Abstract

SFH measurement is less invasive than ultrasound and performs better than abdominal palpation alone. Symphysis fundal height measurement when performed as part of the antenatal assessment, aims to identify gestational age and fetal growth patterns. Deviations from normal growth patterns can identify fetal abnormalities and can be indicative of early signs of fetal compromise.

The midwife’s role is in the prompt referral to obstetric care and to limit unnecessary intervention by facilitating normal pregnancy and childbirth. The woman centred philosophy of midwifery practice accepts that the pattern of fetal growth in pregnancy is unique to each woman.

The increased ethnic, social and cultural diversity within the childbearing population also has associated pathologies and medical conditions. The risk of perinatal mortality and morbidity may be prevented if there is early recognition of abnormal growth patterns present. The individual biological design of maternal and fetal characteristics must be considered as fetal growth patterns may differ Therefore plotting symphysis fundal height on growth curves that are not specific to the population of women examined can indicate a misleading deviation from the normative growth curves if not customised.
Introduction

The midwifery role by definition is one which facilitates birth by promoting normality in pregnancy and identifying risks that may lead to adverse maternal or perinatal outcomes (ICM, 2011). Facilitating the normal physiological process of pregnancy and birth, midwifery care is the amalgamation of art and science. The art, intuitive, holistic and woman centred, is supported by the scientific evidence based knowledge acquired through education and the ongoing learning process. Abdominal palpation, a rudimentary skill in the initial assessment of fetal position and growth, aims to assess maternal and fetal wellbeing. Symphyses fundal height measurement is the use of a metric tape to measure the fundal height and monitor fetal growth patterns with estimation of gestational age. NICE (2008) recommend serial SFH measurements at each antenatal visit in the third trimester of pregnancy. Deviations in fetal growth patterns may indicate a risk of abnormalities such as intrauterine growth restriction, macrosomia, amniotic fluid disturbances or fetal hypoxia (Mc Allion, 2004) CEMACH (2009) reports that 37.2% of unexplained stillbirths were identified as small for gestational age and 62.8% large for gestational age according to standardised growth charts. A review of the literature identifies a need for more consistent methods of measurement along with continuity of care. Improvements in growth curve design in order to customise fetal growth patterns to maternal characteristics may improve sensitivity and specificity in identification of SGA and LGA infants. The early identification of fetal compromise with growth pattern deviations can improve perinatal outcomes (Gardosi, 2004).
Symphysis fundal height measurement technique

Early literature describes the use of abdominal palpation to identify the distension of the uterine fundus ‘in proportion with the augmentation of its contents’. The use of anatomical landmarks such as the ‘navel’ was to confirm that the pregnant uterus was a developing fetus was not another medical condition (Smellie, 1762 p.118). This early paper highlighted a need to define what is normal in pregnancy in order to enable prompt recognition of deviations. Abdominal examination uses the maternal anatomy landmarks such as the symphysis pubis, umbilicus, xiphisternum and uterine fundal position to correlate with gestational age and fetal growth. The aim is to recognise any risk of fetal growth abnormalities or gestational age discrepancy. This technique was critiqued in Beazley and Underhill’s (1970) study which described the use of a generalised landmarking technique to assess gestational age and fetal growth as fallible, The study measured 473 pregnant women, cohort 1 (n=233) <28 weeks gestation and cohort 2 (n=240) >28 weeks gestation, using tape and callipers. There were variations in length between the symphysis pubis and the umbilicus of up to 7.5 centimetres (cm) and between the symphysis pubis and the xiphisternum of up to 5 cm in cohort 1. The measurements between pubis symphysis and umbilicus were 12.5cm to 23cm and from pubis symphysis to xiphisternum were 31.5cm to 36.5cm (30%), 38cm to 43 cm (70%) after 28 weeks of pregnancy in cohort 2. A difference in maternal abdominal length of 17.5 cm implies that individual abdominal length and biological design can affect the measurement result between these physical landmarks. This discrepancy in measurement could correspond with variation in the maternal abdominal length and interpreted as inaccurate gestational age or fetal growth pattern abnormalities. Beazley and Underhill (1970) dispute the accuracy of fundal height with the use of anatomy as a guide to assess fetal growth. The
maternal characteristics such as height, parity and ethnicity of the sample population were not identified. There is an absence of sample inclusion or exclusion criteria in the population or a comparison of results with birth outcomes. As the exact technique of SFH measurement is not outlined it is difficult to determine if examiner bias affected measurements. A study (Faustin, 1991) of 100 pregnant women from the 18th week of gestation examined the relationship of fundal height as a percentage of maternal length (PMAL) compared with fundal height estimates and gestational age. SFH was measured using a consistent technique (Belzian et al. 1978) aimed to limit variables such as maternal position and bladder volume. There was blinding of the examiners knowledge of maternal history and known gestational age in a further 29 pregnant women. The findings that fundal height measurement corresponds more accurately (correlation coefficient of 0.94) than PMAL (correlation coefficient of 0.86) with gestational age supports Beazley and Underhill’s (1970) synopsis, that the use of individual biological anatomy as a guide for fetal development is not reliable. The standardised approach to estimating gestation using an anatomical land marking technique does not account for the variables of a woman’s individual biological design or individual infant growth patterns. Nevertheless assessment of fundal height by fundal palpation and correlation of fundal height with anatomical landmarks continues to be a mainstay in antenatal assessment. Midwifery antenatal care incorporates maternal obstetric and medical history in determining risk, research in the area of fundal height measurement views this knowledge as influential leading to bias. However, in order to evaluate and promote an assessment tool, such as SFH measurement, variables such as bias must be adequately controlled.

