The use of osmolarity in lieu of creatinine to express urinary rations in nutritional field studies*

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SUMMARY

A urinary ratio for the use in nutrition surveys is described using osmolarity in lieu of creatinine as a reference.

Two diverse nutritional groups of African children were studied, one group of 20 poorly nourished children of squatters and one control group of 17 well nourished children from an orphanage. A comparison of total urinary solute output and creatinine excretion in three hour periods revealed a highly significant difference in creatinine excretion while the solute output showed a similar level in both groups. Consequently the difference in nutritional status was better reflected by the urea osmolarity ratios than by the urea creatinine ratios.

INTRODUCTION

Since Folin (1) published his paper on the creatinine excretion in urine, its content in 24 hour urine samples has been taken as a check on the accuracy of collection. This is based on the assumption that the creatinine excretion from day to day in an individual is constant, independent of diuresis and little affected by diet. This constancy of urinary creatinine

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excretion in an individual has also been assumed true for short term collection periods since the publication of Schaffer (2).

Since it is usually impossible to obtain either 24 hours urine or accurately timed urine samples under field conditions and particularly of children under 2 years of age, nutritional workers prefer the use of single random urine samples. The excretion of urinary compounds in these random urine samples are then usually expressed per gram creatinine in so called creatinine ratios. The advantage would be that the effect of irregularity of urine collection is annulled, again assuming a constant creatinine excretion over the day and from a day to day basis. This practice of using creatinine ratios has become increasingly popular with nutritional workers and has been extended to population groups since the success of its use in a survey in Newfoundland by Adamson (3).

Unfortunately this assumed constancy of creatinine excretion is far from reliable. A closer look at Folin's own data shows a 14 to 34 per cent variation of daily output in the same person. More recent investigations by Vestergaard (4) on the constancy of urinary creatinine excretion over short collection periods have revealed a variation in one person from hour to hour which frequently exceeds 100 per cent. It is not clear what causes this variation in creatinine excretion. The influence of preformed dietary creatinine on the urinary excretion seems to be of importance only when large amounts of meat are consumed (5). Bleiler and Schedl (6) sate that the use of creatinine excretion as a reference in interpreting the excretion of other urinary constituents may be invalid when based on single or random urine samples.

The level of urinary creatinine excretion is generally agreed to be dependent on muscle mass (7). as was already stated by Folin. This relation with muscle mass is said to be an edditional advantage and an argument in favour of creatinine ratios as the use of a creatinine reference tends to correct for the size of the individual (8). In contrast with Lowry's opinion authors hold the dependence of creatinine excretion on total muscle mass more as a disadvantage than as an advantage in nutritional surveys. Since total muscle mass is dependent on the protein intake the absolute creatinine excretion will vary parallel to protein intake.

This increases unduely any urinary creatinine ratios in poorly nourished populations with poor muscle development when compared with those or normal muscular development. Therefore we wish to report on an alternative way to express the excretion of urinary compounds, which seems to be less dependent on muscle development.

MATERIALS AND METHODS

Subjects

The sample included 20 children of squatters on the slopes of Mount Kenya on a poor diet (group B) and, as controls, 17 children in a Nairobi orphanage on a good quality diet (group A).

Methods

At the beginning of the collection period at 7 a. m. all children emptied their bladder completely and again after three hours. No food was allowed prior to and during the collection of the timed urine samples. To procure sufficient quantities of urine a calorie free drink of 10 ml per kg body weight was given to each child. The volume of each three hour urine collection was measured. Between 5 and 10 ml were transferred to small containers for the determination of the osmolarity. The rest was acidified to about pH 3 and stored together with the non-acidified samples at —20°C until examined.

Weight and age were also recorded. Weight for age was calculated using Harvard Standards (9).

Chemical Methods

Creatinine was estimated in an autoanalyzer using the method of Folin and Wu (10). Urea was determined also in the autoanalyzer applying a method described by Wootton (11). The osmolarity of each sample was determined by boiling point elevation (12). The apparatus used consisted of two semi-micro ebulliometer vessels with heating elements and cold finger drainage, two thermistors, a Wheatstone bridge and a galvanometer*. One of the ebulliometer vessels was filled with the sample while the other was kept boiling con-

* Apparatus as supplied by Gallenkamp (MW-140, MW-145).

tinuously with distilled water to correct directly for barometric pressure changes. Between 5 and 10 ml samples were required. To achieve an even boiling point, i. e. to avoid super-heating, a few antibumping granules and 4 drops of highly, diluted Brij-35 (10 drops Brij-35 in 50 ml of distilled water) were added to each specimen. A standard curve was obtained by measuring the difference of the resistance of the two thermistors at the boiling point of known concentrations of sodium chloride solutions. The osmolarity of each urine sample was eventually calculated from this curve, which was linear op to 1.0 osmol.

Results

The difference in the nutritional status between the two groups of children studied is obvious from the average weight per age per group (Table 1 and Figure 1). The poorly nourished children of group B were, with 83.8 per cent of the Harvard Standard, significantly more under weight than the children of the control group A, who almost reached the standard level with 95.5 per cent.

