Physical activity behaviour in overweight and obese pregnant women

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Abstract

Background: Increasing physical activity (PA) may help to reduce the risk of obesity related pregnancy complications. However little is known about the amount, type and intensity of PA obese pregnant women engage in, or the most appropriate measurement method. Previous research suggests that obese pregnant women receive limited advice concerning PA from midwives.

Objectives: To investigate the amount of PA carried out by this population and how this changes during pregnancy, to compare measurement methods, and to describe the knowledge, attitudes and practice of midwives surrounding PA.

Methods:

1. 130 pregnant women, BMI$\geq$25kg/m^2, consented to PA measurement at 2 or 3 time points using the Actigraph accelerometer and Recent Physical Activity Questionnaire.
2. Questionnaires were designed and distributed to midwives within 3 NHS Trusts on Tyneside (n=365) with the aim of identifying barriers to discussing and advising PA with obese pregnant women. The design used the Theoretical Domains Framework approach which uses behavioural determinants to investigate implementation difficulties.

Results:

1. At 12-16 weeks gestation over half of the participants achieved 30 minutes of moderate or vigorous PA, decreasing by 36 weeks to 24%. Women who were more active at baseline decreased their PA during pregnancy; those who were less active remained so. Self-reported PA also fell but did not correlate with objectively measured PA.
2. Midwives scored highest on knowledge and social-professional role and lowest on skills, capabilities and environment/context/resources domains. Regression analysis indicated that skills and memory/attention/decision domains had a significant influence on discussing PA.

Conclusion: Research is needed to find methods to encourage obese women to increase and maintain PA levels before and during pregnancy, and to find the most appropriate PA measurement methods. Midwives feel knowledgeable and believe giving PA advice to be part of their role, but lack skills, capabilities and resources. Strategies to remove such barriers are needed.

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I am also grateful to the Directorate of Women's Service, Newcastle upon Tyne NHS Foundation Trust, and North Tyneside Non-Medical Education and Training for supporting and facilitating my research.

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Foreword

Researchers background and research interests

I qualified as a midwife over 20 years ago and since then have worked in all areas of maternity services in several different hospitals. I currently work as a research midwife at The Newcastle upon Tyne NHS Foundation Trust, where I have been employed for 14 years.

As a research midwife I have been involved in many different types of research, including quantitative and qualitative studies. My research interests focus on maternal medicine and metabolism as well as health promotion and behaviour change. Therefore, I relished the opportunity to be involved with/conduct research relating to physical activity, (PA), in overweight and obese pregnant women. My involvement with physical activity research began in 2007/2008 and I registered for a PhD as a member of staff at the beginning of 2010, predominantly on a part time basis. Thus, my PhD was completed whilst I worked as a research midwife on the studies.

Structure of the thesis

This research explores the issue of physical PA in pregnant women with an increased body mass index, (BMI), providing the opportunity to develop further knowledge and interest in the field of behaviour change and health psychology. It investigates possible methods of measuring PA in pregnant women and reports how much and what type of PA a sample of overweight and obese pregnant women undertake. Given the potential benefits of promoting PA in this group of women, the possible barriers and facilitators experienced by practising midwives with regard to advising obese pregnant women about PA are also investigated.

Chapter one comprises a review of the literature surrounding obesity related pregnancy complications and the potential role of PA as a modifiable risk factor. Evidence surrounding PA during pregnancy, current national guidelines and interventions studies aiming to increase PA are presented. The views, attitudes and opinions of women in relation to PA in pregnancy are explored, followed by the views, knowledge and attitudes of health care professionals. The chapter ends with a presentation of my overall rationale for the PhD study and my research objectives.

Chapter two investigates the longitudinal measurement of PA in overweight and obese pregnant women, which involved the analysis of data from two separate studies.

1. ‘Measuring Activity in Pregnancy Study’ (MAPS)
2. ‘UK Pregnancies Better Eating and Activity Trial’ (UPBEAT)

MAPS was conceived and designed by a group of academics at Newcastle University. I contributed to the study design, the ethics application and subsequently designed and produced all the patient information materials. I undertook all recruitment and data collection. The analysis and interpretation of results presented in this thesis is my own work, guided by my supervisors, supported and advised by Dr Colin Muirhead (lecturer in statistics, Newcastle University).

UPBEAT is a multicentre randomised controlled trial, aiming to change dietary and PA behaviour of obese pregnant women. I was not involved in the concept and overall design of this study but was employed to work on phase 1, (the development of the PA measurement tools and PA intervention), and phase 2, the pilot RCT. I was subsequently granted permission to use the data from the control arm of this study to analyse PA patterns.

Chapter three presents a survey carried out with clinical midwives designed to identify barriers and facilitators to providing PA advice to women. I designed the questionnaire with the guidance and support of Dr Vera Araujo-Soares (lecturer in health psychology, Newcastle University), and my supervisors using the ‘Theoretical Domain’s Framework. The conduct, analysis and interpretation of results presented in this thesis is my own work, guided by my supervisors, supported and advised by Dr Colin Muirhead and Dr Vera Araujo-Soares.

Chapter four discusses the key findings in relation to the original research objectives and describes contribution made to the existing literature. An integration of research findings from chapters two and three is presented. Finally, conclusions are drawn and implications for practice and future research are suggested and discussed.

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Abbreviations

ACOG	American College of Obstetricians and Gynaecologists
ANC	Ante natal clinic
AQuAA	Activity Questionnaire for Active Australians
BMI	Body Mass Index
CATPCA	Categorical principle component analysis
CEMACE/ CEMACH	Confidential enquiry into maternal and child health
CI	Confidence Intervals
CNST	Clinical negligence scheme for Trusts
CS	Caesarean section
df	Degrees of freedom
ECG	Electro cardio graph
EE	Energy expenditure
FMU	Fetal medicine unit
GCT	Glucose challenge test
GDM	Gestational diabetes mellitus
GP	General Practitioner
GTT (OGTT)	Glucose tolerance test (oral glucose tolerance test)
GWG	Gestational weight gain
HR	Hazard ratio
HSE	Health Survey for England
IGT	Impaired glucose tolerance
IMD	Indices of Material Deprivation
IOL	Induction of Labour
IOM	Institute of Medicine
IPAQ	International physical activity questionnaire
IQR	Inter quartile ranges
kg	Kilograms
LGA	Large for gestational age
m	Meters
MAPS	Measuring Activity in Pregnancy Study
MAU	Maternity Assessment Unit
METs	Metabolic energy equivalents

MVPA	Moderate or vigorous physical activity
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NMC	Nursing and Midwifery Council
OR (aOR)	Odds ratio (adjusted odds ratio)
PA	Physical activity
PAEE	Physical activity energy expenditure
PCT	Primary Care Trust
PIS	Participant information sheet
PPAQ	Pregnancy Physical Activity Questionnaire
QOL	Quality of life
RCOG	Royal College of Obstetricians and Gynaecologists
RCT	Randomised controlled trial
RMS	Residual mean square
RPAQ	Recent Physical Activity Questionnaire
RR (aRR)	Relative risk (adjusted relative risk)
RSS	Residual sum of squares
SD	Standard deviation
SGA	Small for gestational age
SMART	Specific Measureable Achievable Relevant Timely
SPSS	Statistical package for social scientists
TDF	Theory Domains Framework
TV	Television
UK	United Kingdom
UPBEAT	UK Pregnancies Better Eating and Activity Trial
USA	United States of America
WHO	World Health Organisation

1 Literature Review

1.1 Introduction

Women who are overweight or obese at the beginning of pregnancy are at increased risk of a number of serious pregnancy complications which can have both short and long term consequences for their health and the health of their offspring. Physical activity (PA) is one possible modifiable lifestyle factor which may help to reduce the risk of some obesity related pregnancy complications.

1.1.1 Search Strategy

The aim of this literature review was to examine the prevalence of obesity in pregnancy, identify the increased risk factors encountered by this group of women and investigate the potential role of PA in reducing some of these risks. Research evidence investigating the effects of PA during pregnancy, intervention studies aimed at changing PA behaviour and qualitative research which has explored the views of women and health care professionals will be presented. Important questions that the review will attempt to answer are:

1. Is the amount of PA carried out by obese pregnant women related to their short and long term health and wellbeing?
2. How much PA should pregnant women be aiming for?
3. How much PA do overweight and obese pregnant women actually do and how does this change as pregnancy progresses?
4. What is the best way to reliably monitor PA in this population?
5. What influences the amount of PA carried out by these women?
6. How can PA be increased or maintained in obese pregnant women?

Whilst not a formal systematic review, the search adopted a structured, explicit method in order to include all available sources of information, modes of research and types of literature. Searches were carried out on the databases: Ovid MEDLINE, EMBASE, CINAHL, Social science citation index, EBM review, Cochrane register of controlled trials, Cochrane database of systematic reviews and Web of Knowledge. Quarterly searches of the MIDIRS Midwifery database were also carried out. The National Institute for Health Care Excellence (NICE), Department of Health and Royal College of Obstetricians and Gynaecologists (RCOG) websites were searched quarterly to monitor the publication of new guidelines, press releases and reports. Searches of the proceedings of major, relevant conferences, article reference lists and grey literature were also performed.

Main search terms included:

Pregnancy AND obesity,

Pregnancy AND physical activity,

Physical activity AND activity measurement,

Pregnancy complications AND obesity

Midwives OR midwifery AND physical activity

Midwives AND obesity

Midwives AND attitudes

Health care providers AND behaviour change

Subject areas: O&G, Endocrinology and Metabolism

Refined by: Human and English Language.

In addition, the reference lists of included papers and key relevant literature reviews identified during the search process were also examined for additional relevant studies.

1.1.2 Inclusion/exclusion criteria

The inclusion criteria were broad so as to include all possible sources of information regarding PA.

Randomised controlled trials (RCT's), non-randomised comparative studies, observational studies and population based case series were deemed eligible for inclusion as well as relevant reviews, systematic reviews and meta-analyses. Inclusion was not restricted by methodology used, (for example, qualitative, quantitative, mixed methods).

Participants were not restricted to pregnant women as information regarding the measurement and benefits of PA in different populations would be explored. All BMI categories were included so as not to restrict information about PA in populations where the BMI was in the normal range.

All types of PA measurement methods, (subjective and objective), were included, as were all outcome measures such as physiological, psychological and social.

There were no restrictions placed on type of health care provider/professional so as to identify and include all relevant studies carried out in different health care settings related to PA, obesity, guideline implementation and behaviour change.

Exclusion criteria included references not in English or studies not involving humans. However, important references cited within included studies which provided evidence of the physiological effects of PA in non-human mammals were subsequently obtained.