The technique of SFH measurement has a variety of methods discussed within the literature (Engstrom & Sittler, 1993). SFH measurement with the use of a tape measure or calliper puts a numeric value on the distance between the pubis symphysis and uterine
fundus. SFH measurement was developed in the 1800’s as a tool to assess gestational age and fetal growth patterns. Spiegelberg (1887) cited in Engstrom & Sittler (1993 p.6) presented the use of a tape measure to calculate the distance between the symphysis pubis and the uterine fundus. Methods of measurement with the use of callipers shown to be more accurate yet were somewhat more invasive are no longer common place in practice (Engstrom & Sittler, 1993) The introduction of numerical data in order to quantify and record this clinical observation presented SFH measurement as an assessment tool to be evaluated as a predictive test (Wilcox, 2001)

McDonald (1906) cited in Engstrom & Sittler (1993 p.6) published a technique for SFH measurement which consists of placing one end of a tape measure using the fingers of one hand at the uppermost border of the symphysis pubis and using the extended fingers of the other hand placed at the uterine fundus. The tape measure is then held in the palm of the fundal hand and the length from symphysis pubis to uterine fundus recorded. There are adaptations of this technique such as Belzian et al (1978) where the tape does not remain in continuous contact with the abdomen nor measure the complete uterine fundal curve and Quaranta et al. (1981) includes the upper uterine curve with continuous contact of the tape with maternal abdomen. Westin (1978), advises measuring along the longitudinal axis of the uterus, regardless of fetal position and then along the fetal axis in the third trimester. The tape measure whilst in contact with the skin ends at the top of the uterine or fetal pole and not necessarily the complete uterine fundal curve. The different methods are performed interchangeably within literature and between clinicians in practice. Any of these methods if performed consistently within the same population may limit inter-observer differences but may affect the ability to compare the research between different populations with differing SFH techniques. The non standardisation of one consistent method within the clinical area will also have an affect on inter-observer variation. SFH
measurement and its parts such as maternal position, bladder volume and manual identification of the uterine fundus may present limitations to the accuracy of fundal height assessment.

The importance of accurately identifying the uterine fundus can be influenced by uterine thickness and fetal position. Engstrom et al’s (1993) prospective population based sample of 126 women which recommended further evaluation of the topic area as the estimation of fundal position can be inaccurate compared to the exact position (mean absolute error = 1.25cm). The identification of the uterine fundus on palpation is compared by Euans et al. (1995) in a study of 119, women with singleton pregnancies of between 11 and 42 weeks gestation with ultrasound verification and reported a more positive outcome with only 12% of the study sample showing a discrepancy between measurements of 2 weeks. Obesity or ethnicity did not show to affect results. Although the tape measure was blank side facing up in order to prevent examiner bias to their own measurement, they were not blinded to the gestation or ultrasound and manual results and bias may be a consideration.

