Is measuring postnatal symphysis-fundal distance worthwhile?

Elizabeth R. Cluett, Jo Alexander and Ruth M. Pickering

Objective: **to assess levels of intra-observer and inter-observer variability in the measurement of postnatal symphysis-fundal distance and establish whether the measurement is sufficiently precise for it to be of use in clinical practice.**
Setting: **a consultant obstetric maternity unit in the south of England which caters for approximately 6000 deliveries per annum.**
Methods: **in the intra-observer study 15 midwives took repeated readings of symphysis-fundal distance on 30 postnatal women. In the inter-observer study 13 midwives took readings of symphysis-fundal distances on 24 postnatal women. Repeatability coefficients (the variability to be expected in the change between two measurements) were calculated.**
Findings: **the repeatability coefficient, that is the maximum difference that is likely to occur, 95% of the time, for the difference between two measurements obtained by the same midwife on the same woman is 2.94 cm (intra-observer study). Where measurements are obtained by different midwives on the same mother the repeatability coefficient is 5.01 cm (inter-observer study). In everyday clinical practice variability is likely to be greater than that found in this study.**
Implications for practice: **the daily measurement of the postnatal symphysis-fundal distance with a tape measure cannot be obtained with enough precision to be useful in making clinical judgements and therefore should be discontinued. Further research is required to assess the value of routine palpation of the uterine fundus to assess involution during the postnatal period.**

Elizabeth R. Cluett
MSc, RGN, RM, PGCEA, Midwife Teacher, Southampton University, College of Nursing and Midwifery
Jo Alexander
PhD, RGN, RM, MTD, Principal Lecturer in Midwifery, University of Portsmouth, Portsmouth, UK
Ruth M. Pickering
BSc, MSc, PhD, Lecturer in Medical Statistics, University of Southampton, Southampton, UK
(Requests for offprints to ERC)

Manuscript accepted 22 June 1995

INTRODUCTION

The postpartum assessment of uterine involution is considered important in screening for retained products of conception and/or uterine infection and thus predisposition to secondary postpartum haemorrhage is also assessed. Daily measurement of the abdominal distance between the upper border of the symphysis pubis and the top of the uterine fundus (symphysis-fundal distance or S-FD) may be part of the screening process, though the recording of this measurement is not universal practice. The pattern of postnatal care varies greatly from one country to another (Rush et al 1989). In the UK postnatal care by the midwife continues for a minimum of ten days and this facilitates the undertaking of regular screening procedures, such as measuring the S-FD. This may not be possible in other countries, however, the use of measuring the S-FD as a screening tool has been researched in France (Buisson et al 1993) and in Mozambique (Bergstrom & Libombo 1992). In some maternity units in the UK midwives only observe the lochia and palpate the uterine fundus. In normal postpartum women it is traditionally expected that there will be a daily decrease in S-FD of approximately 1 cm (Sweet 1988). In measuring S-FD midwives are attempting to distinguish a group of women where this daily decrease in S-FD is reduced or absent.

The measurement of postnatal S-FD to screen for abnormal uterine involution can be traced back to 1895 when the practice was advocated as an important aspect of the doctor's postnatal examination. If this measurement was abnormal then surgical exploration of the uterus was recommended (Stevens & Griffith 1896). More recently several authors (Beischer & MacKay 1986, Sweet 1988, Miller & Callander 1989) recommend the measuring the S-FD as part of routine daily postnatal midwifery care. They do not describe exactly how this measurement should be obtained, whether it can be made with precision, or describe the normal pattern of uterine involution to be expected.

Several sources of variability combine to make measuring the S-FD imprecise. It may be difficult to locate the upper and lower landmarks used for the measurement and some imprecision can be expected from taking readings from tape measures. As S-FDs are measured to detect abnormally slow rates of decline in the height of the uterine fundus it is necessary to consider the variability inherent in the change between two readings, compared with expected daily falls in S-FD. In clinical practice successive measurements are often taken by different midwives, and this adds a further, potentially large, source of variation.

The general lack of research underpinning postnatal care was highlighted by Rush et al (1989), while the Report by the Expert Maternity Committee also suggested that some traditional midwifery observations need to be properly evaluated (Department of Health 1993). In relation to the assessment of uterine involution the lack of research has been commented upon by Cook (1992), Montgomery and Alexander (1994) and The Cochrane Collaboration Group (1994). Two studies consider the value of postnatal measurement of the S-FD. Bergstrom and Libombo (1992) concluded that uterine involution can be assessed by simple anthropometry: Buisson et al (1993) found good correlation between S-FD measurements and those obtained by ultrasound. However, there are methodological difficulties with both studies. In addition neither study examined the predictive and preventative value of the measurement, or looked at the accuracy with which the measurement can be obtained.

Since no compelling evidence was found that midwives can measure the S-FD postnatally with precision, it was decided to investigate:

1. intra-observer variability (the variability occurring between measurements obtained when one observer measures the same subject several times);
2. inter-observer variability (the variability occurring between measurements obtained when several observers measure the same subject);
3. repeatability which is the variability that might be expected in the change between successive measurements when measured by the same or different midwives.

METHODS

The study received approval from the local ethics committee. Consultant obstetricians and midwifery managers agreed to women in their care being approached to participate in the study.

