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Validity of routine clinical test weighing as a measure of the intake of breast-fed infants

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SUMMARY Routine clinical test weighing was carried out on 100 bottle-fed infants to assess the accuracy of the procedure; the feed intake was measured by weighing the feeding bottles before and after feeding. Test weight was found to be an unreliable indication of feed weight, underestimating the amount of feed actually taken at test weight values below 60 g, and overestimating the amount of feed taken at test weights over 60 g. The errors were largest in infants having test weights at the extremes of the range. Test weighing with clinical baby scales is an unreliable and inaccurate indication of feed intake in breast-fed infants.

Test weighing (test feeding) is used to determine an infant's breast milk intake by weighing the infant before and after feeding without changing the napkin or otherwise altering the infant's clothing. Its origins are obscure, but Pièrre Budin[1] used the technique not only to determine feed intake but also to measure lactation of his wet-nurses. In the past test weighing has provided nutritional data on breast-fed infants[2 3] but more recently doubts have been cast on its accuracy and desirability.[4] The technique remains familiar to all midwives, and it is described in midwifery textbooks and practised widely, if sporadically, in Britain today.

It would be helpful in small infants, when sucking is just beginning, to know how much milk has been taken from the breast at any one feed so that supplementation can be provided in an attempt to promote optimal growth.[5] Because of our anxieties about the use of test weighing in this role and because, like Culley *et al.*,[6] we could find no formal validation of the technique, it was decided to investigate the accuracy of test weighing as a measurement of feed intake.

Materials and methods

Test weighing was carried out in the Special Care Baby Unit, Jessop Hospital for Women, Sheffield on 100 bottle-fed infants who required special care for a variety of reasons. All patients were test weighed in the usual manner[3] by midwives, student midwives, nursery nurses, and mothers with supervision using standard Salter 'Trent' baby scales. The difference in the infant's weight before and after feeding so determined was designated test weight (TW). The bottles were weighed before and after feeding using a Metler automatic laboratory balance which the test weighers found no difficulty in learning to use. The difference in the bottle weights before and after feeding was designated feed weight (FW). Patients were omitted from the study if they vomited, had any urinary or stool losses not contained within the napkin, or if there was accidental loss of milk between weighings.

Results

A preliminary experiment was carried out to assess the systematic weighing errors of the baby scales and laboratory balance. Five 'unknown' weights (baby feeding bottles containing different amounts of milk for the laboratory balance; and bags of salt weighing between 1:8 and 4:4 kg for the baby scales) were each weighed blind by 25 different test weighers and the results recorded by an independent observer. From these results an estimated systematic weighing error was calculated for FW and TW as 1 standard deviation of the difference of two weights, analagous to the procedure used in test weighing. The estimated systematic weighing error was 0·14 g for FW and 9·6 g for TW.

One hundred test weighings were carried out but in four pairs of results the TW was more than twice the FW. The test weighers considered these results to be obviously wrong, even without knowing the FW value, and they were therefore excluded from further

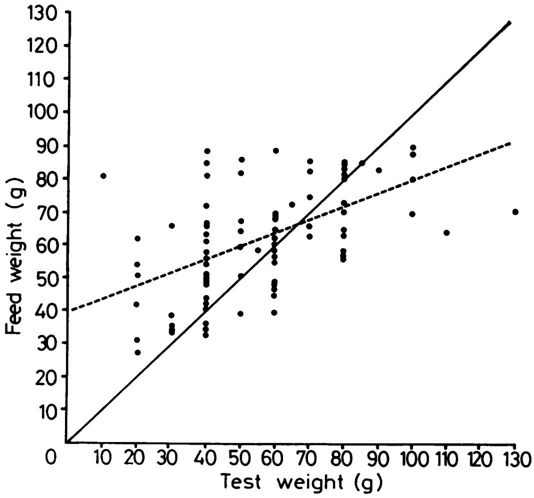

Figure *Scattergram of FW against TW. Linear regression FW = 39·14 + 0·40 TW is denoted by dotted line and the line of identity FW = TW by continuous line.*

calculations. The remaining 96 TW values are shown in the Figure plotted against the corresponding values of FW.