A linear regression model was used and found no significant difference between manual fundal height and ultrasound guided fundal height identification \([R.sup.2]\) of 0.92. If manual palpation of the uterine fundus is effective in identifying the ‘variable point’ of the uterine fundus, it is suggested that by using both hands before placing the tape on the abdomen, may reduce the risk of error when starting measurement at uterine fundus (Morse et al p.812). The subjective use of palpation to identify uterine position, a variable, relied upon to initiate SFH measurement. It is already surmised that abdominal land marks are not accurate in ascertaining gestational age but are still performed routinely in practice. It is possible that, in practice, midwives may still use the visual abdominal landmarks to guide their estimation of manual fundal height when gestation is known.
Engstrom et al. (1993) highlighted that although routine measurements are recommended, there was no specified standardised technique outlined to use at the time publication. Maternal position and its affect on SFH measurement was examined, four positions were adopted: supine, trunked elevated 15 degrees, supine position with knee flexion, trunk elevated with knee flexion. All positions were randomised to give equal representation within each gestational group and all women had empty bladders. The tape used was ungraded and collected after each position and a new tape used for the next measurement. All non obese women had height, parity, ethnicity and gestation recorded. The study found an average difference of 0.95 cm between the supine and trunk elevated positions. Inconsistency in maternal position may show a difference in serial measurements if plotted on a growth chart. The importance of this finding in isolation may not be concerning, yet when presented with other aspects of technique variable, such as bladder volume, a deviation may be falsely identified or missed.

The effect of maternal bladder volume on SFH results was examined in two studies. Worthern & Bustillo (1980) examined urinary volume in 117 pregnant women with the recommendation that SFH measurement is performed on women with an empty bladder. This was further examined in a study by Engstrom et al (1989) in a convenient sample of 200 black women between 16-42 weeks of pregnancy. The examiners were blinded to fetal gestational age and amount of voided urine. There was a mean difference in pre and post void SFH measurements of 0.63 cm, standard deviation (SD) of 1.26cm. The smallest differences in measurements were found in those women that voided urine within 30 minutes of measurement (n=20) an average of 0.16 cm (SD 1.22) than those who voided 30 minutes (n =179) before measurements. Therefore to minimise the effect of bladder fullness on measurement women should be encouraged to void urine with 30 minutes of
SFH measurement. The findings show a fall in measurement difference by 75% in women who empty their bladders within 30 minutes of assessment. The acceptable variation in measurement is within 1.26cm. NICE (2008) recommend routine urine testing at each antenatal visit, therefore often women have voided urine before abdominal palpation and SFH measurement. The control of bladder volume as a variable in SFH measurement is achievable once waiting times at visits are within the optimal timeframe. As variables, the affect of bladder volume and maternal position may not justify more research and in practice +/- 2cm or 3cm of measurement is accepted as within normal limits (Morse et al 2009).