Inclusion criteria

The participating women met the following criteria:

1. a spontaneous or instrumental vaginal delivery;
2. a delivery between the 37th and 42nd completed weeks of gestation;
3. a singleton baby, a healthy baby being cared for primarily by his/her mother in the postnatal ward;
4. a well woman who was, in the opinion of the midwife in charge, primarily self-caring and able to understand the proposed research.

These restrictions were imposed largely to avoid disturbing women who were already stressed.

Sample

A convenience sample of women who were in the postnatal wards was approached to take part in the study by the investigator. They were given written information about the study, the opportunity to ask questions and time to consider their response. No woman participated in more than one part of the study. The midwives were volunteers recruited by the investigator.

Detailed written instructions were given to each midwife specifying: the position of the woman; landmarks between which the measurement should be taken (with a diagram); that the woman should have emptied her bladder within the last 30 minutes; and the manner in which the tape measures should be marked and stored. The comfort and dignity of the women was to be paramount at all times. A separate, inverted strip of a paper tape measure was used for each measurement. The paper tapes were pre-coded for both the woman and the midwife, and were put into coded envelopes at the woman's bedside after the measurement was taken. At the completion of the study the prime investigator (EC) measured each paper tape against a metal ruler marked in centimetres.

A pilot study was conducted after which the clarity of the information letter given to the women, and the instruction sheet given to the midwives, was improved. The pilot study also indicated that there were insufficient hand washing facilities for the inter-observer variability study. A number of hand cleansing sprays were made available for the main study.

A body mass index (BMI) – based on the woman's first antenatal weight and height, the normal non-pregnant range for which is 20–25 inclusive (Thomas 1994) – was calculated for each woman. This was obtained because anecdotal evidence suggests that measurement variability increases with increasing BMI because precise location of any landmarks becomes more difficult. Data from the inter-observer studies were used to compare maternal BMIs against the standard deviation of repeated measurements.

Study design

Intra-observer study

Five midwives each measured the S-FD of one woman ten times. It was decided to carry out ten repeats to limit the disturbance to the women. This number is somewhat larger than the number of repeats used to assess intra-observer variability of the antenatal measuring of the fundal height (Calvert et al 1982, Bailey et al 1989).

In everyday practice women are not repeatedly measured in quick succession. A midwife usually measures several other women before perhaps making a second observation on a woman. This situation was simulated by repeating the measurements with five other midwives each measuring two women alternately until each woman had been measured ten times; and again with five more midwives measuring three different women in rotation ten times. This allowed an evaluation of whether the number of women measured in rotation, and hence the time interval between repeated measurements, influenced the magnitude of intra-observer variability.

No woman was measured more than ten times or by more than one midwife. A series of ten consecutive measurements on one woman took approximately ten minutes; when two, then three women were measured in rotation, the measurements took 15–25, and 30–45 minutes respectively. Due to the time commitment involved, the study was not repeated with larger numbers of women measured in rotation.

Inter-observer study

Study one. Thirteen women participated. The women, who were situated in many rooms across two postnatal wards, were temporarily relocated to one of four rooms so that there were three or four women to each room. Six midwives measured each of the women in the first room once, then undertook a second measurement on the women in that room, in the same order as they had made the first measurements. These women were then able to resume their normal activities and the midwives moved on to the next room of women and undertook measurements on that group of women in a similar manner.

Study two. In order to increase the sample size of the inter-observer study, the process was repeated six weeks later. The second inter-observer study involved seven midwives and 11 women, who were again relocated to one of three rooms during the study. The midwives obtained the measurements on these women in the manner described above.

Assessing variability

Intra-observer study

Variability in the intra-observer study is due to measurement error alone as the woman and midwife are the same for repeated readings. The variability across repeated measurements was assessed by calculating the variance over repeated measurements for each woman (this source of variation is labelled σ^2_{repeat}), from which the standard deviation (SD) can be calculated as the square root of the variance. When observations are normally distributed, 95% of the time repeated readings will lie between ±2*SD of the true underlying mean value.

Repeatability coefficients were calculated for the three groups of women; (those where each midwife measured only one woman; where each midwife measured two women and where each midwife measured three women in rotation). These repeatability coefficients are given by 2*√2*SD and give the maximum difference likely to occur between two repeated measurements by the same midwife on the same woman 95% of the time (British Standards Institute 1979).

Reliability coefficients were also calculated. These are based on the spread of the true values for women in the study measured by the variance (labelled σ^2_{woman}), that is the estimated variability across the women if they were measured without error. The total variability of the measurement is the sum of the two components, $\sigma^2_{\text{woman}} + \sigma^2_{\text{repeat}}$.

The reliability coefficient, R, is given by:

$$R = \frac{\sigma^2_{\text{woman}}}{\sigma^2_{\text{woman}} + \sigma^2_{\text{repeat}}}$$

Thus, R is the proportion of the total variability that is due to true variation across women. A large value for R indicates that the variability over repeated measurements is small in relation to the total variability. Estimates of σ^2_{woman} and σ^2_{repeat} were obtained from ANOVA using the ten repeated readings for the women within each group. The effect of the number of women measured in rotation was investigated by comparing average levels of the variances from individual women between the three groups using ANOVA.