1.1.3 Quantity and quality of the identified literature

Several hundred references were identified as meeting the inclusion criteria. These were diverse in nature, reflecting the search strategy and inclusion criteria. These were categorised according to the main focus of the article before being re-assessed for inclusion in the final literature review. References were rejected when there was a lack of relevance to the focus of this thesis. The quality of the retrieved literature varied enormously, as did the types of reported studies. These included studies reporting small case series to large population based cohort studies. Common weaknesses included small sample size, inappropriate timing of PA measurement and/or the use of poor measurement methods. A formal quality assessment of included studies was not performed. However, the sample size, case definitions, methods, analyses, reported outcomes, attrition rates and interpretations of findings of each study was evaluated. References were not rejected solely due to poor methodological rigour if they were assessed as relevant, but where reported an attempt was made to critique the reported findings in light of the methods used.

1.2 Obesity prevalence in the UK

1.2.1 The general population

Obesity is a growing international public health concern and has been reported as being responsible for 1 in 5 deaths worldwide (WHO, 2013). It is defined as abnormal or excessive fat accumulation that may impair health (WHO, 2006) and the World Health Organisation (WHO) has declared it ‘has reached epidemic proportions globally’ (WHO, 2005). Obesity is often classified using the body mass index (BMI). BMI is calculated by dividing a person’s weight in kilograms (kg) by the square of their height in meters (m). Although quite a crude measure, it is easy to calculate in a variety of settings and has been shown to correlate well with body fat, morbidity and mortality (Aronne, 2002). Table 1 summarises the BMI categories.

Table 1 Categories of Body Mass Index (as defined by WHO, 2005):

≤18.5 kg/m^2	= underweight
18.6 - 24.9 kg/m^2	= normal weight
24.9 - 29.9 kg/m^2	= overweight
≥30 kg/m^2	= obese
≥40 kg/m^2	= morbidly obese

In England the prevalence of obesity in women has risen, from 16% in 1993 to 26% in 2011, and in men from 13% to 24% (Department of Health, 2013). The rate obesity in 2-10 year olds has been rising in a similar manner, between 1995 and 2003 the prevalence rose from 9.9% to 13.7% (Jotangia et al., 2006), and recent statistics from the USA and Australia put this figure as high as 20% (Devi, 2008, The National Obesity Task Force, 2008). More recent UK data suggests that this rate may be beginning to plateau. In 2011 28% of girls and 31% of boys aged 2-15 years were classified as overweight or obese, compared to 29% and 31% the previous year (Department of Health, 2013). Being obese has major health implications for individuals, impacting on physical, emotional and psychological wellbeing. Obesity increases the risks of many life threatening diseases such as cancer, cardiovascular disease, stroke and diabetes whilst the rates of depression, anxiety and stress are much higher in obese individuals compared to their lean counterparts (Deierlein and Siega-Riz, 2012, Howard and Croker, 2012). Not only does obesity affect the quality of life of individuals (Amador et al., 2008), it also increases rates of morbidity and mortality places an immense burden on NHS resources. By the end of 2004 overweight and obesity was estimated to be directly responsible for 7% of mortality and morbidity in the UK with an estimated direct cost to the NHS of £3.23 billion per annum (Allender and Rayner, 2007).

1.2.2 Women of childbearing age

Obesity rates in women of childbearing age have also increased in line with the general population, 20.2% of women aged 25-34 years in 2011 Health Survey for England were defined as obese compared to 11% in 1993 (Department of Health, 2013). Obese women are known to be more likely to suffer from gynaecological problems; amenorrhoea, anovulation, polycystic ovary syndrome and infertility are all more prevalent in obese women (Brewer and Balen, 2010), and following the menopause they are at greater risk of endometrial cancer and breast cancer (Linne, 2004). The success of fertility treatment is also reduced and weight loss is advocated before treatment (Nelson and Fleming, 2006, Kennedy et al., 2006).

1.2.3 Pregnant population

The prevalence of obesity in the maternal population has also increased sharply (Heslehurst et al., 2007a, Kanagalingam et al., 2005). The proportion of women obese (BMI≥30kg/m^2) at pregnancy booking has doubled from 8% to 16% over the 19 years up to 2007 (Heslehurst, 2009). Of these obese women, 1.29% were morbidly obese, (BMI≥40kg/m^2), and 0.11% super morbidly obese, (BMI≥45kg/m^2). The proportion of women overweight at booking has also increased, although not so dramatically, from 22.3% to 24.80% over the same time period. The North East of England has one of the highest obesity rates in the country; 28% in the general adult female population (Department of Health, 2008), and 17.3% in pregnant women (Heslehurst, 2009). Obese pregnant women are more likely to be older, multiparous, of black/black British ethnic origin and are also 33% more likely to be unemployed and live in more deprived areas than pregnant women with normal BMI (Heslehurst et al., 2010, Heslehurst et al., 2012).

1.3 Obesity related pregnancy complications

Being obese at the onset of pregnancy is associated with increased risk of a range of adverse pregnancy outcomes. Rates of early miscarriage and repeat miscarriage are higher in obese women (Lashen et al., 2004) whilst the rate of stillbirth doubles. A recent systematic review and meta-analysis of 38 cohort studies reported that even a small increase in maternal BMI was associated with an increase in the risk of stillbirth, fetal, neonatal, perinatal and infant death (Aune et al., 2014). The reported relative risk (RR) of stillbirth in women with a BMI ≥35kg/m^2, for example, was 1.78, (95% confidence intervals [CI] 1.67-1.91) compared to normal weight women. Whilst the mechanism underpinning the association is poorly understood, Kristensen (2005) reported more unexplained fetal deaths and fetoplacental dysfunction in obese pregnant women (Kristensen et al., 2005).

The risk of a number of congenital anomalies, such as neural tube defects, cardiac anomalies, hydrocephaly and cleft lip and palate, is increased in obese women (Stothard et al., 2009, Rasmussen et al., 2008). The only anomaly for which obesity appears to confer a reduced risk is gastroschisis (OR 0.17, 95% CI 0.10-0.30). Biggio (2010), suggests that some of these congenital anomalies could be attributed to undiagnosed pre-gestational diabetes and not maternal weight alone (Biggio et al., 2010).

Gestational diabetes, pre-eclampsia, induction of labour (IOL) and caesarean section (CS), are more common, with the highest risk occurring in women with a BMI over 35kg/m^2 (Bhattacharya et al., 2007, Kerrigan and Kingdon, 2008, Catov et al., 2007, Poobalan et al., 2008, Smith, 2008). The risk of developing pre-eclampsia appears to be associated with obesity and pregnancy weight gain. The odds ratio (OR) for women with a BMI over 30kg/m^2 developing pre-eclampsia was reported as 2.59 (95% CI 2.87-3.01) compared to women with a BMI below 30kg/m^2. This risk increases with increasing BMI category, in women with super-morbid obesity (BMI≥50kg/m^2), the OR of developing pre-eclampsia if pregnancy weight gain was low was 3.90 (95% CI 3.21-4.74) whereas the OR in the group with high pregnancy weight gain was 13.4 (95% CI 7.93-22.7) (Mbah et al., 2010).

Postpartum haemorrhage, wound infection and thromboembolism are also serious health concerns. In a recent Confidential Enquiry into Maternal Deaths almost half of the women who died during the three year period covered by the report were obese (Lewis, 2007). The most common cause for CS in labouring obese women has been reported as delay in the first stage (OR 3.54, 95% CI 2.17-5.78) (Zhang et al., 2007). The myometrium from obese women has been shown to contract with less force and frequency *'in-vitro'* than the myometrium of normal weight women. This may explain the increased risks of slow labour progress and post-partum haemorrhage. Potential anaesthetic complications and difficulty with venous access add to possible delivery difficulties.

Obese women are also more likely to deliver a macrosomic infant, even obese women who have a normal glucose tolerance throughout pregnancy. There is no general consensus for the definition of macrosomia, which can be either defined in absolute terms, as a birth weight greater than 4000g or 4500g, or as a customised centile of birth weight for gestational age, for example greater than the 90^{th}, 95^{th} or 97^{th} centile (Walsh and McAuliffe, 2012, Campbell, 2014). The increased weight is attributed to increased adiposity as opposed to lean body mass (Sewell et al., 2006, Hutcheon et al., 2006, Ovesen et al., 2011) and increases the associated risk of shoulder dystocia. A high fetal weight gain during pregnancy also puts the infant at increased risk of hypoglycaemia, meconium aspiration and hyperbilirubinaemia (Hedderson et al., 2006, Stotland et al., 2006).

A growing body of evidence suggests that a fetus subjected to a suboptimal intrauterine environment with consistently high circulating glucose, insulin and triglycerides may become ‘pre-programmed’ to be obese in infancy and have subsequent cardiovascular disease and other metabolic disorders such as diabetes (Poston et al., 2011, Laitinen et al., 2012, Reynolds et al., 2013). Maternal insulin resistance has been associated with increased infant weight gain and adiposity in the first year of life (Hamilton et al., 2008), development of insulin resistance in-utero (Catalano et al., 2009), and increased risk of metabolic dysfunction in childhood (Catalano, 2010, Drake and Reynolds, 2010). A long term follow up study in the UK which examined the records of over 37000 pregnant women and followed their offspring into adulthood, reported an increase in all-cause mortality from cardiovascular disease for the offspring of overweight and obese women (Hazard ratio [HR] 1.42, 95% CI 1.19-1.69). BMI was calculated before the 20^{th} week of pregnancy and results were adjusted for maternal age at delivery, socio economic status, gestational age at delivery, gender and birth weight (Reynolds et al., 2013), suggesting that the in-utero environment is independently associated with infant health outcomes. Despite knowledge of the continued risk to the infant, research evidence to date cannot reliably determine the contributions of the in-utero environment, shared genetic factors or the shared family environment and eating habits (Nelson et al., 2010).

1.3.1 Clinical constraints related to care

Caring for obese pregnant women is often challenging for health care professionals. Palpating the presentation, position and growth of the fetus is difficult due to adiposity. Obtaining good quality ultrasound images and auscultating/monitoring the fetal heart are also difficult (Chang et al., 2013, Heslehurst et al., 2007b). Monitoring the fetal heart in labour can sometimes prove impossible if a fetal scalp electrode cannot be attached; this inability to monitor the wellbeing of the fetus may possibly contribute to the high CS rate.

Obese pregnant women have been shown to need increased numbers of appointments, time with maternity staff, tests and screening, increased clinical intervention rates as well as practical issues such as needing larger beds and theatre tables (Heslehurst et al., 2007b). Obesity in pregnancy is associated with a 45% increase in the number of maternity admissions and a 9% increase in the duration of stay compared to women within the normal BMI range (Denison et al., 2013).

Obese women are also more likely to retain weight gained during pregnancy beyond the post-natal period (Nohr et al., 2008) and so increase their long term risk factors for chronic diseases such as type 2 diabetes and high blood pressure (Villamor and Cnattingius, 2006). They are also likely to enter a subsequent pregnancy with a higher BMI.