Once the affect of maternal position and bladder volume are adequately managed measurement is applied using a tape. The dependability of any assessment tool to produce measurements that are reliable with consistent methods can still be influenced by the clinician performing the assessment. The examiner’s own capability in producing the same results (intra-examiner) or between different examiners (inter-examiner) in identical situations affect the reliability of the assessment tool. Calvert (1992) recorded SFH measurements of 12 pregnant women at various gestations by six examiners. The average measurement of 27.05cm rated the intra-observer co-efficient of variation at 4.6% with mean standard deviation of 1.24cm. The inter-observer co-efficient variation of 6.4% where the mean standard deviation was 1.72 cm. These findings show SFH measurement is not exact and although examiner knowledge of gestation, maternal history or a numerical preference were prevented, clinician experience did not assist the reliability. The average measurement difference between examiners results were a small percentage of the overall average measurement and this does not increase even with the least experienced examiner. Fundal height measurement has the same reliability when performed with a consistent method regardless of examiner experience. Engstrom et al (1993), with a prospective
population based sample measured SFH in 60 women using both marked, unmarked tape and callipers. The study reported that inter-examiner measurement differences were the least with use of callipers and the tape over the complete abdominal curve than those not over the curve. The intra-examiner differences were less with use of callipers than tape and overall average difference of 0.68cm to 1.74cm compared to inter-examiner average difference of 1.36cm to 3.60cm. The calliper technique is more precise as a SFH measurement tool and the study recommended further evaluation of this method. The same examiner also reduces the variation in the recorded lengths of SFH. The effect of measurement technique variation and level of clinician experience are examined in survey conducted by Griffiths et al (2008). The methods used varied with examiner experience and those with >10 years clinical experience used SFH more in practice. The survey results report that accuracy is decreased due to inter-observer variations based on inconsistent methods of measurement. The use of a standardised method of SFH measurement can limit the inter-observer variation but as highlighted in a prospective study of 102 women (Jelks, 2007) the affect of bias can reduce intra-observer reliability. The knowledge of gestation and markings on tape affected all clinicians regardless of experience. Interestingly those with less than 2 years experience were more influenced by BMI than their more experienced counterparts. Nevertheless, the less experienced clinicians’ bias reduced over the study period whereas those with >10 years experience did not. Knowledge of pregnancy gestation may lead the examiner to expect a certain measurement. It is this expectation and its relationship to bias that Engstrom et al (1993) examined in a convenience sample of 240 pregnant women. Marked and unmarked tape measurements of SFH ascertained that the difference between results were less with unmarked tape, average difference of 0.61cm than marked tape, average difference of 0.97cm. The clinicians were affected by their ability to see the numerical marks on the tape along with
the knowledge of pregnancy gestation. The findings suggest that examiners blind themselves to their own measurements and knowledge of maternal history in order to reduce bias and its affect on intra and inter-observer variation. Clinician experience does not affect results to the same extent as knowledge and varied methodology. SFH is a practical non invasive tool, callipers although more accurate than disposable non elastic tape, the latter is cost effective with less infection control issues.

The Perinatal Institute (2011) recommendation of a SFH measurement technique describes recording the length, starting from uterine fundus to symphysis fundus with the women in a semi recumbent position with an empty bladder. The tape is used with numeric markings facing towards the abdomen and measurement of SFH to include the upper curve. The measurement is along the longitudinal axis of the uterus and then along the fetal axis without compensating. This protocol presented by Morse et al (2009) aims to standardise the method of SFH measurement in order to limit the affect of the variables of maternal position, bladder volume, intra and inter-observer variation on the results. The ‘standardised protocol’ includes serial plotting with a customised chart and a referral procedure for further tests if fetal growth deviation is identified (Morse et al, 2009 p.809) As part of a care pathway, SFH measurement encourages education in technique for all levels of experience. The consistent method if integrated into practice across multidisciplinary centres in both community and hospital may assist the comparison of future research across populations. Morse et al (2009) describe the formula of 1cm = 1 week gestation as a flawed hypothesis due to research in the area of population based curves (Rai et al, 1995). In standardising the technique the result interpretation should not be generalised but documented as the accurate measurement for each unique mother and baby. It is therefore important to measure consistently and accurately and limit variable
influences whilst plotting serial measurements on growth curves formulated for the individual.

Symphysis fundal height measurements plotted on growth charts

The value of the SFH as a measurement tool is based on its predictive value in identifying the risk of abnormal fetal growth. In order to assess the risk, a normal or average growth curve is used in which to plot the serial measurements, once reliability is improved by using a consistent method of SFH measurement. The aim is to document changes or deviations in growth along the curve and to refer for further investigations to aid in prevention of adverse outcomes. The standard deviation is identified for the population and centile charts are formulated. The patterns that fall either in the 10th or 90th centiles are indicated as needing further investigation. Other referral indications are static growth patterns or two measurements that are +/- 1 standard deviation (SD) from the normative curve (Westin 1977).