Inter-observer studies

In these studies variability in the measurement of S-FD can come from several sources, each source providing a component to the variance. Firstly, as with the intra-observer study, there is the component due to variability across the women's true values (this source of variation is labelled σ^2_{woman}). The component due to the variability across repeated measurements on the same woman by the same midwife is the variance over repeats (σ^2_{repeat}). There is also the possibility that midwives vary in how they take measurements on the same woman, and this is represented by a new component, ($\sigma^2_{midwife}$). If the impact a particular midwife has on variability of measurement is simply to lower or raise her readings by the same amount relative to the true value for all the women she measures then the variance components σ^2_{woman}, $\sigma^2_{midwife}$ and σ^2_{repeat}, adequately describe the situation. If, as is most likely, the impact of the midwife varies depending on the particular woman she is measuring then another component needs to be considered, $\sigma^2_{woman*midwife}$ (Healy 1989).

The reliability coefficient is the true variance across mothers, (σ^2_{woman}) as a proportion of total variance, (the sum of all components). Thus, R is given by:

$$R = \frac{\sigma^2_{woman}}{\sigma^2_{woman}+\sigma^2_{midwife}+\sigma^2_{woman*midwife}+\sigma^2_{repeat}}$$

Repeatability coefficients were also calculated for the inter-observer study. The maximum difference likely to occur between two measurements taken by different midwives on the same woman 95 % of the time is given by:

$$2*\sqrt{2}*\sqrt{\{\sigma^2_{midwife} + \sigma^2_{woman*midwife} + \sigma^2_{repeat}\}}.$$

If the two measurements are taken by the same midwife then the measurements are likely to differ by up to $2*\sqrt{2}*\sqrt{\sigma^2_{repeat}}$. In both cases the appropriate SD used to calculate repeatability is derived from the components causing measurements to vary. Using the statistical package SAS (SAS Institute Inc. 1985), TYPE1 estimates of variance components for the inter-observer studies were obtained from procedure VARCOMP. The two inter-observer studies were then analysed simultaneously to obtain combined estimates.

Midwives suggested an actual decrease in uterine size, due to uterine contraction resulting from repeated palpation, and the difficulties of measuring women with large BMIs as possible explanations for the degree of variability found. To investigate the first of these possibilities the mean S-FD for each woman, calculated from all the first measurements obtained by the midwives on that woman, were compared to the mean S-FD for the same woman, calculated from all the second measurements made by the midwives, using a paired *t*-test. To investigate the second possibility, Spearman correlation coefficient was calculated to assess the relationship between the woman's BMI and the SD of the S-FD of all the readings taken on that woman.

FINDINGS

Intra-observer study

The spread of readings obtained from three women measured in rotation by one midwife are shown in Figure 1. It can be seen that repeated measurements lay between approximately 0.5–4cm on either side of their mean value. The intra-observer study for the three groups of mothers, the group measured on their own, and those where two or three women were measured in rotation are shown in Table 1.

The term σ^2_{repeat} estimates the variance over repeated measurements. Although there was a higher variance when three women were measured in rotation there were no statistically significant differences between the groups (P=0.262). The term σ^2_{woman} was also larger when three women were measured in rotation because the group contained two women with large mean S-FDs of over 18 cm. The repeatability coefficients show that up to 2-3 cm difference may be expected when two repeated readings are taken. The reliability coefficients seem high, but these relate the precision of a single measurement to the spread of values of S-FD in the total sample. In clinical practice we are interested in the change between two daily readings and the repeatability coefficients show the variability that can be expected.

Inter-observer study

The first measurement obtained by each midwife on each woman, in the first inter-observer study are plotted in Figure 2 where each midwife is represented by a different symbol. A tendency for some midwives to obtain measurements which are predominantly at the top

Table 1 Variance components; reliability coefficients; and repeatability coefficients from intra-observer study when different numbers of women were measured in rotation

	Number of women measured in rotation		
	1	2	3
σ^2_{woman}	5.82	3.52	10.73
σ^2_{repeat}	0.63	0.53	1.08
Reliability coefficient	97.4%	86.9%	90.79%
Repeatability coefficient 95% range for difference between two measurements on same woman – 2*√2*SD	2.24cm	2.06cm	2.94cm