1.4 Modifiable factors

Ideally women should have a healthy lifestyle and BMI within the normal range prior to conception. Behaviour change intervention directed towards weight loss pre-pregnancy could allay many of the problems previously discussed both in the short and long term (Catalano, 2010). However, few women seek advice prior to pregnancy, not all interventions are successful and long term weight loss is difficult.

Once pregnant it is the role of health care professionals to make women aware of possible increased risk factors associated with their BMI and support and advise them regarding lifestyle changes. It has been suggested that pregnancy should be an ideal ‘teachable moment’ for health promotion (Phelan, 2009).

Women may be more willing to engage in behaviour change if they feel it will benefit their baby as well as themselves (Lawlor and Chaturvedi, 2006). Unfortunately many professionals find it difficult to know what to advise and focus more on symptom recognition and management (Schmied et al., 2011). Much of the previous research carried out during pregnancy has focused on dietary advice and/or controlling gestational weight gain (GWG). GWG guidance in the USA follows the Institute of Medicine (IOM) recommendations (IOM, 2009). These recommendations acknowledge that the maternal pre-pregnancy weight has a greater impact on the health of a mother and her baby than GWG but nevertheless the recommendations advocate that a woman should aim to stay within a specific weight gain range depending on her pre-pregnancy BMI. A woman who has a BMI within the 'normal' range pre-pregnancy, for example, should aim to gain between 25-35 pounds (11-16kg), whilst a women with a BMI over 30kg/m^2 should aim to gain 11-20 pounds (5-9.7kg). These figures are based on observational evidence of the weight gain associated with optimal pregnancy outcomes. In the UK the NICE and CMACE/RCOG joint guidelines do not focus on the IOM recommendations as the evidence from which they are derived originates from observational studies that have made associations between weight gain and the best outcomes. These studies do not prove that achieving the recommended weight gains are possible or that they would be effective in producing the desired outcomes. Ideally more robust intervention studies are needed to prove the efficacy of weight gain recommendations. Rather, the UK guidelines emphasise that women should be made aware of the importance of healthy eating and appropriate exercise during pregnancy in order to prevent excessive weight gain and gestational diabetes (Modder and Fitzsimons, 2010, NICE, 2010).

1.4.1 Physical activity as a modifiable factor

There is increasing interest in the promotion of PA during pregnancy, not only in relation to maintaining energy balance and reducing excessive GWG, but also for its potential to improve pregnancy outcome for both mother and infant (Sorensen et al., 2003, Oken et al., 2006, Dempsey et al., 2004c, Chasan-Taber et al., 2008, Meher and Duley, 2007, Nelson et al., 2010). PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (EE) (Lagerros and Lagiou, 2007). An individual's total EE is a result of posture, PA, resting metabolic rate and the thermic effect of feeding, it is PA that predominantly affects variation in total EE. PA can be further divided into sport related or non-sport related activity, the latter includes EE related to occupational, leisure time, household, transportation and caring activities (Plasqui and Westerterp, 2007). When considering the health benefits of PA, the patterns, (that is, the frequency, intensity and type of PA), are as important as absolute EE. PA intensity is dependent upon the power required to perform the activity and also the body weight of the individual, (Watts x kg), and is more commonly considered in terms of metabolic energy equivalents/turnover (MET values) (Lagerros and Lagiou, 2007). At rest the average adult uses 1MET of energy per hour. Depending on the intensity of an activity it can be allocated a MET value from a standard reference list (Ainsworth et al., 2000a). Activities are usually categorised in terms of their intensity, that is, sedentary, light, moderate, vigorous or very vigorous. The intensities, equivalent MET values, physiological descriptions and PA examples are presented in table 2.

Table 2 PAEE intensities

Intensity	MET value	Description*	example
Sedentary	≤1	Resting, no PA effort	Sitting watching TV
Light	1-2.9	Little effort, no change to heart rate	Slow walking, Light housework, Cooking, Ironing
Moderate	3-5.9	Requires moderate effort, accelerates heart rate, still able to hold a conversation	Brisk walking, Cycling for pleasure, Aqua aerobics Active play with children
Vigorous	≥6	Requires a large amount of effort, causes rapid breathing, sweating and substantially increases heart rate	Jogging/running, Heavy lifting, Climbing, Fast swimming or cycling, Shovelling heavy loads.

*dependant on age, gender, cardiorespiratory fitness, muscle mass

1.5 Evidence supporting the role of physical activity from diseases in non-pregnant individuals

Evidence from studies in non-pregnant individuals has shown that increasing PA can improve many physiological, metabolic and psychological parameters and reduce the risk of developing some chronic diseases such as osteoporosis, sacropenia, hypertension and cardiovascular disease (Melzer and Schutz, 2010). Physical inactivity has also been cited as the most significant cause of insulin resistance (LaMonte et al., 2005). Lifestyle changes which include dietary modification and increased PA have been shown to reduce the risk of type 2 diabetes in individuals who were previously at risk. A systematic review and meta-analysis of interventions designed to prevent type 2 diabetes reported that PA or PA/education interventions reduced the risk of developing the condition (OR 0.53, 95% CI 0.40-0.70) whilst diet plus PA interventions reduced the risk even further (OR 0.43, 95% CI 0.35-0.53) (Merlotti et al., 2014).

Recommended levels of daily PA, (which includes an accumulation of 30 minutes of moderate or vigorous PA [MVPA] on all or most days of the week), have been shown to reduce the risk of coronary heart disease and improve lipid oxidation in individuals with type 2 diabetes (Hu and Tuomilehto, 2007, Trenell et al., 2008). A review of cohort studies published between 1996-2006 examining the relationship linking PA and health in women highlighted the role of PA in the primary prevention of cardiovascular disease, diabetes and some cancers (Brown et al., 2007b). Levels of PA have been shown to be inversely related to the development of metabolic syndrome (Franks et al., 2004) and increasing levels of PA may even have a more beneficial effect in unfit individuals. This research group also found that EE due to PA predicts the progression to metabolic syndrome independently of other confounding factors such as obesity (Ekelund et al., 2005).

It would therefore seem plausible that PA levels in overweight and obese pregnant women may modify some obesity related complications, particularly those such as gestational diabetes and pre-eclampsia which are associated with poor glycaemic control, insulin resistance and metabolic syndrome.

1.6 Physical activity measurement

Ideally any epidemiological study aiming to measure PA should examine all elements of bodily movement including the amount, intensity, frequency and duration. It is only by accurate measurement that true cause and effect between exposure and outcome can be hypothesised and conclusions drawn regarding the relationship between PA, health and disease. Difficulties in measuring, analysing and interpreting PA can lead to inaccurate conclusions regarding the effect of PA on health outcomes (Corder et al., 2007).

It therefore follows that to investigate the effects of PA in pregnancy an appropriate and reliable measurement method is required. It must also be acceptable to pregnant women, fit for purpose and sensitive enough to record the type and intensity of PA carried out in this population. In non-pregnant individuals PA has been measured extensively using one or more of these five methods:

- Direct observation
- Self-report, e.g. questionnaires, diaries, interviews
- Physiological, e.g. heart rate, temperature, ventilation
- Motion sensors, e.g. accelerometers, pedometers
- Indirect calorimetry, e.g. doubly labelled water

(Plasqui and Westerterp, 2007)

1.6.1 Objective measurement methods

Objective measurement methods include the use of pedometers, accelerometers, heart rate monitors, combined sensors (accelerometer and heart rate monitor, e.g. Actiheart), direct calorimetry and doubly labelled water (Plasqui and Westerterp, 2007). The use of doubly labelled water is considered to be the gold standard for monitoring EE. It involves ingestion of stable isotopes of water which are excreted via the urine over a 1-2 week period depending on the participants PA levels. Excretion rates are proportionate to the amount of metabolic carbon dioxide production, and therefore the oxygen consumption and EE during the isotope excretion time. This method is precise and safe for use in pregnant women, however, it is expensive and the protocol required is not always acceptable to study participants (Lagerros and Lagiou, 2007). This method is often used to validate other measurement methods, such as questionnaires and activity monitors.

Accelerometers, such as the Actigraph GT1M and GT3X models, are a simpler and cheaper alternative. They are attached to an individual via an elastic belt or clip and are placed over the right hip. Other models exist which can be attached to the ankle or wrist and a newer model which also senses body temperature and heart rate attaches to the non-dominant upper arm. They measure motion in uniaxial, (GT1M), and triaxial, (GT3X), plains and produce output in the form of activity and step counts. These activity counts can then be analysed via computer software packages to estimate time spent in different activity intensities, such as sedentary, light, moderate and vigorous. Movement can therefore be converted to PAEE. Unfortunately they are not waterproof and so must be removed for bathing and swimming, and are not especially reliable at monitoring the activity generated whilst cycling. Accelerometers are also affected by compliance; an individual is responsible for removing and replacing the monitor during the course of a day, forgetfulness, illness and discomfort can all impact on reliability of results.

The Actiheart device monitors participant's heart rate and has an inbuilt accelerometer which records activity counts, duration and intensity. The device is very small and attaches via 2 electro cardio graph (ECG) electrodes which are placed horizontally across the left side of the chest from the sternum. The monitor has the advantage of being waterproof; not being affected by the size and shape of the abdomen, which is important in obese or pregnant individuals, and once fixed should stay in place for several days without having to be removed. The computer software then calculates activity levels and EE more accurately than an accelerometer alone.

Pedometers are a relatively cheap and very well tolerated form of activity monitor. Newer versions are electronic and have either a horizontal spring-suspended lever arm that moves with the hips, (eg. Yamax, Digiwalker, Sportline), a glass enclosed magnetic reed proximity switch, (e.g. Omron and Oregon Scientific) or a horizontal beam and plezoelectric crystal (e.g. New Lifestyle and Lifecorder). More technically advanced models can estimate EE and distance travelled; however this measure is not valid or reliable enough for use in research. Daily step counts are then used as a proxy measure for activity and subsequent EE. Unfortunately pedometers are unable to give information about activity intensity or measure bouts of activity, (bouts of 10 minutes or more of moderate activity are believed to deliver the greatest health benefits) and are prone to many of the same limitations as accelerometers, for example, they do not register upper body movement (Corder and Ekelund, 2007). Whilst they do not give the depth of information that the other monitors give, because of their relative cheapness and availability pedometers can be used in larger population based studies and are often used successfully as motivational tools in intervention studies and programs (Bravata et al., 2007, Araiza et al., 2006). Individuals can monitor their own step counts via the display, unlike with accelerometers which must be downloaded to provide any results.