Westin (1977) outlined a gravidogram design, a visual aid to emphasis deviations from normal growth patterns. This normal curve indicates that those at the lowest centile are at risk of intrauterine growth restriction (IUGR). This SFH curve predicted 75% of small for gestational age (SGA) infants when growth patterns emerged from serial measurements as static or below the average by -1 standard deviation (SD). The curve identified 64% of appropriate gestational age (AGA) infants when SFH measurements were within the normative curve and measurements that deviated above the mean by +1 SD predicted 65% of the large for gestational age (LGA) infants. The study of 428 women highlighted that SFH correlated well with gestational age. Belizan et al. (1978) developed a curve design that had a higher prediction of 86% of SGA infants with a lower misidentification of SGA of 10% and a specificity of 90% suggesting SFH measurement as a good method in
identifying IUGR. Quaranta et al. (1981) advised that the optimum gestation to predict a risk of IUGR was at 32 to 33 gestational weeks. This fundal height curve had a lower predictive value of 73% and a higher misidentification of SGA infants of 23%. The 1985 study by Wise and Engstrom examined predictive validity of Belzian et al. (1978) and Quaranta et al. (1981) SFH curves in a convenience retrospective sample of women with at least 3 SFH measurements were obtained after 19 gestational weeks. In this sample of women and babies in the postnatal period, 22 infants were identified as SGA (n=12) and LGA (n=10) The rationale for the curves selected to contrast was due to the high differential values of normal limits and lack of research in predictive values for LGA infants. The results showed poor predictive value (8.6%) of SGA, Belzian et al. curve identified 100% of LGA infants whereas Quaranta et al. curve predicted only 50% of cases. Belzian et al (1978) and Quaranta et al. (1981) used different measurement techniques, the tape in contact with maternal abdomen measures the upper uterine curve and not complete the abdominal curve respectively. This was a retrospective trial and the techniques of SFH measurement were not controlled. The study suggests that the development by clinicians of their own population based normative curve can increase the predictive value of the assessment. A prospective randomised controlled trial of 1639 (Lindhard, 1990) concludes that SFH does not assist in the prediction of SGA infants at birth but it does have some diagnostic value in assessment of risk. The SFH measurements were performed in 2 groups, a SFH group (n=805) and the control group (n=835) with a consistent method of SFH measurement (Westin 1979). The identification of SGA fetus (sensitivity) was 27.9% in the SFH group and 47.9% in control group. The specificity or those identified as within normal limits accurately were 96.9% and 96.7% SFH and control group respectively. Kennedy (1992) criticises the study as not maximising the test as only 3 measurements were undertaken in 79% of women. The control group performed better in
test sensitivity and this may be due to the control of technique in this group. Neilson (1999) reviewed SFH measurement in pregnancy evaluating one prospective randomised controlled trial (Lindhard et al, 1990) reporting that insufficient research exists to determine whether it improves pregnancy outcomes. Since this review, further papers have been published. Gardosi and Francis (1999) further evaluated the SFH measurement tool and devised a customised chart based on maternal characteristics. The prospective, non randomised, controlled population based study of 1272 women with singleton and ultrasound dated pregnancies. Study findings between customised versus standardised growth curves were increased antenatal detection of SGA (48% vs. 29%) and LGA (46% vs. 24%), less referrals and no differences in perinatal outcome. Comparison between Lindhard et al (1990) and Gardosi and Francis (1999) show that by standardising the SFH technique, test sensitivity improves for SGA (47.9% and 48%). The growth charts or curves when customised give better sensitivity to SGA and LGA fetal patterns. The importance of individual growth curves based on maternal characteristics in order to identify normal individual fetal growth patterns is highlighted.

Population based growth curves are based on a similar hypothesis that: determining the normal within a population will assess deviations with that population. A prospective study of 100 women (Rai et al 1995) identified growth pattern of 2.1 cm per week between 29 and 32 weeks gestation then a slowing in growth until 40 weeks gestation. A large population based study (Clausson et al, 2001) of data collected data from 326,377 births between 1992 to 1995. A population based growth standard and a customised centile chart were compared. It found increased sensitivity in assessing risk growth restricted fetuses and therefore risk of neonatal morbidity and mortality were reported. Mc Cowan et al (2005) compared customised centiles with that of population based centiles and pregnancy outcome in a cohort of 374 SGA pregnancies and general population of 12,879 women.
The customised centiles recognised more babies at risk of perinatal morbidity and mortality. In order to customise centiles maternal ethnicity, weight, height, and gestation must be ascertained. The gestation related optimal weight (GROW) customised centiles and antenatal charts software is available. The term optimal weight (TOW) is estimated by using maternal characteristics without pathologies to predicate a curve that represents how the normal growth patterns will achieve the term weight. Term is determined as 280 days gestation with estimated date of delivery an important factor in maintaining accuracy.