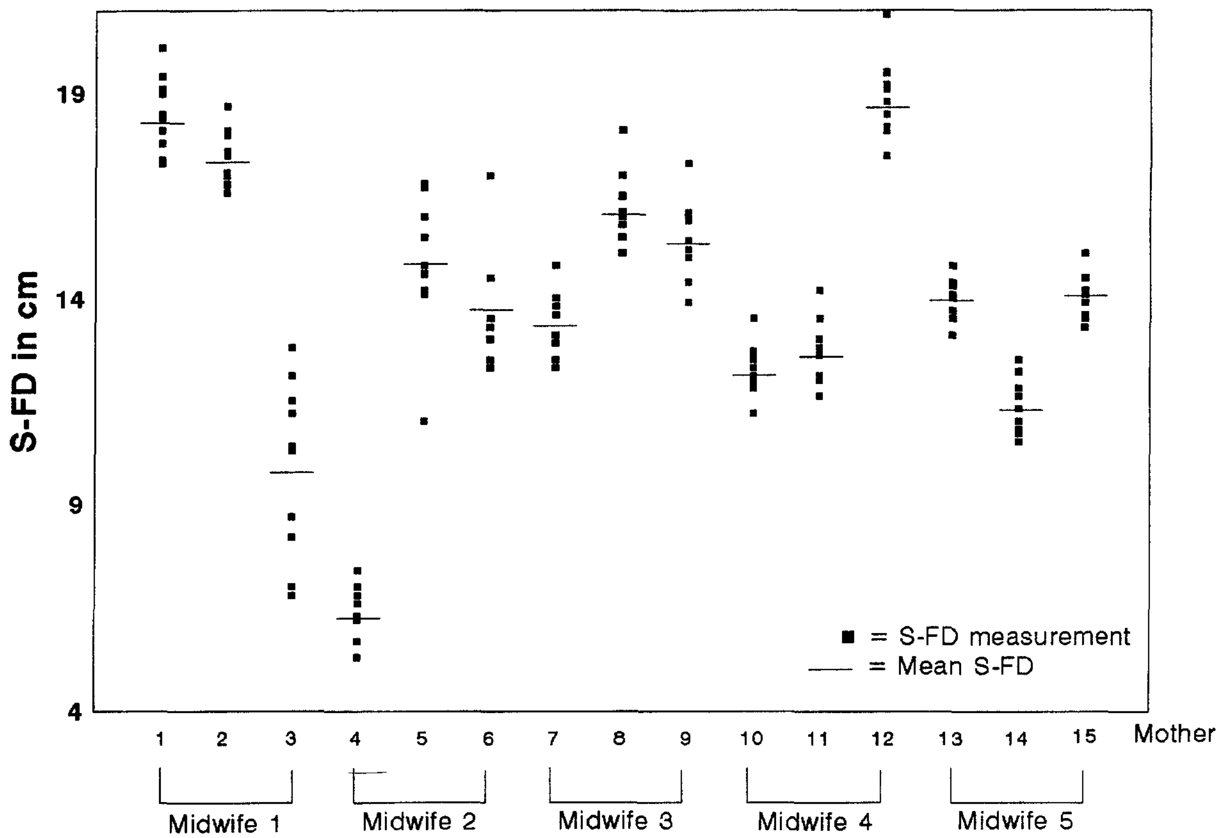

Fig. 1 The S-FD measurements obtained when one midwife measured three women in rotation in the intra-observer study.

or bottom of the range of measurements can perhaps be discerned, but there is no clear pattern for each midwife.

Estimates of the variance components due to each source from the two inter-observer studies and the two studies combined are shown in Table 2. The estimated variability across the true underlying values is somewhat greater in the first study (3.70) than any of the other sources of variability in that study. Though there is a tendency for individual midwives to affect the measurements they take, the pattern cannot be simply described. A particular midwife's impact on measurement varies depending on the woman, and this (expressed by the $\sigma^2_{woman*midwife}$ component of 2.46) approaches the variability across true values (3.70). In the second inter-observer study the two components expressing variability over midwives are smaller. The components due to pure repetition are similar in the first and second studies (0.88 and 1.08 respectively). These sources of variability in measurement combine to give a very low reliability of 47.7% in the first study and a somewhat better reliability of 66.5% in the second study. It is useful to see how these sources of variability have a bearing on the change between repeated readings on the same woman. If, as would occur in practice, these are taken by different midwives, the first study suggests that differences up to 5.69 cm should be expected due to measurement errors alone, while the second study suggests differences up to 4.23 cm. In the final column of Table 2 a combined estimate based on both studies, and thus larger numbers, of 5.01 cm for the repeatability of two measurements taken by different midwives is shown. If it were possible to ensure that each woman was measured by the same midwife, then the measurement would be more precise. The first study suggests differences up to 2.65 cm in this situation; the second suggests differences up to 2.94 cm; while the combined estimate of 2.80 cm lies in between.

The variance components for repetition, (σ^2_{repeat}), can be compared to those obtained in the intra-observer study. Values of 0.88 and 1.08 in the first and second inter-observer studies respectively, compare particularly well to corresponding values of 1.08 when three women were measured in rotation in the intra-observer study.

The average of all the first S-FD measurements made on each woman compared with the average of all the second measurements obtained on each woman are shown in Figure 3. If, as suggested by the participating midwives, the S-FD decreases with repeated examination it might be expected that the average of the second series of measurements would be smaller than the average of the first series. This was not the