TABLE 1

COMPARISON OF WEIGHT FOR AGE IN 17 WELL NOURISHED (GROUP A) AND IN 20 POORLY NOURISHED CHILDREN (GROUP B)

Weight for Age	Group A		Group B
Mean	95.5%		83.8%
S D	8.4%		9.5%
Significance level		$p<0.001$	

TABLE 2

A COMPARISON OF THE TOTAL SOLUTE AND CREATININE EXCRETION IN THREE HOUR PERIODS AND OF THE RESPECTIVE UREA RATIOS IN 17 WELL NOURISHED (GROUP A) AND IN 20 POORLY NOURISHED CHILDREN (GROUP B)

	Group A			Group B			Significance level
	Mean	SD	Coeff. of variation %	Mean	SD	Coeff. of variation %	
V. O.	23.3	7.9	33.9	24.5	8.0	32.7	n. s.
V. C.	30.9	9.9	32.0	22.0	7.2	32.8	$p<0.010$
$\frac{U}{O}$	22.3	7.3	32.5	9.9	3.6	36.1	$p<0.001$
$\frac{U}{C}$	16.3	5.5	33.6	10.9	3.2	29.3	$p<0.005$

V = volume in ml

O = osmolarity in mOsmol/ml

C = creatinine in mg/ml

U = urea-nitrogen in mg/ml

V. C. = creatinine excretion in mg/3 hours.

V. O. = total solute excretion in mOsmol/3 hours.

$\frac{U}{O}$ = urea-nitrogen excretion in mg per mOsmol solute.

$\frac{U}{C}$ = urea-nitrogen excretion in mg per mg creatinine.

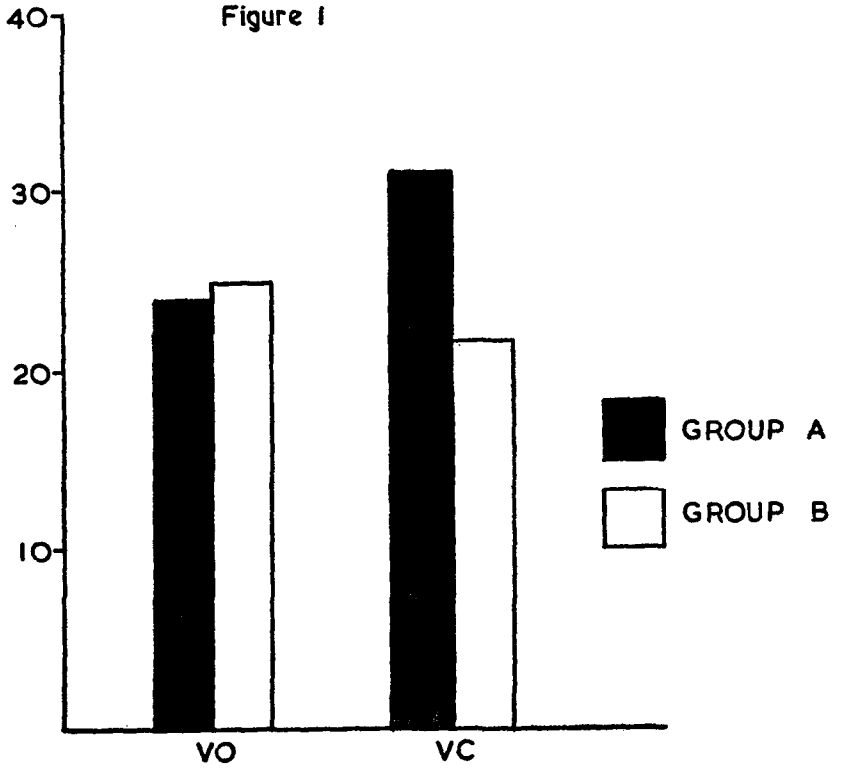

Figure 1

A comparison of the average three hourly excretion of total solutes in mOsmol and of creatinine in mg in 17 well nourished (group A) and in 20 poorly nourished children (group B).

V. O. = total solute excretion in mOsmol per 3 hours.
V. C. = creatinine excretion in mg per 3 hours.

To determine the absolute creatinine excretion over three hours the volume of each urine obtained was multiplied by the urinary creatinine concentration (V.C.). The mean creatinine excretion amounted to only 22.0 mg in the group of poorly nourished children (group B) while the excretion in the control group (group A) was with 30.9 mg significantly higher ($p<0.001$). On the other hand the product of urine volume and its osmolarity (V.O.), i. e. the total solute excretion, was

with 24.5 mOsmol for Group B and 23.3 mOsmol for Group A highly similar (see also Table 2 and Fig. 1). As an example for the relevance of these findings to nutrition surveys the urea-nitrogen/osmolarity and urea-nitrogen/creatinine ratios were calculated, as indicators of protein intake (13) Table 2 and Fig. 2 demonstrate that the clear cut difference of nutritional status between group A and group B is most obvious when the urea-nitrogen/osmolarity ratio is used.

