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Measurement of urinary constituents and output using disposable napkins

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SUMMARY A procedure for estimating 24 hour urine output in infants using disposable nappies has been validated. In addition, it has been shown experimentally that the urinary concentrations, and hence 24 hour outputs of a range of constituents (sodium, potassium, nitrogen, creatinine, urea, amino acids, and deuterium oxide), may be measured accurately using samples of urine obtained from nappies. It is concluded that the urine collection procedure described has several major advantages over traditional urine bag methods, and has a wide application in clinical practice and research.

Urine is the body fluid most available for clinical monitoring and research in infants. Concentrations and daily output rates of a wide range of natural constituents of urine are measured frequently in clinical practice, and in renal, metabolic, and nutritional studies. There has also been interest in using information on urinary concentrations of harmless substances administered orally, to quantify body composition and aspects of metabolism such as protein turnover.[1 2]

Usually, urine is collected from infants by means of a urine bag, which can be aspirated continually if 24 hour values are required. This procedure is far from ideal; it is difficult to use effectively on girls, frequent monitoring is required, and bag displacement is common, especially in the older mobile infants. In addition, repeated application of bags may cause discomfort and excoriation of the skin. A simple, alternative procedure would be to extract urine from the infants' nappies or from cotton wool balls placed inside the nappy. The effects, however, if any, of these procedures on the concentrations of urinary constituents have received little attention. Moreover, it has not been established whether samples collected in this way could be used to provide information on 24 hour output rates of urine, bearing in mind the inevitable loss of a proportion of samples due to mixing of urine with stools.

In this study we describe a procedure for extracting urine from disposable nappies, and have assessed its effects on the concentrations of a number of urinary constituents. In addition we have investigated whether a nappy collection procedure can be used to measure accurately 24 hour urine output.

Methods

Study 1: effects of a nappy extraction procedure on concentrations of urinary constituents. Urine enriched with 0·01% deuterium oxide (^2H_2O—a stable isotope of water used in studies on growth and body composition) was added in varying amounts (5 to 45 ml) to disposable nappies (Pampers, Proctor and Gamble). Each nappy contained a cotton wool ball to facilitate subsequent extraction of a sample when the urine volume was small. The nappies were sealed in plastic bags and incubated at 34 to 36°C for 0·5 to 10 hours, to simulate a range of normal use. Two nappies were used for each experimental condition. Urine was extracted at the end of the incubation period by compressing the damp fibre from the nappy and wool ball inside a disposable syringe. The extracted urine and a sample of the original solution of urine were stored at −20°C until analysis.

All the urine samples were analysed in duplicate for concentrations of sodium, potassium, phosphorus, nitrogen, creatinine, and urea. In addition, a limited number of samples were also analysed for concentrations of calcium, amino acids, and enrichment of ^2H_2O. Sodium and potassium concentrations were measured using a flame photometer (Instrumentation Laboratory). Creatinine, urea, and phosphorus concentrations were measured by colorimetric methods (creatinine – kit number A-

1421/B, Roche Diagnostica; urea – kit number 124770, Boehringer Mannheim; phosphorus – kit number 89440, Smith Klyne Instruments, USA). Nitrogen concentrations were measured by an automated Dumas procedure (Nitrogen Analyser 1500, Carlo Erba); calcium concentrations by atomic absorption, amino acid concentrations by amino acid autoanalysis (Alpha-plus Model, LKB Biochrom), and ^2H_2O enrichments by mass spectrometry (Aqua Sira Model, VG Isogas). The results are expressed as the mean percentages of values for the original urine solution.

Study 2: measurement of 24 hour urine output. Urine was collected for 24 hours from six well, growing, male preterm infants (birthweight 750 to 1306 g; gestational age 27 to 32 weeks; postnatal age 7 to 46 days; weight at time of study 856 to 1667 g) using a standard 24 hour urine bag. The urine was aspirated from the bag three hourly and weighed. Times of defecation were noted in relation to aspiration times. The infants were weighed at the beginning and the end of the study. Ethical approval and informed parental consent were obtained. The results were evaluated statistically using Student's *t* test for paired values.

Results

Study 1. Table 1 shows the concentrations of urinary constituents in urine extracted from nappies dosed with a single volume (25 ml) of urine and incubated at 34 to 36°C for 0·5 to 10 hours, together with the coefficient of variation for each assay. The concentrations of constituents are expressed as percentages of values for the original urine solution. Incubation did not influence the concentrations of sodium, potassium, nitrogen, creatinine, urea, amino acids, or deuterium oxide. Phosphorus concentrations, however, were 5·9% higher on average than in the original urine solution, and calcium concentrations were 36·7% higher.