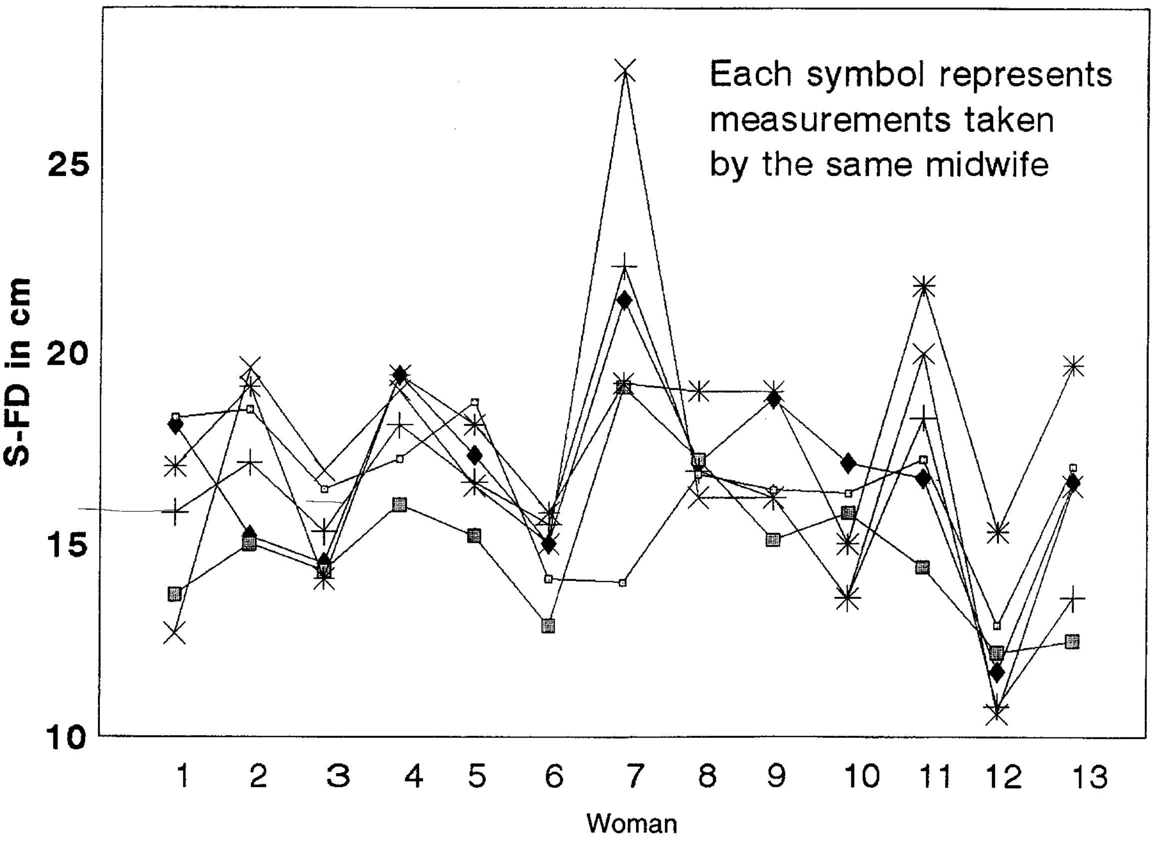

Fig. 2 The first measurement obtained by each midwife on each woman in the first intra-observer study.

case (Figure 3). Subtracting the average of the second series from the average of the first gave a mean difference of –0.04 cm. Thus, it appears that the S-FD did not reduce over repeated examination and the large degree of variability in S-FD measurements cannot be attributed to actual change in uterine size.

The SDs of S-FD were plotted against the BMI for the mothers who participated in the inter-observer variability studies (Figure 4). A trend for the SDs to increase with the BMI can perhaps be seen suggesting that variability in S-FD measurement may increase with increasing maternal size. One notable exception was the woman whose BMI was 32.4 but whose SD was low. Spearman's correlation was r = 0.1556 ($P<0.05$).

Table 2 Variance components, reliability coefficients and repeatability coefficients from inter-observer studies

	First study	Second study	Combined
σ^2_{woman}	3.70	4.44	4.45
$\sigma^2_{midwife}$	0.71	0.32	0.51
$\sigma^2_{woman*midwife}$	2.46	0.84	1.65
σ^2_{repeat}	0.88	1.08	0.98
Reliability coefficient	47.7%	66.5%	58.6%
Repeatability coefficient 95% range for difference between two measurements on same woman by different midwives – $2*\sqrt{2}*SD$	5.69 cm	4.23 cm	5.01 cm
Repeatability coefficient 95% range for difference between two measurements on the same woman by the same midwife – $2*\sqrt{2}*SD$	2.65 cm	2.94 cm	2.80 cm

DISCUSSION

The inter-observer studies (different midwives measuring the same woman) gave a repeatability coefficient (the maximum difference likely to occur between two measurements taken, 95% of the time), as 5.01 cm and for reasons described below this is probably an underestimate. The investigation of intra-observer (the same midwife measuring the same woman) variability in measuring S-FD gave a repeatability coefficient of 2.94 cm. Thus, even if it were feasible in clinical practice for the same midwife to make all the measurements on a womam, measurements could still be expected to vary by almost 3.00 cm purely due to measurement error. This degree of variability has the potential to obscure any real change (or any lack of change), and may result in some women having unnecessary additional investigations, or having symptoms missed.