1.6.2 Subjective measurement methods

Subjective methods include self-completion questionnaires, diaries, direct observation and recall interviews. The benefit of such methods is that large population based surveys can be carried out relatively easily and cheaply, producing considerable amounts of data. Many of the more commonly used questionnaires such as the International Physical Activity Questionnaire, (IPAQ), the Kaiser Physical Activity questionnaire and the Norfolk Physical Activity Questionnaire, (EPIC), have been validated against accelerometers, doubly labelled water or direct calorimetry (Wareham et al., 2003). Their correlation with objective measurement methods and their repeatability varies, but in general they can distinguish between individuals who are relatively more or relatively less active. They also provide information about the types of recreational activity engaged in and the domains in which energy is expended, (work, home, transport or leisure). However they are less good at quantifying absolute PA amount (Wareham et al., 2003).

Unfortunately subjective methods tend to overestimate PA levels. An individual's perception of their activity intensity may differ from reality and the wish to give socially desirable answers will also consciously or subconsciously affect responses (Adams et al., 2005). Results are also subject to respondent and recall bias: an individual's ability to recall vigorous intensity activities has been shown to be greater than their recall of light intensity activities (Richardson et al., 2001). During pregnancy the type and intensity of PA that women carry out changes and includes more habitual activities of lower intensity. Many questionnaires focus on leisure time PA which again may not be appropriate for pregnant women or capture their EE (Fell et al., 2009, Ning et al., 2003). Studies in non-pregnant individuals have shown that increasing overall EE can have an important effect on glucose tolerance, (although not necessarily on cardiorespiratory fitness), thereby emphasising the importance of capturing low intensity habitual activity (Wareham et al., 2000).

Chasen-Taber (2004) designed a Pregnancy Physical Activity Questionnaire, (PPAQ), following the completion of three PA recall interviews on 235 ethnically diverse pregnant women in the USA. Responses from the recalls were then used to establish a list of activities for the questionnaire, which was subsequently validated against accelerometry. Three different accelerometer intensity 'cut-points' were tested against the PPAQ results and Spearman's correlation coefficients was found to be 0.25-0.34 for vigorous PA, 0.20-0.49 for moderate PA and -0.08-0.22 for light PA. Correlations were found to be good for more vigorous activity such as sport or exercise and occupational activities but not for household and care giving activities (Chasan-Taber et al., 2004b).

1.7 Physical activity in pregnancy

1.7.1 Evidence of effects: physical

There is increasing interest in the role PA may play in reducing the risk of certain physiological, metabolic and psychological complications in pregnancy as well as helping to maintain energy balance and control weight gain. Pregnant women undergo physiological changes to meet the increased metabolic demands of their bodies and the growing fetus, however they are still likely to benefit from PA in a similar manner to non-pregnant individuals (Gradmark et al., 2011, Melzer et al., 2010a). The potential benefits of regular PA include lower GWG, reduced risk of impaired glucose tolerance/gestational diabetes mellitus (IGT/GDM), pre-eclampsia, pregnancy induced hypertension, improved cardiac function, decreased musculoskeletal discomfort and improved mood stability (Melzer et al., 2010a). However, once pregnant, many women decrease PA levels, adopting or continuing a sedentary lifestyle which has the opposite effect of all the benefits listed above. Many observational studies have aimed to assess the association between the amount, type and intensity of PA before and during pregnancy and the subsequent development of complications. Table 3 highlights these studies and their main outcomes.

Several studies of varying size have compared PA levels to the subsequent development of GDM. These studies have predominantly used self-report PA measures such as interviews or questionnaires. However, one small study conducted in Sweden involving 35 pregnant women and 73 non-pregnant women used various objective measurement techniques (combined heart rate monitor and accelerometer, doubly labelled water, indirect calorimetry). The results indicated that PA was associated with a decreased first phase insulin response in both groups, suggesting that PA conveys similar benefits on glucose homeostasis in both pregnant and non-pregnant individuals (Gradmark et al., 2011). Four large prospective cohort studies and one case control study carried out in the USA are also presented (Deierlein et al., 2012, Zhang et al., 2006, Oken et al., 2006, Dempsey et al., 2004d, Dempsey et al., 2004b). All report an association between self-report PA and reduced risk of GDM. Three of these studies also measured pre-pregnancy PA and report a similar association between PA and reduced risk of GDM (Dempsey et al., 2004b, Dempsey et al., 2004d, Oken et al., 2006). Two retrospective studies also investigated the association between self-reported PA and GDM risk. A small Italian study found no association (Bertolotto et al., 2010), whilst a larger study in the USA found that PA was associated with a reduced risk of GDM in women with a BMI greater than 33kg/m^2 (Dye et al., 1997). Conversely one of the previously discussed cohort studies report that in overweight or obese women there was no association between PA and GDM (Deierlein et al., 2012). The findings of a Cochrane review also indicate no difference in the incidence of GDM in women who receive an exercise intervention during pregnancy, compared to those who do not, although the quality of available studies was reported as generally poor (Han et al., 2012). Some uncertainty also exists regarding the influence of BMI. This is further complicated by the fact that pre-pregnancy BMI has been shown to be an independent predictor of abnormal plasma glucose (Bertolotto et al., 2010).

The evidence associating PA and pre-eclampsia risk is mixed. Two large prospective studies carried out in Denmark and Holland found no association between self-reported PA and subsequent development of pre-eclampsia (Hegaard et al., 2010b, Vollebregt et al., 2010). Whilst a large prospective study carried out in the USA reported that regular leisure time PA, measured via self-report, resulted in a reduced risk of pre-eclampsia (Saftlas et al., 2004). A small retrospective case control study in the USA also found that regular PA prior to, or in early pregnancy resulted in a risk reduction (Sorensen et al., 2003). However, these results should be reviewed with caution as the data regarding pre and early pregnancy PA was collected via self-report interview in the post-natal period. A Cochrane review examining the association between PA and prevention of pre-eclampsia concluded that there was ‘insufficient evidence for reliable conclusions about the effects of exercise on prevention of pre-eclampsia and its complications' (Meher and Duley, 2006, Meher and Duley, 2009).

Similar disagreement has been reported regarding the association of PA and pregnancy outcomes such as gestation at delivery and infant birth weight. Four studies using self-report PA measurement methods report no association between PA and gestation at delivery (Jukic et al., 2012, Alderman et al., 1998, Duncombe et al., 2006, Both et al., 2010). Three of these studies also report no influence on birth weight, whilst one reports a decreased risk of delivering a large for gestational age (LGA) infant in women who self-reported more than two hours of leisure time MVPA per week (Alderman et al., 1998). Conversely, two studies also using self-report methods found an increased risk of low birth weight infants if women participated in vigorous PA five or more times per week (Campbell and Mottola, 2001, Magann et al., 2002), and a greater incidence of IOL and longer first stage of labour (Magann et al., 2002). Interestingly the later study involved women who were engaged in active duty in the USA Navy and participated in vigorous mandatory training and additional intense voluntary exercise. As such these results are unlikely to be generalisable to the wider civilian population (Magann et al., 2002). Two smaller studies which used objective measurement methods found that birth weight was inversely associated PA (Perkins et al., 2007) and women engaging in more than 30 minutes of MVPA per day were more likely to have a shorter second stage of labour and were less likely to have an operative delivery (Melzer et al., 2010b).

Other positive benefits of PA on chronic disease risk not presented in Table 3 include a decrease in the mean triglyceride concentrations. A linear relationship has been found between PA levels and triglyceride and cholesterol concentrations during pregnancy (Pivarnik et al., 2006, Butler et al., 2004), and lower concentrations of leptin have also been recorded in active pregnant women (Ning et al., 2005).

Possible mechanisms explaining why these risks are reduced in more active women include an enhanced placental growth and vascularisation, a reduction in pro inflammatory markers, cytokinins and leptin, a reduction in oxidative stress and increased antioxidant activity and improved plasma lipid and lipoprotein metabolism. Regular weight bearing exercise may also moderate insulin resistance (Pivarnik et al., 2006, Weissgerber et al., 2006).

Conclusions regarding benefits associated with PA remain unclear, possibly due to differing or poor study designs and measurement methods. Many of the studies collected data retrospectively and via self-report, thereby being prone to recall bias, social desirability bias and inaccurate perceptions of frequency and intensity of PA carried out. More robust evidence is required from large, well conducted prospective studies which use validated PA measurement methods to provide definitive results.

Table 3 Observational studies investigating effects of PA on disease risk.

GDM

Author	Study type	Population	Measurement method	Outcomes/Results
Deierlein (Deierlein et al., 2012)	Prospective cohort USA	1437 pregnant women	7 day self-report PA assessed via telephone interview at 17-22 wks, prior to OGTT. PA that was '*somewhat hard'* classified = moderate intensity, *'hard'* = vigorous	Any MVPA associated with lower risk hyperglycaemia, (aRR 0.73, CI 0.54-0.99). Women with BMI>25 = no association, (aRR 1.14 CI 0.78-1.66)
Gradmark (Gradmark et al., 2011)	Case control Sweden	35 pregnant women (28-32 wks) 73 non-pregnant women	Objectively measured PA via combined heart rate monitor and accelerometer, doubly labelled water, expired gas indirect calorimetry.	Total PA associated with reduced first phase insulin response in both groups, ρ non-pregnant = -0.47, pregnant = -0.36, ie. similar benefit on glucose homeostasis
Bertolotto (Bertolotto et al., 2010)	Retrospective observational Italy	268 pregnant women	OGTT at 27 wks. Self-report PA via IPAQ	PA not associated with GDM. Pre pregnancy BMI = independent predictor of abnormal plasma glucose.
Retnakaran (Retnakaran et al., 2009)	Longitudinal observation Canada	851 pregnant women, 28-32 wks, having glucose challenge test (GCT) and OGTT	Pre-pregnancy self-report PA via Baecke questionnaire	Trend for improved glucose tolerance status with increasing pre-pregnant PA. Women with normal GCT and OGTT reported higher vigorous PA pre-pregnancy
Zhang	Prospective	21765 non-	Self-report mailed questionnaire at	Inverse association vigorous PA