Table 2 shows the concentrations of constituents in the urine samples extracted from nappies dosed with a range of urine volumes (5 to 45 ml) and incubated at 34 to 36°C for three hours. Concentrations of sodium, potassium, nitrogen, creatinine, urea, amino acids, and ^2H_2O were within 2% of those in the dose solution. There was no trend in concentration of any of these constituents in relation to the volume of urine in the nappy. As with the previous experiment (above), however, concentrations of phosphorus and calcium were higher than in

Table 2 *Concentrations of constituents of urine extracted from nappies, after incubation of 4 to 45 ml urine at 34–36°C for 3 hours*

Constituents	*Concentration (% concentration before incubation) Urine volume (ml/nappy)*					
	0·5	*15*	*25*	*35*	*45*	*Mean 5–45*
Sodium	101·4	100·0	100·7	100·0	104·2	101·3
Potassium	104·3	98·2	99·1	96·5	97·4	99·1
Phosphorus	108·0	105·4	103·8	107·0	105·2	105·9
Nitrogen	99·1	98·9	100·8	101·1	102·1	100·4
Creatinine	101·8	100·0	100·6	100·7	100·5	100·7
Urea	95·0	100·3	100·4	97·8	102·3	99·2
Calcium*	113·3	—	—	—	126·7	120·0
Leucine*	98·6	—	—	—	99·9	99·3
Lysine*	100·0	—	—	—	100·0	100·0
Tyrosine*	100·0	—	—	—	99·9	100·0
Glutamate*	99·7	—	—	—	100·9	100·5
Deuterium oxide*	99·9	—	—	—	100·0	100·0

*Information not available for urine volumes 15 to 35 ml. Data on other amino acids is available on request.

Table 1 *Effects of 0·5 to 10 hours' incubation in disposable nappies kept at 34 to 36°C on the concentration of urinary constituents*

Constituents	*Coefficient of variation of assay (%)*	*Concentration (% concentration before incubation) Incubation time (hours)*						
		0	*0·5*	*1*	*2*	*3*	*10*	*Mean 0·5–10*
Sodium	1·7	100	102·7	101·3	100·0	102·7	102·7	101·9
Potassium	1·6	100	100·0	100·0	99·1	98·2	99·1	99·3
Phosphorus	2·8	100	97·1	108·5	108·0	106·4	108·5	105·7
Nitrogen	2·0	100	100·1	99·2	99·5	102·8	100·4	100·4
Creatinine	1·8	100	100·8	101·4	101·2	101·4	99·2	100·8
Urea	3·8	100	97·8	101·0	103·5	101·1	98·4	100·2
Calcium*	1·2	100	126·7	—	—	—	146·7	136·7
Leucine*	0·5	100	100·0	—	—	—	99·9	100·0
Lysine*	0·5	100	100·2	—	—	—	99·9	100·1
Tyrosine*	0·5	100	99·7	—	—	—	97·3	98·5
Glutamate*	0·5	100	101·3	—	—	—	101·0	101·2
Deuterium oxide*	0·2	100	99·8	—	—	—	100·3	100·2

*Information not available for incubation periods 1 to 3 hours. Data on other amino acids is available on request.

Table 3 *Urine output of 6 male, preterm infants during 8 consecutive 3 hour periods*

Subjects	*Urine output (g/3 h per kg body weight) Time periods (3 hours each)*								*24 hour urine output (g)*	
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Measured*	*Calculated†*
1	17·5	19·2	21·5	17·8	23·9*	9·5	17·2*	18·1	144·7	138·1
2	15·9	15·6	19·2*	20·1	17·7	18·9	19·5	19·5	146·4	145·4
3	20·7	20·1	18·0	18·9*	16·8	21·0	19·8	18·0*	153·3	155·2
4	12·3*	15·2	18·7	21·0	22·2	14·0*	19·9	22·2*	145·5	155·2
5	21·0	12·6*	18·9	16·8	15·0	20·4*	18·9	20·7	144·3	148·4
6	16·0	10·9	17·8*	16·6	16·0*	18·1	14·8	19·0	129·2	127·2
Mean (SD)	17·2 (3·3)	15·6 (3·6)	19·0 (1·3)	18·5 (1·8)	18·6 (3·6)	17·0 (4·0)	18·4 (2·0)	19·6 (2·0)	143·9 (7·9)	144·9 (10·8)

*Indicates that stools were produced during the 3 hour period.
†24 hour urine output=mean of 3 hour output when defecation did not occur ×8.

the original urine solution (by 5·9% and 20%, respectively).