The above findings were from measurements repeated within a short time period (up

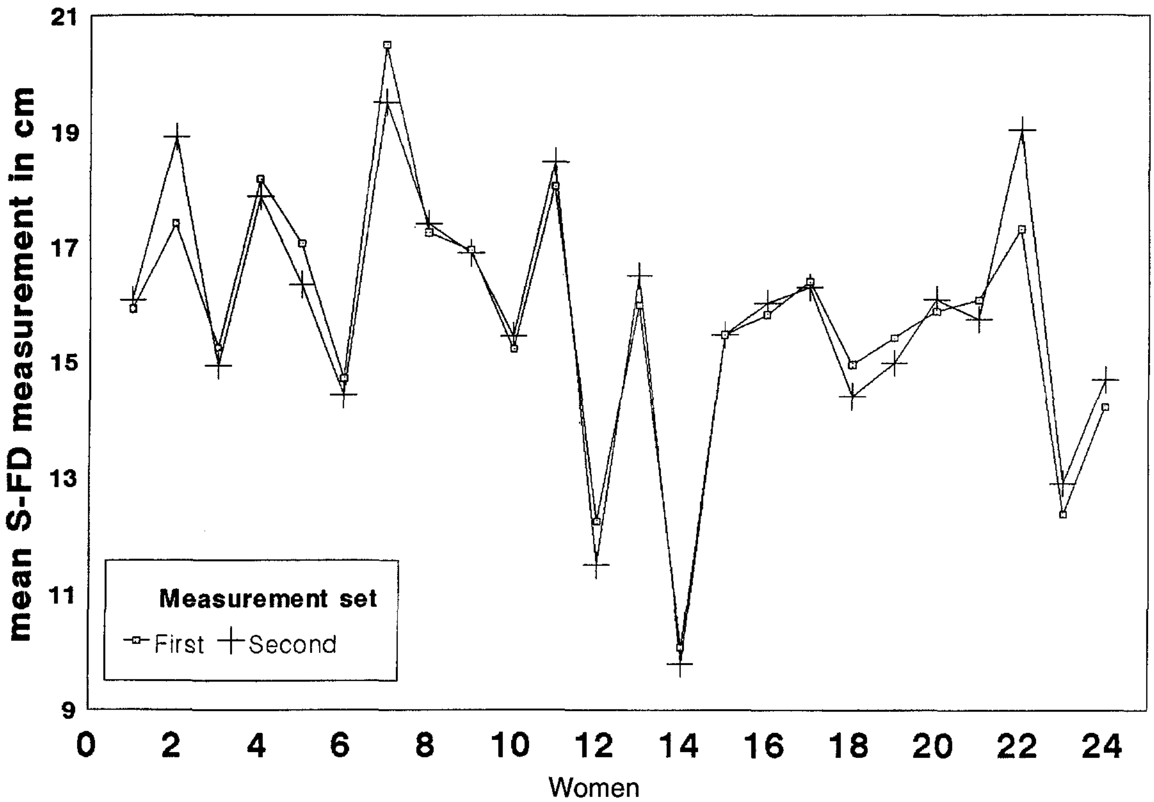

Fig. 3 A comparison between the first and second set of mean S-FD measurements from the inter-observer variability studies combined.

to a maximum of 45 minutes). In clinical practice a midwife would be unlikely to repeat measurements on one woman in rapid succession, intervals of up to 24-hour intervals are more realistic. Although the effect of the time intervals was not directly considered in the studies, statistical analysis of the data from the intra-observer variability study indicated a tendency for an increase in the number of women measured in rotation to increase the amount of variability, though this was not significant. As increasing the number of women measured in rotation necessarily increased the time interval between the repeated measurements, this tendency of increased variability might also reflect the effect of increasing time between observations. Thus, it is likely that the degree of intra-observer variability that occurs in clinical practice, when there is a greater time interval between repeated measurements, would probably be greater than that found in this study.

The inter-observer studies were necessarily quite small, due to practical constraints in organising the event and the limits imposed, in consideration of maternal comfort, and on the number of times each woman could be measured. Thus, variability across midwives was based on small numbers in each study, although the overall sample size was increased by repeating the study. Interestingly, the variability with which the midwives obtained the S-FD measurements in the second study was reduced. As six weeks had elapsed between the two parts of the study it is possible that the attention given to the measurement process in the first study had increased awareness of the subject, and perhaps greater care was taken in following the instructions which detailed the technique to be used. The higher degree of variability displayed in the first study may therefore present a more accurate picture of what happens in clinical practice than the combined findings, even though it is based on smaller numbers. Alternatively, the difference found between the two inter-observer studies could be due to chance fluctuations inherent in small samples.

Variability and the woman's BMI

It would have been desirable to have based BMI on the women's weight just prior to the examination, however, the first recorded antenatal weight was used as these were readily available and by using values close to the woman's non-pregnant weight a comparison with the normal range of BMI for non-pregnant women was possible. This study involved a convenience sample of women who did not necessarily represent the normal population and the sample did not include an adequate number of women at each end of the range of the BMI to give clear findings. These limitations mean that