(Zhang et al., 2006)	cohort USA	pregnant women, followed up through pregnancy	3 time points prior to pregnancy. Estimated intensity and duration PA. Adjusted for BMI and dietary factors.	and GDM (RR 0.77 CI 0.69-0.94). Brisk walking also = lower GDM (RR 0.66 CI 0.46-0.95) 20 hr/wk TV + no vigorous PA = (RR 2.30, CI1.06-4.97)
Oken (Oken et al., 2006)	Longitudinal cohort USA	1805 pregnant women in first trimester	Modified PA Scale for the Elderly questionnaire.1 x questionnaire to reflect pre-pregnancy PA. 1x questionnaire at 26-28 wks to reflect previous 3 months. Adjusted for age, BMI, ethnicity	Any vigorous PA in year before pregnancy = reduced risk GDM, (OR 0.56 CI 0.33-0.95). Vigorous PA before pregnancy + light/moderate during GDM OR= 0.49 CI 0.24-1.01. No association television viewing and GDM
Dempsey (Dempsey et al., 2004a)	Prospective cohort USA	909 women in early pregnancy	Structured interview questioning PA in year prior to pregnancy and for 7 days prior to recruitment.	Any PA in year before pregnancy = risk reduction GDM, (RR 0.44 CI 0.21-0.91) compared to non-exercisers. Increasing levels of PA were associated with greater risk reduction. PA before and during pregnancy = RR 0.31 (CI 0.12-0.79).
Dempsey (Dempsey et al., 2004b)	Case control, USA	155 cases GDM 386 controls	PA prior to pregnancy and first 20 weeks via interview on the post-natal ward following delivery	Recreational PA in first 20 wks = reduced risk GDM (OR 0.52, CI 0.33-0.80). PA before pregnancy = reduced risk GDM but before and during pregnancy = greatest reduction, (OR 0.40 CI 0.23-0.68)
Dye	Retrospective	12799 women	Personal interview, women asked	When stratified for BMI, exercise

(Dye et al., 1997)	observational USA		on average how many times per week they exercised 30 mins above usual activities during pregnancy.	associated with reduced rates of GDM only in women with BMI>33

Pre-eclampsia

Author	**Study type**	**Population**	**Measurement method**	**Outcomes/Results**
Hegaard (Hegaard et al., 2010b)	Prospective observational Denmark	2793 pregnant women, gestation 12-18 weeks	Self-report questionnaire, asking basic questions re: leisure PA in year prior to pregnancy	Tendency towards lower risk of pre-eclampsia in women with highest PA, but no significant association.
Vollebregt (Vollebregt et al., 2010)	Prospective cohort Holland	3679 nulliparous women	Self-report questionnaire at first ante-natal appointment. PA via questions re: leisure time activities and intensity	No association between PA and pre-eclampsia or gestational hypertension.
Saftlas (Saftlas et al., 2004)	Prospective cohort USA	2739 pregnant women before 16 wks gestation	Interview including questions re: work and leisure time PA before and during pregnancy	Women who engaged in regular leisure PA, (OR 0.66, CI 0.35-1.22), or had non-sedentary jobs (OR 0.71, CI 0.37-1.36) had reduced risk pre-eclampsia.
Sorensen (Sorensen et al., 2003)	Case control, USA	201 cases pre-eclampsia, 383 normotensive	PA prior to pregnancy and first 20 weeks via interview on the post-natal ward following delivery	Regular PA in early pregnancy = reduced risk of pre-eclampsia, (OR 0.65 CI 0.43-0.99). Brisk walking compared with no walking = 30-33% reduced risk. PA prior to pregnancy= similar risk reduction.

Pregnancy outcomes

Author	Study type	Population	Measurement method	Outcomes/Results
Jukic (Jukic et al., 2012)	Prospective observational USA	1647 healthy pregnant women	PA self-report via telephone, 7 day recall at 14 weeks gestation. Perceived PA intensity in different domains.	Odds of pre-term birth lower with increasing frequency of first trimester recreational vigorous PA. aOR=0.08 (CI 0.006-1.0). Total vigorous PA no effect on gestation at delivery or birth weight.
Melzer, (Melzer et al., 2010b)	Prospective observational Switzerland	44 health pregnant women	PA via indirect calorimetry and Actiheart at 35-41 weeks gestation.	Active women had shorter second stage of labour, (88min v 146min, p=0.05), and were less likely to have operative delivery, p=0.06. No difference birth weight or other outcomes.
Both (Both et al., 2010)	Prospective observational (ALSPAC study) UK	11759 pregnant women, singleton fetus	PA in first and second trimester via postal questionnaire	PA not associated with birth weight, survival or gestation at delivery.
Lof (Lof et al., 2008)	Prospective observation Sweden	223 healthy pregnant women	Pre-pregnancy PA assessed via questionnaire at 12 wks gestation.	Women with high pre-pregnancy PA gained 0.1 kg/wk less than women reporting moderate PA (p=0.04). Pre-pregnancy PA not associated with birth weight.
Perkins (Perkins et al., 2007)	Prospective observation USA	51 healthy pregnant women	PA measured for 48 hours at 20 and 32 wks gestation via self-report recall diary, accelerometer	Birth weight inversely associated with accelerometry measured PA, (r=-0.42)

			and heart rate monitor	
Dumcombe (Duncombe et al., 2006)	Prospective observational Australia	148 healthy pregnant women	Pre-pregnancy PA data via retrospective questionnaire, recall diary at 3 time points during pregnancy, and post-natally	No association between length, intensity and frequency of PA and birth weight or gestation at delivery.
Magann (Magann et al., 2002)	Prospective observational USA (Navy)	750 healthy active pregnant women	Self-report of participation in mandatory and voluntary PA. Divided into quartiles depending on amount, intensity and gestation stopped exercise	Women doing more exercising more likely to need IOL RR= 1.84, (CI 1.05-3.20), have longer first stage, RR=1.38 (CI 0.16-2.60), and smaller babies, mean difference 86.5g (not significant)
Campbell (Campbell and Mottola, 2001)	Retrospective case control Canada	163 cases where birth weight ≤15th percentile for gestational age. 365 controls	Self-report PA questionnaire	Increased odds of low birth weight if participated in structured exercise ≥5 times per week aOR 4.61 (CI 1.73-12.32), and if <3 times per week aOR=2.64 (CI 1.29-5.39). Results relative to women who participated 3 or 4 times (considered optimal)
Alderman (Alderman et al., 1998)	Retrospective observational USA	291 randomly selected women for whom birth data available	Self-report PA via telephone questionnaire (carried out during pregnancy for a different study)	Any MVPA carried out for ≥2 hours per week associated with decreased risk large infant size, OR 0.3 (CI 0.2-0.7). No effect on SGA babies or gestation at delivery

*aRR= adjusted relative risk

1.7.2 Evidence of benefits to psychological health

Women frequently experience changes in mood and psychological wellbeing during pregnancy. Depression and anxiety are common (Howard and Croker, 2012) with the prevalence of depression being estimated as 18.7% in pregnant women and anxiety as 16.8% in women at 30 weeks gestation (Poudevigne and O'Connor, 2006). Women suffering from depression, anxiety and fatigue have reported that these symptoms are barriers to participation in PA during pregnancy. Ironically, these symptoms have been attenuated in non-pregnant women by increasing PA levels (Poudevigne and O'Connor, 2006). Research on non-pregnant individuals has also demonstrated a consistent relationship between inactivity and mood disturbances (Poudevigne and O'Connor, 2006). It is therefore plausible that PA in pregnancy confers psychological and emotional benefits. In a study by Da Costa (2003) 180 pregnant women were interviewed regarding the amount, frequency and intensity of leisure time PA undertaken during the first, second and third trimesters. Women also completed monthly questionnaires regarding depressed mood, state anxiety and Pregnancy Specific Stress and Hassles Scale. The results indicated a consistent association between psychological well-being and leisure time PA, especially in the first and second trimesters (Da Costa et al., 2003). Results from a large Danish birth cohort (involving 70866 women) reported a decreased risk of prescribed anti-depressant medication for women who participated in vigorous PA, as assessed by telephone interview at 12 weeks gestation (OR 0.81, 95% CI 0.66-0.99). However, there was no association with other intensities of PA or with hospital admission for depressive symptoms (Strom et al., 2009). A review of the literature surrounding PA patterns and psychological health found that both PA and mood decreased as pregnancy progressed, although the author could not say if the two were directly related as the validity of some of the PA measurement methods was poor (Poudevigne and O'Connor, 2006). However, more recently a study in the USA involving 141 pregnant women reported an inverse association between depressive symptoms and objectively measured PA using Actigraph accelerometers over a seven day period (Loprinzi et al., 2012).

Having a high BMI has also been associated with depressive symptoms and anxiety post-natally (Carter et al., 2000). These findings have been supported by the results of a large birth cohort in the USA which included data from 1053 women in the post-natal period (LaCoursiere et al., 2010). This study reported that women with a pre-pregnancy BMI ≥ 35kg/m^2 were at an increased risk of developing post-natal depression (OR 2.87, 95% CI 1.21-6.81 for BMI≥35kg/m^2, and OR 3.94, 95% CI 1.38-11.23 for a BMI ≥ 40 kg/m^2). It is therefore likely that increasing PA in obese pregnant women will be even more beneficial to their psychological wellbeing both antenatally and post-natally.

1.7.3 Evidence of potential harm

The risks associated with participating in PA during pregnancy have also been debated. Concerns regarding contact sports, team sports or activities requiring balance have long been raised and participants should be made aware of musculoskeletal and blood pressure changes during pregnancy as well as being warned to avoid dehydration and hyperthermia (ACOG, 2003, Bell and Dooley, 2006, Benelam, 2011, Olson et al., 2009). The risks of more serious pregnancy complications are unclear. Higher levels of PA have been linked with increased risk of miscarriage, pre-term birth, IOL, prolonged labour and reduced infant birth weight (Jukic et al., 2012). Animal studies have shown that there is a decreased uterine blood flow during PA; however, studies in pregnant women have been inconclusive (Jukic et al., 2012). Concerns have also been raised about a reduction in the supply of oxygen and glucose to the fetus when the mother participates in exercise. This decreased supply of oxygen and nutrients to the placental site leads to decreased intervillous and fetal partial pressures of oxygen, so resulting in an increased fetal heart rate. However, PA also stimulates an increase in haemoconcentration and improved placental perfusion, together these three factors result in maintenance of fetal tissue perfusion and oxygen uptake (Clapp, 2003). Commencing exercise once pregnant is also thought to be safe. A study which randomly allocated 46 previously sedentary pregnant women to either continue with no exercise or to participate in an 8 week weight bearing exercise program found that mid-trimester placental growth rate was faster, and indices of placental function greater in the exercise group (Clapp et al., 2000). Alternatively, in a study involving 75 healthy, exercising pregnant women, who subsequently reduced the exercise levels they participated in after 20 weeks gestation, placental growth was found to be greater than in those women who continued with moderate intensity and weight bearing exercise (Clapp et al., 2002). Women who continued with the high volume of exercise also had babies that were lighter, (mean birth weight 3.39kg versus 3.81kg) and leaner (8.3% fat versus 12.1% fat), compared to women who reduced their exercise volume. It is important to highlight that both groups had acceptable mean birth weights and that lower body fat mass is unlikely to be a disadvantage in an otherwise healthy baby.