Only 31 of the TW values were within ± 10% of the corresponding FW value, 51 were within ± 20% of the FW value, and 10 exceeded ± 30% of the FW value. There was an overall tendency for TW to underestimate FW and 42 of the TW values underestimated FW by more than 10%, while 23 of the TW values overestimated FW by more than 10%. The scatter of the population of TW values was wider than that of the FW values; FW ranged from 31·1 to 100·7 g compared with TW which ranged from 10 to 130 g.

The linear regression of FW on TW:

FW = 39·14 + 0·40 TW ($r=0·56$) differed significantly ($P<0·001$) from the line of identity: FW = TW.

Discussion

The preliminary evaluation of the accuracy of the two types of weighing shows the systematic weighing error for FW to be 14·6% of that for TW. FW can therefore be considered a valid yardstick against which to evaluate clinical test weighing. Blind weighing of inanimate objects on the baby scales can be expected to assess inaccuracies caused by imprecision of the baby scales and observer error. In clinical test weighing however, additional sources of error may operate—such as unrecognised losses from the napkin, or movement of a restless, hungry infant during weighing. The systematic weighing error for TW as determined by the above method is therefore likely to be an underestimate of that for clinical test weighing.

Although greater precision is possible using a sophisticated electronic balance,[7] our purpose was to investigate the accuracy of routine test weighing in the clinical context, rather than as an optimised research procedure.

The TW values clustered at 10 g intervals (Figure) owing to difficulties recording differences less than 10 g with the baby scales; and there was a wide scatter of FW values in infants who, by virtue of their identical TW values, were deemed clinically to have taken the same amount of milk (for example TW = 40 g; FW = 32·5–88·4 g; Figure).

The regression of FW on TW is significantly different from FW = TW indicating that TW exhibits systematic bias as a measure of feed intake (FW), underestimating FW at low values of TW and overestimating FW at high values of TW. The magnitude of the error is smallest at TW values around 60 g.

This finding is a result of the wider scatter of the population of TW values than that of the population of FW values. An individual TW value will deviate further from the TW population mean than the corresponding FW value from the FW population mean. This tendency leads to progressive underestimation of FW by TW as TW falls further below the population mean, and progressive overestimation of FW by TW as TW increases above the population mean.

Regression analysis shows that body weight *per se* does not greatly influence the precision of test weighing.

In their preliminary validation of test weighing on 115 artifically-fed infants, Culley *et al.*[6] measured FW volumetrically, and all TWs were determined by one observer. They obtained a larger coefficient of correlation ($r=0·83$) between TW and FW although a regression relationship was not evaluated. Their results, like ours, show considerable scatter (for example, FW = 60 ml, TW = 21–90 g, n = 32).

It has been said that 'test feeding must be done for 24 hours to get a day total or else it might as well not be done . . .'.[3] This is generally done to take account of variations in feed volume taken at different feeds at different times of day,[1–3] and to attempt to reduce the error by increasing the number of observations made. From the above results, it would appear that the errors would tend to cancel each other if a series of TW values around 60 g was obtained, or if a group of measurements below 60 g (underestimates) was compensated for by a similar number of observations of over 60 g (overestimates). A 24-hour series of test weighing results of values on each occasion below 60 g however, could increase the errors leading to gross underestimate of the feed intake. Most clinicians would be critical of a laboratory measurement where, in addition to a physiological 'reference range', there was a procedural error of 20–30% or more. This high level of error may reflect a loss of skill in the technique of test weighing during the last 20 years by our nursing staff, perhaps owing to the pressures of modern technology on neonatal care.

Conclusion

We have found routine clinical test weighing using standard baby scales to be a poor indication of feed intake, the errors being smallest in infants who appear to take about 60 g of feed. The availability of a sophisticated electronic balance taking a mean of a number of weights in quick succession[7] would give more accurate results, and methods such as deuterium enrichment of saliva[8] are unsuitable for anything other than research. Without these sophisticated aids the best guide to adequate nutrition of the breast-fed small infant must remain adequate growth.

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