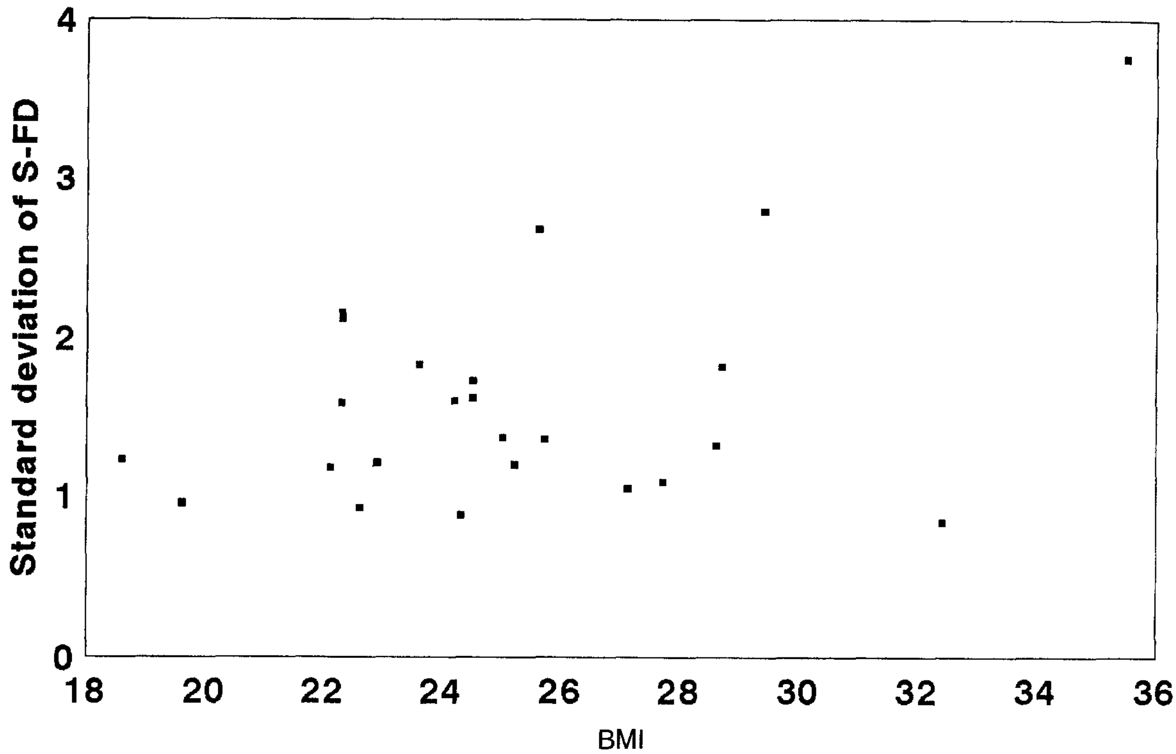

Fig. 4 Comparison between maternal BMI and the variability of the obtained S-FD measurements as indicated by the SD for the women in both inter-observer studies.

this aspect of the investigation, while of interest, can only be considered to suggest a possible relationship which requires further research.

Study organisation

Two aspects of the organisation of the study may have affected the measurements obtained. Firstly, the paper tape measures used were not blank on both sides; however, the blank side was uppermost when the midwives made and marked measurements. It is unlikely that any midwife could have gained information from the scale, even if she had tried to, as the tapes used had been cut from longer lengths in an uneven manner and thus the numbers visible did not relate to the distance from the end of the tape being used. Secondly, it came to the attention of the investigator some time after the completion of the study, that in one of the inter-observer variability sessions, some biro marks were left on the women's abdomens during the process of marking the paper tape measures. Such marks may have served as a guide to subsequent midwives as to the location of the uterine fundus.

If the two factors described above did in fact influence the measurements recorded by the midwives their effect would have been to reduce the amount of variability observed. The actual variability in clinical practice could therefore be greater than that found in the study.

Antenatal measurement of the distance between the symphysis pubis and the uterine fundus

In contrast to the postnatal situation, the measurement of antenatal fundal height is a widely accepted practice although the variability of repeated measurement is debatable (Calvert et al 1982, Bagger et al 1985, Bailey et al 1989). The values of antenatal fundal heights are larger (usually 30–40cm in third trimester) than in postnatal S-FD (usually less than 15 cm) and so any imprecision in measurement is relatively less important. Furthermore, antenatal changes are measured over between one and four weeks and the changes expected are generally greater compared to the postnatal situation where daily measurements are taken. Even in the context of antenatal measurement, however, it might be worth reconsidering the imprecision in measurement of change in fundal height using repeatability coefficients.

Implications for practice

These findings suggest that measuring S-FD is insufficiently precise to detect abnormally slow daily changes in S-FD. This raises the question as to whether another technique is required which could detect such changes with greater precision. The use of ultrasonography may be a method of assessing postnatal uterine involution, and indeed this technique has been utilised in several studies (Rodeck & Newton 1976, Szoke & Kiss 1976, Van Rees et al 1981, Lavery & Shaw 1989, Tekay & Jouppila 1993). However, research is required to evaluate whether such screening would improve clinical outcome for the women. It also seems likely that the ultrasonic screening of all postpartum women would be impractical, both because of the inconvenience to women and the resources that would be required.

CONCLUSION

This study did not investigate the predictive value of anthropometric assessment (palpating) of uterine involution or of assessing the lochia, in screening women for increased risk of puerperal sepsis or secondary postpartum haemorrhage. Research into this issue is planned (Alexander – personal communication 1994).

The findings in this investigation did suggest that measuring S-FD is insufficiently precise to detect abnormally slow daily changes in S-FD. However, this might not exclude the possibility that a single measurement taken by midwives at a specific stage in the puerperium, for example on the tenth postnatal day (either the actual measurement or the change in measurement from the day of delivery to the tenth day might be used for screening). As at present there is no information as to what a 'normal' range of S-FD measurements might be on any specific postnatal day, or the normal pattern of involution, this has not been evaluated. The natural history of uterine involution is the subject of an ongoing study by one of the investigators (EC).