A large cohort study carried out in Denmark involving 92671 pregnant women found that women who reported recreational exercise, (especially high impact), for more than 7 hours per week had a higher risk of miscarriage in the first trimester compared to non-exercisers (HR 3.7, 95% CI 2.9-4.7). The study aimed to collect the PA data prospectively at 12-16 weeks gestation via a telephone based questionnaire, however, women who had already miscarried by that point reported their PA retrospectively. Although adjustments were made for gestational age of interview and amount of exercise reported, the authors suggest that the findings should be treated with caution because the values were based on self-reported PA levels (Madsen et al., 2007).

A Cochrane review which examined the evidence surrounding aerobic exercise for women during pregnancy concluded that the ‘available data are insufficient to infer important risks or benefits for the mother of infant’ (Kramer and McDonald, 2006). More methodologically robust, larger studies were recommended before evidence based advice could be given.

1.8 Guidelines and advice surrounding physical activity in pregnancy

In the absence of either medical or obstetric complications professional bodies in the UK and USA encourage the maintenance of PA during pregnancy. The RCOG recommends that ‘all women should be encouraged to participate in aerobic and strength-conditioning exercise as part of a healthy lifestyle during their pregnancy’ (Bell and Dooley, 2006), whilst the American College of Obstetricians and Gynaecologists, (ACOG), recommends the adoption of non-pregnant guidelines, which includes a total accumulation of 30 minutes or more of moderate exercise on all or most days (ACOG, 2002, Physical Activity Guidelines Advisory Committee, 2008, ACOG, 2003).

In July 2010 NICE published new guidelines on dietary interventions and PA interventions for weight management before, during and after pregnancy. (www.nice.org.uk/guidance/PH27)(NICE, 2010).

The recommendations are based on strategies which have been shown to be effective for the non-pregnant population and are assumed to help women to maintain a healthy weight in the long term. The advice aims to benefit all pregnant women but particularly obese women. It includes evidence based information about healthy eating and suggestions as to how to incorporate more PA into everyday life. This includes recreational activities and also habitual activities such as stair climbing instead of using lifts, and modes of transport that involve PA, whilst simultaneously reducing sedentary time. The more specific guidance about the amount and type of PA during pregnancy are as follows in table 4.

:

Table 4: Guidelines regarding PA in pregnancy

- Advise that moderate-intensity physical activity will not harm her or her unborn child. At least 30 minutes per day of moderate intensity activity is recommended.
- Give specific and practical advice about being physically active during pregnancy.

    Recreational exercise such as swimming or brisk walking and strength conditioning exercise is safe and beneficial.

    The aim of recreational exercise is to stay fit, rather than reach peak fitness.

    If women have not exercised routinely they should begin with no more than 15 minutes of continuous exercise, three times per week, increasing gradually to daily 30-minute sessions.

    If women exercised regularly before pregnancy, they should be able to continue with no adverse effects.
- Explain to those women who would find this level of physical activity difficult that it is important not to be sedentary, as far as possible. Encourage them to start walking and to build physical activity into daily life, for example, by taking the stairs instead of the lift, rather than sitting for long periods.

In order to implement these guidelines it is therefore essential to know how much PA pregnant women, specifically overweight and obese pregnant women, are doing, so that health care professionals can support and advise pregnant women accordingly.

1.9 Physical activity levels in pregnancy

There is limited data describing contemporary PA levels among pregnant women. Available data is mostly based on self-report, which may over-estimate activity albeit providing valuable information about activity trends and correlates. Much activity in pregnancy is low intensity and dominated by childcare and domestic tasks, activities which may be less well captured by questionnaires as many focus on leisure time fitness related activities (Ning et al., 2003, Evenson

et al., 2004b). Semi-structured interviews and recalls provide a richer source of information about the variety of activities carried out by women.
All studies reporting subjective assessment of PA during pregnancy report a decrease in comparison to pre-pregnancy levels or between first and second or first and third trimesters, (Borodulin et al., 2008, Borodulin et al., 2009, Clarke et al., 2005, Derbyshire et al., 2008, Duncombe et al., 2009, Fell et al., 2009, Lof and Forsum, 2006, Mottola and Campbell, 2003, Pereira et al., 2007, Hausenblas et al., 2011).

The most common types of reported leisure time activities are walking followed by swimming (Evenson, 2004, Liu et al., 2011). Participation in most sports seems to decrease. However, reported levels of walking remain stable, (Pereira et al., 2007), or increased (Mottola and Campbell, 2003), although the walking pace decreases as pregnancy progresses, so leading to a decrease in EE (DiNallo et al., 2008).

When questioned, most pregnant women report carrying out child or adult care, household and outdoor activities such as gardening (Borodulin et al., 2009, Clarke et al., 2005, Derbyshire et al., 2008, Schmidt et al., 2006a). Whilst there tends to be a shift towards lighter household activities, the proportion of EE from these habitual activities often increases through pregnancy as work and leisure time EE decreases.

Few studies have measured PA objectively during pregnancy. Rousham (2006) measured activity in 58 women throughout their first pregnancy using an Actiwatch (an accelerometer attached to the ankle) and self-report. With both measures there was a decrease in PA between the second and third trimesters. However, compliance with wearing the monitors also decreased between the first and third trimester (Rousham et al., 2006). Evenson et al (2011) also measured PA objectively in all three trimesters using Actigraph accelerometers in 359 health pregnant women in the USA (Evenson and Wen, 2011). MVPA decreased between first and second trimesters to the third trimester (11.5 minutes, 14.3 minutes and 7.6 minutes per day respectively). Over half of the participants recorded time was spent in sedentary activities throughout pregnancy. Harrison et al (2011) used the Yamax pedometer and IPAQ to measure PA in 97 pregnant women, (mean BMI=30.3, age=31.7), at 12-18 weeks and 26-28 weeks gestation in an observational study in Australia (Harrison et al., 2011). Recorded mean daily step count decreased between measurement time points, from 5437 to 4097, however self-reported PA remained stable and there was no correlation between step count and IPAQ total calculated MET values.

Several studies report that pregnant women do not meet the recommended activity guidelines. Less than 12% of women self-reported achieving 30 minutes of moderate PA per day in a study by DiNallo, (DiNallo et al., 2008), whilst Borodulin, 2008, found that only 38% of their participants met the Centre for Disease Control and Prevention and the American College of Sports Medicine guidelines which include all types of PA (Pate et al., 1995). Meanwhile only 3% met the ACOG exercise during pregnancy guidelines (Borodulin et al., 2008, ACOG, 2003).

1.9.1 Factors associated with activity levels

The associations between PA levels carried out by women during pregnancy and demographic characteristics have been investigated in several studies. Higher leisure time PA has been found in women with higher education, younger age and excellent or very good health compared to those with fair or poor health (Evenson, 2004). Exercise in the year before pregnancy was found to be the best predictor of PA during pregnancy, (OR 48.9, 95% CI 16.6-143.6) (Ning et al., 2003)). Mottola, (2003), also found that participation in regular recreational activities was associated with postsecondary education, not having children at home and not-smoking. Having other children, being overweight pre-pregnancy and a higher weight gain during pregnancy are all associated with discontinuing regular exercise or not meeting recommended levels of PA (Mottola and Campbell, 2003, Pereira et al., 2007, Fell et al., 2009).

1.10 Intervention studies in pregnancy

Given the growing evidence highlighting the beneficial effects of PA on obesity related pregnancy complications several intervention studies have been undertaken. Many of the primary research outcomes for these interventions have focused on minimising GWG in the expectation that this would reduce complications, have a positive effect on post-partum weight retention and therefore lower the risk of the development of future chronic disease such as Type 2 diabetes or GDM in subsequent pregnancies (Mottola, 2009). Table 5 documents the published studies that include some form of PA behaviour change intervention. The interventions vary widely from group, individual education or supervised exercise sessions to home based unsupervised activities. Many contain goal setting, motivational or behaviour change techniques. Interventions which do not contain a PA component have not been included.

Table 5 **Intervention studies in pregnancy involving PA**

Author	Design	Participant characteristics	Intervention	Results	Comments
Gray Donald, (Gray-Donald et al., 2000)	Canada, Non-randomised, historical control group	Cree Indian community, (high risk of Type 2 Diabetes). BMI=all. No history of IGT. Intervention n=112, Control n=107	Social learning theory. Individual dietary counselling, PA sessions, community activities based around nutrition advice- supermarket tours, cookery classes.	No difference in rate of weight gain or total GWG between groups.	In community = desirable to be ‘plump’ and not desirable to be physically active during pregnancy.
Polley, (Polley et al., 2002)	USA, RCT	Low income population. BMI>19.8, Age>18 yrs Intervention n=57, Control n=53	Behavioural intervention. Stepped care approach Advice re: GWG, healthy eating and PA. Personalised weight gain chart, more intensive input if exceeding IOM guidelines	Intervention group: women with BMI<25 less likely to exceed IOM guidelines than control Women BMI>25 more likely to exceed guidelines,	Post-partum weight retention strongly related to weight gain in pregnancy, r=0.89
Olson, (Olson et al., 2004)	USA Non-randomised. Historical control group	BMI 19.8-29.0 Age> 18yrs Intervention n=179, Control n=381	Education provided via post. Guidance re: weight monitoring. Aim- to keep GWG within IOM recommendations	Overall no difference in GWG between groups. Low income women in intervention gained less weight	Overweight low income women less likely to retain weight post natally.
Hui, (Hui et al., 2006)	Canada. RCT	BMI= all Intervention n=24, Control n=21	Individual session with dietician- ‘food choice map’, group exercise x1 week, 45 mins with personal trainer + home based sessions 3-5 /wk	Increase in PA in intervention group, otherwise no difference in GWG or birth weight.	Pilot study only, concluded that feasible to deliver the intervention.
Kinnunen,	Finland.	Para 0	Counseling sessions with	No difference between	

(Kinnunen et al., 2007b)	Non-randomised controlled trial	Age >18yrs Intervention n=49, Control n=56	public health nurse re: PA and diet recommendations. 1 x primary PA session + 4 booster session, 1 x primary diet session + 3 booster sessions. Optional exercise session.	GWG or % exceeding IOM guidelines.	
Claesson, (Claesson et al., 2008b)	Sweden Non-randomised controlled trial	BMI≥30 Intervention n=155, Control n=193	Education and motivation at weekly 30min sessions with midwife. Women involved in setting own goals. Aqua aerobic classes offered 1-2 times/week	GWG in intervention group signif less, $p<0.001$, and higher proportion within IOM guidelines. No differences in pregnancy outcomes.	Women reported positive experience from individual motivational sessions.
Ong (Ong et al., 2009)	Australia RCT	BMI≥30, ≥18 weeks Intervention n=6, Control n=6	10 week home based, supervised exercise on stationary cycle x3 per week. PPAQ and OGTT before and after intervention	Intervention attenuated the decline in insulin sensitivity form baseline to 28 wks. No differences in self-reported PA, insulin, glucose.	Small sample size but good compliance with intervention.
Asbee, (Asbee et al., 2009)	USA RCT	Stratified by BMI Age 18-49yrs Intervention n=57, Control n=43	Dietician x1 at beginning of pregnancy. Advised GWG Encouraged to engage in MVPA 3-5 times/wk. Encouragement and feedback at subsequent health care contacts.	Lower GWG in intervention group No differences in achieving IOM guidelines or pregnancy outcomes No neonatal outcomes	An important predictor of adherence to IOM guidelines = normal pre-pregnancy BMI. PA not measured.
Guelinckx (Guelinckx et	Belgium 3 arm RCT	BMI≥30 n=65 per arm.	Brochure = advice on diet, PA and tips to limit GWG.	PA decreased in all groups by 3rd trimester.	Self-report diet recall and Beake PA questionnaire.

