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Comparisons of spot vs 24-h urine samples for estimating population salt intake: Validation study in two independent samples of adults in Britain and Italy

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Abstract *Objectives:* To assess the reliability and reproducibility of estimations of group mean 24-h urinary sodium (Na) excretion through timed spot urines compared to 24 h urinary Na output in two independent cross-sectional population samples including men and women and different ethnic groups.
Methods and Results: Study 1 was carried out in Britain and included 915 untreated 40–59 yrs male and female participants (297 white, 326 of black African origin and 292 South Asian). Study 2 was carried out in Italy and included 148 white men (mean age 58.3 yrs). All participants provided both a 24-h urine collection and a timed urine sample as part of population surveys. Na, creatinine (Cr) and volume (V) were measured in all samples. Age, body mass index (BMI) and blood pressure (BP) were also measured. We compared the daily Na excretion through 24-h urine (gold standard) with its estimate from timed urine samples with two methods: Tanaka's predictions and Arithmetic extrapolations, and assessed them with correlation coefficients, Bland–Altman plot, prediction of quintile position and Receiver Operating Characteristic (ROC) Areas Under the Curve (AUC) for a cut-off of <100 mmol of Na/day. In Study 1 (discovery study) with the Tanaka method there were poor correlations between predicted and measured 24-h Na excretions in different ethnic groups and genders ($r_{Spearman}$ from 0.055 [$R^2 = 0.003$] in black women to 0.330 [$R^2 = 0.11$] in white women). The Bland–Altman plots indicated consistent bias with overestimate for low and underestimate for high intakes. ROC AUCs varied from 0.521 to 0.652 with good sensitivity (95–100%) but very poor specificity

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(0–9%). With the Arithmetic extrapolations correlations varied from 0.116 [$R^2 = 0.01$] to 0.367 [$R^2 = 0.13$]. Bias was detected with both Bland–Altman plots and through quintile analyses (underestimate at low levels and overestimate at high levels). Finally, ROC AUCs varied from 0.514 to 0.640 with moderate sensitivity (64–70%) but low specificity (20–53%). In Study 2 (validation study) results were consistent with the discovery phase in white men.
Conclusion: Based on these results, 24-h urinary collection for the measurement of Na excretion remains the preferred tool for assessing salt intake when compared with reported methods based on timed spot urine samples.

Introduction

In steady state conditions, the kidneys handle most of the sodium (Na) eaten in a day, so that the majority (up to 95%) is eventually excreted in the urine in the subsequent 24-h, the remaining being excreted in sweat, saliva and gastrointestinal secretions. The daily renal excretion rate of Na is not constant throughout the 24-h, depending on variables, such as time of day, individual's posture, and neurohormonal influences. A 24-h urinary collection is the gold standard for assessing salt intake through 24-h urinary Na excretion both in individuals and in populations [1]. This method has been used for a long time in physiological, metabolic and epidemiological research. However, particularly for repeated use in large population studies, 24-h urine collections are often deemed inconvenient and alternative methods have been derived [2–4]. Spot and timed urine samples have been suggested as an alternative and several methods have been devised and tested to calculate the daily excretion from partial urine collections [5].

The aim of the present study was to investigate if spot urine can be an acceptable substitute for 24-h urine to estimate group mean 24-h Na in men and women from different ethnic groups (discovery study). The study tested the validity of spot urines applying different methods used in the literature and replicated the analysis in an independent population of white men (validation study).

Data and methods

Study 1 (discovery study)

Participants were selected from general practitioners' registers in the South-West London area, as described in detail elsewhere [6,7] (www2.warwick.ac.uk/go/cappuccio/whss). In brief, the study was a population-based cross-sectional survey of men and women between 40 and 59 years old of three different ethnic groups: northern European origin (whites); West African or Caribbean origin (blacks) and South Asian Indian origin (S Asians). The study was designed so that there were approximately 250 people in each gender and ethnic group stratum. In all 1577 participants were studied between 1994 and 1996. The present analysis includes 915 participants (297 white [131 men], 326 of black African origin [125 men] and 292 South Asian [154 men]) who were untreated and who provided both 24-h urine collections and timed urine samples. The study had ethical approval (EG/CL/92.5.17 and 10/H1211/29) and participants gave their informed consent. The participants were asked to attend a screening unit between 08.00 am and 12.00 noon. They were requested to fast for the 12-h prior to the visit. All attendees were administered a questionnaire, which was used to determine age and ethnic origin. Height and weight were measured and used to calculate body mass index (BMI) (weight/(height)^2). Supine blood pressure (BP) was measured with standardised procedure using an automatic machine as previously described [7]. After the interview participants were asked to collect 24-h urine sample within a few days. They were given written detailed instructions on how to collect complete 24-h urine sample. Complete urine collections were either returned by the participants or were collected at the participant's address. Time and volume of collections were immediately recorded, aliquots taken and stored at −20 °C until assayed. A timed urine collection after an overnight fast was also obtained on the morning of the investigation after the participants had drunk one-to-two glasses of tap water in the morning. Volume (in ml) and duration (in min) of the collection were recorded and specimens were aliquoted and stored at −20 °C until assayed. Urinary Na and creatinine (Cr) concentrations were measured using an automated analyser.

Study 2 (validation study)

The study started in 1975 with periodical follow-up for 30 years and involved the Olivetti factories male workforce in southern Italy (www.olivettiheartstudy.org). Data presented in this study were collected during the 2002–2004 follow-up examination; a total of 148 healthy men, aged 32–75 years were examined, as described elsewhere [8]. The local ethics committee approved the study protocol, and participants gave their informed consent. Body weight and height were measured on a standard beam balance scale. Body weight was measured to the nearest 0.1 kg and height was measured to the nearest centimeter. The BMI was calculated as in Study 1. BP was taken after the subject had been sitting upright for at least 10 min. Systolic and diastolic (phase V) BP were measured with a random zero sphygmomanometer (Gelman Hawksley Ltd., Sussex, UK) three times, 2 min apart. The first reading was discarded, and the average of the last two readings was recorded. A 24-h urine collection was obtained from each participant for the measurement of Na excretion to estimate daily dietary Na intake. On the day before the visit,