Measuring the S-FD has become part of routine postnatal care in the unit where the study was conducted, and anecdotal evidence suggests that the women expect this examination to occur. This can be compared with the routine taking of blood pressure which has become part of medical care that patients expect as part of hospitalisation whether they have a condition where the blood pressure is important or not (O'Brien & Davison 1994). This ritualistic behaviour, which is well documented in nursing literature (Walsh & Ford 1989), may give both the midwife/nurse and the client a sense of security (Burroughs & Hoffbrand 1990). It is associated with the medical model of care where medical staff establish routines, or set observation regimens to be carried out by midwives/nurses which are rarely changed (O'Brien & Davison 1994). This medical model is the antithesis of what midwifery care is aiming for, a holistic, individualised approach where childbirth is viewed as part of normal human development and not a medical condition. It is desirable that postnatal observations, such as measuring the S-FD during the puerperium, are carried out only when there is evidence that there is benefit to the woman. We suggest that the practice of measuring the S-FD daily using a tape measure should be discontinued.

REFERENCES

Bagger P V, Sindberg-Eriksen P, Secher et al 1985 The precision and accuracy of symphysis fundus distance measurements during pregnancy. Acta Obstetricia et Gynecologica Scandinavica 64 (5): 371–374.

Bailey S M, Sarmandal P, Grant J M 1989 A comparison of three methods of assessing inter-observer variation applied to measurement of the symphysis fundal height. British Journal of Obstetrics and Gynaecology 96 (11): 1266–1271

Beischer N A, MacKay E V 1986. Obstetrics and the Newborn, 3rd Edn. WB Saunders, London

Bergstrom S, Libombo A 1992 Puerperal measurement of the symphysis-fundus distance. Gynaecological and Obstetric Investigation 44 (7): 425–427

British Standards Institute 1979 Precision of test methods 1: Guide for the determination and reproducibility for a standard test method (BS 5497 part 1). British Standards Institute, London.

Buisson P, Tomikowski J, Santarelli J et al 1993 Etude clinque et echographique de l'involution uterine dans le post-partum physiologique. Revue Francaise de Gynecologie et D'Obstetrique 88 (1): 12–18

Burroughs J, Hoffbrand B I 1990 A critical look at nursing observations. Postgraduate Medicine Journal 66: 370–372

Calvert J P, Crean E E, Newcombe R G et al 1982 Antenatal screening by measurement of the symphysis – fundus height. British Medical Journal 285 (12): 846–849

Cochrane Collaboration Group 1994 Pregnancy and Childbirth Database. Update Software Publishers. Oxford. Disk Issue one

Cook C 1992 The mystery of the postpartum uterus. Professional Care of Mother and Child 2 (6): 180–181

Department of Health 1993 Changing Childbirth. Part 1 Report of the Expert Maternity Group. HMSO, London

Healy M J R 1989 Measuring measuring errors. Statistics in medicine. 8: 893–906

Lavery J P, Shaw L A 1989 Sonography of the puerperal uterus. Journal of Ultrasound Medicine 8 (9): 481–486

Miller A W F, Callander R 1989 Obstetrics Illustrated, 4th edn. Churchill Livingstone, Edinburgh

Montgomery E, Alexander J 1994 Assessing postnatal involution – a review and a challenge. Midwifery 10 (2): 73–86

O'Brien D, Davison M 1994 Blood pressure measurement: rational and ritual actions. British Journal of Nursing 3 (8): 393–396

Rodeck C H, Newton J R 1976 Study of the uterine cavity by ultrasound in the early puerperium. British Journal of Obstetrics and Gynaecology 83 (10): 795–801

Rush J, Chalmers I, Enkin M 1989 Care of the new mother and baby. In: Chalmers I, Enkin M, Keirse MJNC, (eds). Effective care in pregnancy and childbirth. Oxford University Press, Oxford

SAS Institute Inc 1985 SAS User's Guide Statistics. Cary, NC, USA

Stevens T G, Griffith W S A 1896 Notes on the variation in height of the fundus uteri above the symphysis during the puerperium, the conditions which influence this and the practical conclusions which may be drawn from such observations. In: Duncan W, Boulton P, (eds). Transaction of the Obstetrical Society of London. Longmans, Green and Co., London

Sweet B R 1988 Mayes' Midwifery. A textbook for Midwives. Baillere Tindall, London

Szoke B, Kiss D 1976 The use of the ultrasonic echo technique in examining the normal and pathological involution in the puerperium. International Journal of Gynaecology and Obstetrics 14: 513–516

Tekay A, Jouppila P 1993 A longitudinal doppler ultrasonographic assessment of the alterations in peripheral vascular resistance of uterine arteries and ultrasonographic findings of the involuting uterus during the puerperium. American Journal of Obstetrics and Gynaecology 168 (1): 190–198

Thomas B E (ed) 1994 The manual of dietetic practice, 2nd edn. Blackwell Scientific Publications, Oxford

Van Rees D, Berstiene R L, Crawford W 1981 Involution of the postpartum uterus: an ultrasonic study. Journal of Clinical Ultrasound 9 (2): 55–57

Walsh M, Ford P 1989 Nursing rituals: research and rational actions. Butterworth Heinemann, Oxford