al., 2010)		1.Passive advice from brochure, 2. Brochure + lifestyle education, 3. Control group	Lifestyle education = 3x1hr group sessions with nutritionist. Healthy balanced diet and ideas of how to increase PA	No difference between groups in terms of GWG, obstetric and neonatal outcomes.	
Shirazian, (Shirazian et al., 2010)	USA Cohort with matched controls	BMI≥30 first trimester Intervention n=24, Controls n=21	Written material, counselling sessions and seminars re: healthy eating and walking to increase PA. Given pedometer and food diary.	Lower GWG in intervention group,	
Hopkins (Hopkins et al., 2010)	New Zealand. RCT	Para 0, women <20 weeks. Age 20-24 yrs. BMI=All. Intervention n=47, Control n=37	Home based stationary cycling, individually prescribed up to 5x40 min sessions/week. Insulin sensitivity measured at 19 and 34-36 weeks.	Birth Wt and BMI of intervention group offspring and IGF in cord blood lower. No difference in insulin sensitivity	Effect of exercise on fetal growth independent of insulin sensitivity.

Studies published since commencing thesis

Author	**Design**	**Participant characteristics**	**Intervention**	**Results**	**Comments**
Huang (Huang et al., 2011)	Taiwan 3 arm RCT	BMI= all 1.Programme from 16 wks gestation -6 months post-partum. n=61. 2.Programme from birth to 6 months post-partum. n=64. 3.Comparison,	1.= 1x 40 min individual counselling session re: diet. PA goals set re: GWG, + 5x booster sessions + brochure. 2.=First session 24-48 hours after birth, 2x booster sessions, + brochure.	GWG lower for intense intervention group 1, weight retention lower for both intervention groups than comparison group.	

		routine care. n=64			
Phelan (Phelan et al., 2011)	USA, RCT 'Fit for Delivery' study	Diverse ethnic and socioeconomic population. BMI=all Intervention n=201, Control n=200	1x face to face visit, discussion re: GWG, PA and diet goals set. Weekly supportive mailed material. Individual graphs of weight gain, 3 telephone feedback sessions.	Fewer women with BMI<25 exceeded IOM GWG in intervention group. No difference if BMI>25. 6 weeks PN all women in intervention more likely to achieve pre-conception weight.	Women with BMI>25 may need a more intense intervention during pregnancy. Information learnt during pregnancy implemented P/N.
Nascimento (Nascimento et al., 2011)	Brazil RCT	Age≥18 yrs, BMI≥26 Gestation 14-24 wks Intervention n=40, Control n=42	Aim=increase PA and improve QOL. Counselling re: GWG, exercise and nutrition. 1x supervised class/wk. 5x unsupervised home exercise sessions.	No difference in GWG, hypertension, C/S, LGA babies.	Compliance with home exercise stated as 60%
Vinter (Vinter et al., 2011)	Denmark RCT LiP study (Lifestyle in Pregnancy)	BMI≥30, Age 18-40, Gestation 10-14wks. Intervention n=180, Control n=180	4x counselling sessions with dietician, aim to limit GWG. Encouraged to do more than 30mins MVPA, given pedometer, free gym membership, 1x class wk with physio.	Lower GWG in intervention group, no diff in % women meeting IOM guidelines or any obstetric outcomes.	
Haakstad (Haakstad and Bo, 2011)	Norway. RCT	Para 0 Sedentary lifestyle, Gestation<24 weeks, BMI<25 Intervention n=52, Control n=53	2x60 min dance aerobic group classes/wk for 12 wks + 30 mins self-imposed moderate PA at home on other days + short bouts PA encouraged generally	No difference in birth weight between groups. Good compliance with intervention	No evidence of harm from aerobic classes
Luoto, (Luoto	Finland	Normal OGTT + 1	Diet + PA counselling at 5	Intervention group had	

et al., 2011)	Cluster RCT NELLI study	other risk factor for GDM. Gestation 8-12 wks Intervention n=246, Control n=196	antenatal appts. with midwife. PA= increase leisure time PA up to recommendations. Aim to achieve 800 MET mins per week. Invited to monthly group session.	reduced birth weight, -133g, 95%CI -231 to -35. No difference in incidence of GDM	
Wilkinson, (Wilkinson and McIntyre, 2012)	Australia RCT, Evaluation: 'Health Start to Pregnancy'	BMI=All Intervention n=178, Control n=182	1 hour group session. Involving assessment of diet and lifestyle, advice re: nutrition and PA, and links to more specialist services.	Assessment of diet, lifestyle and PA at baseline and 26 weeks. No differences in PA or diet quality.	Low intensity, healthy lifestyle workshop. Only 48% attended workshop.
Barakat, (Barakat et al., 2012)	Spain. RCT	Healthy pregnant women. Intervention n=40, Control n=43	3x per week exercise classes (land or aqua), throughout pregnancy.	Fewer cases of IGT in the intervention group. No difference in GWG	Mean BMI within normal range.
Stafne (Stafne et al., 2012)	Norway RCT	Health, low risk pregnant women. Gestation 18-22 wks. Intervention n=429 Control n=426	12 week exercise program. 1x60 min group exercise session with physiotherapist per week + 2x 45min home exercise sessions per week	No difference in incidence GDM or insulin resistance between groups at 32-36 weeks.	
Price (Price et al., 2012)	USA. RCT	Sedentary women, BMI<39, Gestation 12-14 wks Intervention n=43, Control n=48	4 x week 45-60 minute supervised aerobic training sessions of at least moderate intensity.	Intervention = improved fitness + strength. Higher vaginal delivery rate. No difference in other outcomes.	Excellent compliance with intervention.
Oostdam (Oostdam et	Netherlands RCT, FitFor2	BMI≥25, At risk of GDM.	2 x week 60 minute supervised exercise	No differences in fasting glucose, insulin, HbA1C,	Poor compliance Decrease in PA in both

al., 2012)	programme.	Intervention n=62, Control n=59	sessions, comprising of aerobic and strength PA.	GWG obstetric/neonatal outcomes or objectively measured.	groups as pregnancy progressed.
Poston (Poston et al., 2013)	UK Pilot RCT 'UPBEAT'	BMI≥30, Gestation≥15 wks <18wks. Intervention n=94, Control n=89	8x face to face group sessions with study health trainer. Lifestyle, dietary and PA advice given, goal setting approach. Handbook, DVD and pedometer given.	Improved nutrition/GI in intervention group. No difference in objectively measured PA.	Main trial underway, primary outcome= difference in IGT + LGA between groups.
Rauh, (Rauh et al., 2013)	Germany. Cluster RCT FeLIPO	BMI≥18.5, Age≥18yrs, Intervention n=167, Control n=83	2 individual counselling modules in the 20th wk (60min covering nutrition, PA and GWG), and 30th wk (30min problem solving).	GWG + % exceeding IOM recommendations less in intervention group. No difference obstetric/ neonatal outcomes or self-reported PA (IPAQ)	Difference in BMI categories between groups at baseline, greater % BMI≥25 in control
Dodd (Dodd et al., 2014)	Australia RCT LIMIT study	BMI≥25 Gestation 10-20wks Intervention n=1108, Control n=1004	Diet + lifestyle advice, goal setting + cognitive behaviour change. Dietician x 2 face to face. Research assistant 3x telephone, 1x face to face. PA advice= increase walking and incidental PA	Intervention less likely to have infant >4000g. No difference in LGA babies, maternal or neonatal outcomes	

Published protocols, studies in progress					
Author	**Design**	**Participant characteristics**	**Intervention**	**Outcome measures**	**Comments**
Smith (Smith et al., 2010)	UK, Prospective Study 'Community Lifestyle Programme'	BMI≥30 Planned n=400	10 wk programme, 1.5 hours/wk. Designed to increase skills + knowledge to adopt healthy behaviours.	GWG, C/S, birth weight, psychological outcomes. Experience of pregnancy, PA levels, diet, acceptability.	
Moholdt (Moholdt et al., 2011)	Norway RCT ETIP trial	BMI≥30 Sedentary, Planned n=150	3x organised exercise sessions per week starting at 14 weeks	GWG, exercise capacity, PA level, body composition, serum markers etc at 37wks. Baby: Apgar + Anthropomorphic	
Nagle (Nagle et al., 2011)	Australia RCT	BMI≥30 Para 0, Gestation<17 wks Planned n=214	Intervention = continuity of care midwifery model + info leaflet on managing GWG. Control = standard care + leaflet	Primary = % women not exceeding IOM GWG. Secondary = evidence of care from notes + women's experiences.	
Skouters (Skouteris et al., 2012)	Australia RCT	BMI 18.5-25. Gest <18 wks Planned n=220	1x face-face individual session with health coach + 1x telephone session + 2x 2hr group education sessions. Control = 2x 2hr group education sessions	BMI, waist circumference and psychological factors measured baseline, 32 wks and post-natally up to 12 months.	Normal range BMI
Warren (Warren et al., 2012)	UK. Feasibility and	Assessing the 'Eat Well Keep Active' program	Client centered, motivational interviewing, goal setting at 12-16 weeks, balanced diet	Self-report food frequency questionnaires, PA via	

	acceptability study		and PA. Personalised goal card, telephone contact after 2 weeks. Semi structured interview after 6 weeks	PPAQ, Health care self-determination theory pack HC-SDT.	
Adamo (Adamo et al., 2013)	Canada RCT, 'MOM' - maternal obesity management.	BMI>18.5 Gestation 12-20 wks Intervention n=30, Control n=30	Healthy pregnancy handbook, 2x exercise classes/wk, 3x nutrition classes over whole pregnancy.	Feasibility and compliance. GWG, baby BMI + anthropomorphic measures.	Objective and subjective PA measurement. 7 day diet recall
Jelsma (Jelsma et al., 2013)	9 European countries. RCT DALI (Vitamin D and lifestyle intervention for GDM prevention)	BMI>29 Gestation <19+6 Planned n=880, 8 arm RCT, n=110/arm	4 of 8 arms contain PA element, on its own or in combination with diet, diet + vit D, diet + placebo. PA= 5x face-face +4 booster telephone calls with lifestyle coach. Aim moderate PA≥ 5days/wk, ≥30mins	GWG, fasting glucose + insulin sensitivity, obstetric and neonatal outcomes.	
Briley (Briley et al., 2014)	UK Multicenter RCT 'UPBEAT'	BMI≥30, Gestation≥15 wks<18wks. Planned n=1546	As pilot above	Reduced IGT and macrosomia in intervention group. Neonatal and obstetric outcomes.	6 month post-natal and planned 3 yr follow up of infants