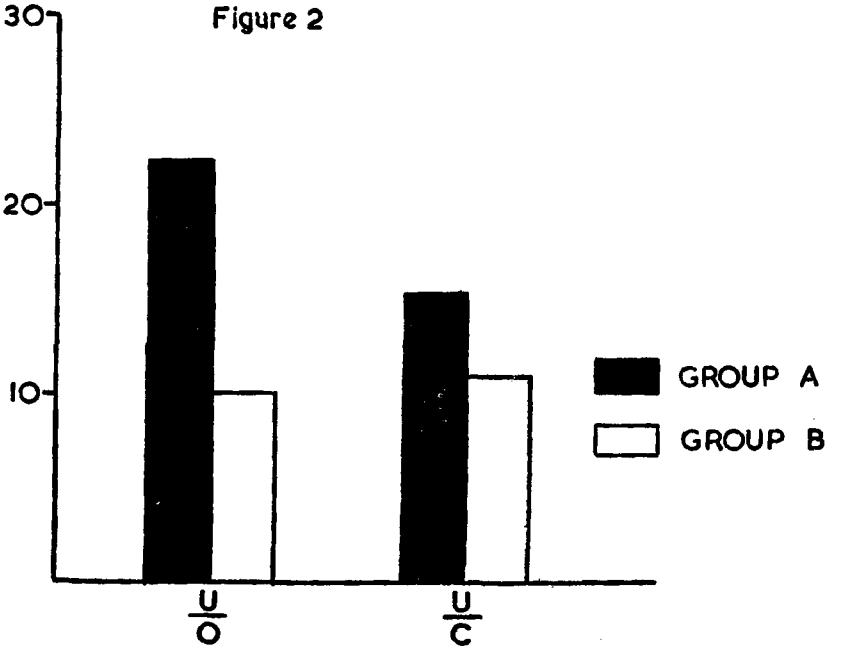

Figure 2

A comparison of the average urea osmolarity ratio with the average urea creatinine ratio in 17 well nourished (group A) and in 20 poorly nourished children (group B).

$\frac{U}{O}$ = Urea-nitrogen excretion in mg per mOsmol total solute (urea-osmolarity ratio).

$\frac{U}{C}$ = Urea-nitrogen excretion in mg per mg creatinine (urea-creatinine ratio).

DISCUSSION

The total solute excretion in a three hour period gave almost the same results in malnourished children (Group B) as in normal controls (Group A), while the creatinine excretion was clearly reduced in the group of malnourished children. It is evident that urinary compounds expressed in ratios with creatinine as the denominator will be relatively too high in malnourished children, due to this low level of creatinine excretion.

Expressing urinary constituents as concentration ratios with the osmolarity as the denominator apparently has the advantage over creatinine ratios of being less dependent on body weight. Osmolarity ratios therefore seem to be of value in nutrition surveys provided the total solute intakes are similar. The variability of osmolarity ratios was not greater than that of creatinine ratios in our study (Table 2).

It should however be mentioned that the constancy of the total solute excretion in a given period is like creatinine not entirely independent of diet. The osmolarity of urine is to a large proportion influenced by the intake of electrolytes and to a lesser extent by nitrogen containing compounds. Considering the large endogenous variations in creatinine excretion and its dependence on muscle mass, osmolarity ratios might be of value in nutritional field studies, provided the intake and output of electrolytes are well balanced and constant as it is in most communities in developing countries where nutritional surveys are done. Excessive mineral intake seldom occurs. The method for the determination of the boiling point elevation is simple and very accurate. The volumes required have to be measured only approximately. Disadvantages are the relatively large volumes required and the fact that the urine cannot be used for other estimations after boiling. It should be possible to obtain similar results by the determination of the specific gravity as suggested by Luyken (13) though this is less accurate or by determining the freezing point depression which would however not take account of those compounds that are insoluble at low temperatures. The refractometric determination of total solutes in urine as described by Rubini and Wolf (14) might also be accurate and simple.

Though the suggested method of expressing urinary compounds as osmolarity ratios gave very promising results in our study, further investigations in other parts of the world under different nutritional and climatic conditions are essential before its application on a comprehensive scale.

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RESUMEN

El uso de la osmolaridad en reemplazo de la creatinina para el cálculo de la excreción de nutrientes en la orina y su empleo en estudios nutricionales de campo

Se describe el uso de una relación para el cálculo de nutrientes excretados en la orina, empleando la osmolaridad como referencia en lugar de la creatinina. El método se aplicó en dos grupos de niños africanos; uno estaba integrado por 20 niños, hijos de colonos, ubicados en las laderas del Monte Kenya y sometidos a una alimentación deficiente, y el grupo control constituido por 17 niños de un orfanato de Nairobi, alimentados adecuadamente.

Se observó una diferencia significativa entre la excreción de creatinina durante un período de 3 horas, mientras que la excreción total de soluto en la orina mostró niveles similares en ambos grupos. En consecuencia, la diferencia entre el estado nutricional se evidencia mejor con la relación urea/osmolaridad que con el uso de la relación urea/creatinina.

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