In a preliminary study, not described here, we showed that a single addition of urine to nappies gave the same results as when the urine was added by multiple dosing with urines of different concentrations (experimentally representing several voidings in each nappy).

Study 2. Table 3 shows the urine output of six healthy, male preterm infants. Urine was aspirated from the bag every three hours for 24 hours and weighed, to simulate a nappy collection procedure in which the nappy was changed regularly. There was a large variation in urine output between the three hour measurements (250% in the case of one infant). There were no significant differences, however, in three hour output rates between periods when defecation occurred and periods when it did not. Urine output over 24 hours was calculated for each infant from the three hourly values when defecation did not occur, and adjusted for the loss of data. These values were not significantly different from the real 24 hour rates of output.

Discussion

The technique described here for extracting samples of urine from infants' nappies has a number of advantages over traditional urine bag systems. In particular, it can be used for prolonged periods of time to collect samples of urine from both boys and girls, requires only minimal supervision, and is completely non-invasive. In a laboratory experiment, we tested the collection procedure over a wide range of urine volumes and incubation times (to simulate different lengths of time a nappy might remain on an infant). Phosphorus and calcium concentrations averaged 5·9 and 28·4% higher, respectively, in the extracted urine samples, suggesting that these minerals were leached from the nappies by the urine. The collection procedure, however, did not influence urinary concentrations of sodium, potassium, nitrogen, creatinine, urea, amino acids, and deuterium oxide. These findings indicate that biochemical analysis of urine collected from nappies is a valid procedure for a wide range of constituents (excluding phosphorus and calcium), provided that evaporation of water in urine can be minimised by careful positioning of the nappy. In a single infant, we assessed the extent of evaporation by using a clean nappy containing a known amount of water. Subsequent reweighing of the nappy showed a loss of water by evaporation of less than 0·4% per hour (the absence of any urine in the nappy was confirmed by nitrogen analysis of a sample of extracted fluid). Thus, significant losses of water from nappies can be avoided during the collection of urine.

The feasibility of using a nappy collection procedure to determine 24 hour urine output was also investigated. Urine volume was measured for 24 hours in six preterm infants using a standard urine bag, and there was no significant difference between the measured amounts and values calculated from three hour outputs for when defecation did not occur. Thus, a nappy collection procedure in which nappies are weighed before and after use can be employed to calculate accurately 24 hour output in infants similar to those investigated here. Information on urine weights should be taken only from those nappies that do not contain stools, since it is not possible to differentiate between urine and faecal liquid in the soiled nappies. If urine samples are extracted from the nappies at the time of reweighing and the samples pooled in proportion to the weight of urine in the nappy, information can also be obtained on 24 hour output rates of constituents of urine.

The largest error we incurred by calculating 24 hour urine output was 6·7% (compared with the measured value), and this occurred in the infant

with the greatest number of bowel actions (three per day). Thus, it is likely that our method will be less accurate than reported here if it is used in those infants with four or more bowel actions per day. In these cases, information could still be valuable for groups of subjects, or accuracy might be improved by extending the duration of the measurement period. Several groups of workers, however, have reported that the mean stool frequency in infants and young children is in the range one to two per day, with 97% of young children less than three per day.[3–5] These observations suggest that our method for measuring urine output may have wide application.

In summary, our study has indicated that an accurate alternative to the use of urine bags in infants is extraction of urine from nappies. This procedure can be used to determine accurately urine output over long periods of time.

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References

[1] Jackson AA, Shaw JCL, Barbar A, Golden MHN. Nitrogen metabolism in preterm infants fed human donor breast milk: the possible essentiality of glycine. *Pediatr Res* 1981;**15:**1454–61.
[2] Pencharz PB, Masson M, Desgranges F, Papageorgiou A. The effects of post-natal age on the whole body protein metabolism and the urinary 3-methyl histidine excretion of premature infants. *Nutr Res* 1984;**4:**9–19.
[3] Wolman IJ. *Laboratory applications in clinical pediatrics*. New York: McGraw Hill, 1957:696–7.
[4] Lemoh JN, Brooke OG. Frequency and weight of normal stools in infancy. *Arch Dis Child* 1979;**54:**719–20.
[5] Weaver LT, Steiner H. The bowel habit of young children. *Arch Dis Child* 1984;**59:**649–52.

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