's medical officer were consistent with others' assessments and weight changes, and that only two of the eight study variables that had achieved clinical significance were employed by the study's medical officer to form a diagnosis, reduce the impact of this potentially severe limitation. Despite potential limitations, this descriptive study provides valuable information to progress the development of validated and standardized dehydration assessments for hospitalized older people, as none currently exist, to better recognize and treat dehydration.

Currently, the most accepted process for confirming dehydration is an assessment of body fluid loss by weight change as a percentage of total body weight (Weinberg and Minaker, 1995; Murphy, 1998). Further studies involving measurement of plasma volume in addition to total body, intra and extra-cellular water studies in humans would improve knowledge of fluid dynamics during the dehydration process. A better understanding would thus be gained of the relative usefulness of assessment parameters with progressive dehydration. The physiological changes evident when different percentages of body weight as water is lost could be used to validate the degree of weight change as an assessment

method for the verification or identification of intracellular dehydration in contrast to volume depletion. Although possible with the well older person, the challenge remains the practicality of measurement within the real clinical setting.

5. Conclusions

The prevalence of mild dehydration (fluid deficit) was higher than dehydration identified through hospital coding of older people admitted to hospital. Given that no standardized or validated clinical dehydration assessment exists for older hospitalized people, the study documented the associations, with globally assessed dehydration, of a number of individual parameters potentially used in the clinical assessment of hydration status upon admission to hospital. This study addressed a clinically practical question in a naturalistic setting under real clinical conditions. In those patients assessed with mild dehydration, the systolic blood pressure drop on standing, sternal skin turgor, tongue dryness and BMI all differed at levels considered to be clinically significant by medical consultants. No consistent associations between mild dehydration and biochemical parameters were demonstrated, including a lack of support from those established in the literature. Consequently, physical rather than biochemical parameters were found to be practical indicators of mild dehydration amongst older people admitted to hospital.

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