The importance of accurate estimated date of delivery is fundamental in the measurement of SFH and ascertaining normal growth patterns. Jehan et al (2010) compared 3 methods of measurement in 1128 women to estimate date of delivery. Ultrasound is a more precise tool when estimating gestational age and works with SFH measurement to improve validity. A large prospective study of data collection (Kayem et al, 2009) randomised a population into 2 cohorts, 7138 women with SFH measurement and 1689 women with SFH and ultrasound measurement within 8 days. Ultrasound versus SFH measurement sensitivity in identifying the risk of SGA infants, results in 50.7% versus 41.2% and in LGA infants 54% versus 37.1% respectively. Hargreaves et al (2011) in an electronic retrospective review of ultrasound and birth outcomes reported sensitivity of ultrasound as 40% versus SFH as 20% in identification of SGA infants. The test sensitivity in determination of SGA is reported as 27.9% with a specificity of 96.6%. The efficacy in predicting the risk of fetal growth pattern abnormalities is based on the assessment tool’s ability to determine the normal growth curve of each individual fetus (Gribbin & James, 2005). The Royal College of Obstetricians and Gynaecologists (2002) recommend the use of customised charts when plotting serial antenatal SFH measurements. As a predictive risk assessment test, SFH has sensitivity between 20% to 48% for identifying SGA fetal growth patterns and LGA of 24% to 46% (Hargreaves, 2011, Gardosi & Francis, 1999). In maternity a non invasive
fetal assessment test, such as fundal height measurement, that can be performed by a midwife at antenatal visits enhances care and may improve outcomes. The use of individualised charts reiterates the woman centred ethos and supports the unique biological design of mother and baby. However it is important that the SFH tool realises its full potential with a standardised method plotted on customised growth charts.

**Discussion**


The level of evidence prior to Neilson’s (2000) review and the introduction of customised charts (Gardosi & Francis,1999) was 2 and 3 grade Bd. The introduction of customised centiles improved SFH measurement technique’s accuracy in SGA infant prediction, evidence level 2 grade Bd which is equivalent to the evidence recommending serial ultrasound growth measurements (Gribbin & James, 2005) The sensitivity of ultrasound in assessment of infants < 2500g is 50.7% and >4000g is 54. % (Jehan et al, 2010) SFH
measurement is showing improved accuracy in predicted risk of fetal growth deviations at the lower and higher customised centiles and falling within ultrasound parameters that use standardised growth curves (Gardosi & Francis, 1999).

In an audit of plotting fundal height measurement the most common error in practice is performing SFH measurement too frequently (35.5%) and not entering the numerical value (2.6%) (Wright et al, 2006). The use of anatomical landmarks to identify growth deviations with a reported sensitivity of 30% and use of SFH measurement without plotting on a growth curve is performed frequently in practice (Jones 2011).

**Conclusion**

Further research in the area of SFH measurement requires a standardised method with serial plotting on customised charts and a referral guideline adhered to in maternity practice (Perinatal Institute, 2011). Therefore increasing fetal growth pattern deviation sensitivity and specificity and making it easier to quantify the reliability and validity of SFH measurement as a fetal assessment test. The need for larger controlled prospective studies across the population could be fulfilled if a consistent methodology is integrated into maternity practice.

The implications to midwifery, is as an assessment tool, SFH measurement is less invasive than ultrasound and performs better than abdominal palpation alone. The increased sensitivity of SFH measurement to SGA infants with less misidentification of constitutionally small infants as SGA, lead to less unnecessary referral for interventions and improve quality of care. It is also important that it is understood that as an assessment tool SFH measurement should enhance clinical skills and not replace holistic care. In populations where ultrasound is not available it can aid in the identification of gestational age discrepancy and abnormal fetal growth patterns (White, 2011).
Childbearing populations are increasingly diverse, with increased maternal age and associated pathologies and a variety of maternal characteristics that put pregnancy at risk of medical conditions. It is important to identify fetal growth abnormalities and sequelae in order to improve perinatal outcomes.
Reference List


McDonald, E. (1906) 'Mensuration of the child in the uterus with new methods.', *JAMA*.