Despite all the theoretical evidence and evidence from the non-pregnant population regarding the role of PA, dietary factors and health outcomes, (especially in overweight and obese women), there is still no definitive evidence from intervention studies regarding the most appropriate programme to deliver to this at risk group of women. Evidence confirming that PA levels can be effectively increased and whether this increase would result in improved outcomes remains unclear. Possible problems include poor compliance with interventions by participants, (for example Nascimento 2011, Wilkinson 2012, Oostdam 2012), or the fact that PA behaviour change was not achieved (Poston, 2013). PA has frequently been measured by self-report which, as previously discussed, is prone to bias and possible overestimation by individuals. Results from studies may indicate PA has been increased with no resulting benefit in outcomes. Alternatively, PA may not have been measured at all thereby making it impossible to show efficacy of the intervention.
Results from systematic reviews have found the quality of evidence from intervention studies to date to be very low and the results to be of insufficient quality to enable recommendations for clinical practice (Ronnberg and Nilsson, 2010, Dodd et al., 2010). All of the studies in both of these reviews contain interventions which included a dietary component, whilst less than half also provide a PA component.

Intervention studies and systematic reviews that have been conducted and reported since the start of this thesis reinforce these conclusions. Meta-analyses of results from studies have also been problematic and provided inconclusive results due to the heterogeneity in intervention content and differing demographic characteristics of participants. A Cochrane review focusing on preventing excessive weight gain during pregnancy (Muktabhant et al., 2012) concluded that for high risk women, none of the 28 interventions examined appeared to reduce excessive weight gain. Of these 28 interventions, 10 included both dietary and PA components, three contained just PA components, one gave advice about appropriate GWG and the remaining 14 studies contained a diet only intervention. The components of all of the interventions were very heterogeneous and many of the results could not be combined. It was concluded that significant methodological limitations contributed to the inability to provide evidence based recommendations from the review.

Campbell et al (2011) included eight qualitative studies that investigated the views of women regarding weight management, and five quantitative studies which included diet and PA interventions in their systematic review. No difference in GWG between the intervention and control groups in the pooled analysis was found, and it was suggested that the interventions failed because specific barriers women face when trying to maintain a healthy weight gain were not addressed (Campbell et al., 2011). A meta-analysis by Gardner et al (2011) did find a small but significant positive effect on GWG by interventions involving diet and PA behaviour change. However, the authors report moderate between-study heterogeneity of results; four of their included studies were effective, eight ineffective. Also, despite the differences in intervention content and participants, (for example, some studies included all BMI categories, some included just overweight or obese women), all results were pooled into the same meta-analysis. The authors conclude that successful active ingredients of interventions could not be identified due to a failure to adequately explain intervention content, monitor behaviour change or identify the psychological determinants of the behaviour (Gardner et al., 2011). Skouteris et al (2010) included ten studies in their review however only five of the studies measured PA, six measured diet whilst four measured neither (Skouteris 2010). Inconsistent findings were reported with four of the included studies having no effect on GWG, one was effective in normal weight women, one in low income women, one in overweight women and two in obese women. Only one of the studies appeared to be effective in participants within the whole BMI range. Again, it was impossible to identify which intervention components were successful and the authors concluded that greater consideration of the psychological factors involved in behaviour change would be beneficial (Skouteris et al., 2010). Thangaratinam et al (2012) identified 44 studies (including a total of 7278 pregnant women) that involved either a dietary or lifestyle intervention (Thangaratinam et al., 2012b). Eighteen studies involved a PA intervention, 13 involved a dietary intervention whilst 13 contained a mixed dietary and PA intervention. Studies that reported change in maternal weight found that, compared to the control group, the intervention group had a lower GWG although there was no difference between groups in terms of meeting IOM GWG recommendations. The pooled overall effect on pregnancy outcome found a reduction in the rates of pre-eclampsia, but only a trend towards a reduction in GDM, pregnancy induced hypertension and no difference in gestation at delivery, IOL or C/S rates. Dietary interventions alone appeared more successful, showing a reduced risk in GDM and a reduction in hypertension and pre-term delivery. In contrast, there appeared to be no difference between the control and intervention groups in PA and mixed approach studies. However, sensitivity analyses carried out on studies where women did not have GDM found a significant reduction in GWG in all study types, (dietary, PA, and mixed). This systematic review would appear to indicate, and concludes, that lifestyle interventions, especially dietary interventions are effective in reducing GWG without any reported adverse effects on the fetus. However, Heslehurst, (2013), urges caution when interpreting the results of this review, suggesting that this synthesis does not take into account the quality of some of the data sources, which were rated as low to very low (Heslehurst, 2013). Other issues which have not been taken into consideration are whether or not the participants in the included studies engaged and complied with the intervention or whether a behaviour change was achieved. It is impossible to say if a specific intervention is, or is not, effective if there is no evidence that the intervention, or desired behaviour change, has actually been carried out. Poston (2012) proposed that it is not surprising that only a modest reduction in GWG was achieved with no difference in clinical outcomes, as the proportion of pregnant women who achieved IOM GWG recommendations did not differ between the control and intervention arms of the meta-analysis (Poston and Chappell, 2012).

A common conclusion from many of these reviews is that further, larger RCT.s are required, which use well designed interventions, robust methodology, appropriate measurement methods, have the necessary sample size to show statistically significant differences and which focus on the most appropriate outcome measures, (that is: pregnancy outcomes and long term health of the mother and baby) are required (Thangaratinam et al., 2012a, Poston et al., 2011, Muktabhant et al., 2012).

1.11 Women's view, attitudes and opinions surrounding physical activity in pregnancy

Many different and varied factors impact upon an individual's activity levels. Education, socio economic status, culture, race and ethnicity have all been cited as associated issues (Evenson and Bradley, 2009). Pregnancy adds another dimension to this, and being overweight or obese yet another. A woman's knowledge, attitudes, views and pre-pregnancy lifestyle will impact on her behaviour during pregnancy. Positive influences on PA levels include the presence of adequate social support, encouragement and knowledge of the potential benefits for both the mother and the fetus. A study of 1306 women in the USA reported that many women have misconceptions about PA recommendations and safety during pregnancy (Evenson et al., 2009). Thirty two percent believed that women should not start exercising during pregnancy if they have not exercised pre-pregnancy, and few women agreed that moderate or vigorous activity was beneficial (73% and 13% respectively). Lack of awareness of the benefits of PA and the potential risks of inactivity, low motivation, and feelings of embarrassment or low self-esteem often have a negative influence. Many women are completely unaware of the health risks associated with inactive lifestyles, and these risks are increased dramatically in obese individuals. Others choose to ignore this information, or do not relate this risk to themselves and are unable or unwilling to prioritise healthy lifestyle choices.

Pre-pregnancy exercise levels have been shown to be a strong predictor of behaviour during pregnancy and influence women's attitudes to activity during pregnancy (Devine et al., 2000, Haakstad et al., 2009, Ning et al., 2003). Women who are more active before pregnancy tend to show a reduction in the intensity of their PA but are more likely to continue to be active, whereas even if pre-pregnancy non-exercisers are actively encouraged they are unlikely to spontaneously start exercising (Krans et al., 2005). However, even for previously active women with a BMI within the normal range barriers to remaining active exist. A Danish study reporting the findings of 19 qualitative interviews with previously active pregnant women found that discomfort, fatigue, nausea, pregnancy complications and a sense of insecurity or worry about miscarriage were given as reasons not to exercise (Hegaard et al., 2010b).

1.11.1 Social support

A lack of social support and social network can be detrimental to participation in activities. Women frequently put the needs and demands of family life and childcare above their own 'self' time (Befort et al., 2008, Levy, 1999). Results from Project Viva, a longitudinal study in the USA examining the self-reported changes in PA from pre-pregnancy through to the post-natal period, found that the main predictor of decreasing PA levels during pregnancy was having a child at home (Pereira et al., 2007). Employment and caring responsibilities also impact on time constraints as women often have to manage multiple responsibilities (Welch et al., 2009).

Women's PA beliefs and behaviours are influenced by family, friends and their social network (Thornton et al., 2006). Husbands or partners have been found to exert the most influence on healthy lifestyle changes by being encouraging and supportive or the converse (Symons Downs and Ulbrecht, 2006, Heslehurst et al., 2013a, Leppa¨nen et al., 2014). Women rely on social support for childcare, companionship and encouragement. Therefore if family and friends are not supportive women are unlikely to participate in formal exercise. Obese women in particular have reported feeling lonely and isolated, embarrassed and conspicuous (Furness et al., 2011). This factor is particularly relevant for women who have just moved into an area, and are likely to have no local support network.

Conversely, family and friends can be counterproductive with their well-meaning advice and encourage the 'rest' and 'put your feet up' attitude (Befort et al., 2008). Gross, (2004), found that family discouragement of activity outweighed family encouragement (Clarke and Gross, 2004). Women also need support from health care professionals. However, several studies have highlighted the negative impact and reactions that obese women have had from carers. Obese women in general report feeling stigmatised and stereotyped, being treated dismissively, feeling 'not quite human', disempowered and given poor information and explanations (Merrill and Grassley, 2008, Nyman et al., 2010, Furber and McGowan, 2010).

1.11.2 Wellbeing

Physical limitations were shown to be the greatest barrier to exercise in a study exploring women's behavioural, normative and control beliefs about exercising during pregnancy (Symons Downs and Hausenblas, 2004). These limitations include fatigue, nausea, musculoskeletal pain, low levels of fitness and low exercise self-efficacy (Symons Downs and Ulbrecht, 2006, Cramp and Bray, 2009). Psychosocial factors including depressive symptoms have also been shown to have a detrimental effect on health behaviours in early pregnancy which could include an active lifestyle (Walker et al., 1999).

Many women are unaware of the potential benefits of achieving recommended PA levels during pregnancy and many believe that too much strenuous or intense activity may pose a risk to the safety of the fetus or themselves and therefore this ultimately affects participation. In a longitudinal study involving 158 pregnant women who self-reported exercise participation and beliefs at three time points, it was reported that PA levels decreased with increasing gestation. The main reason given for not exercising at all time points was 'too tired or unwell', and this was followed by 'too busy' (Duncombe et al., 2009). A small proportion of these women expressed safety concerns as a reason for not exercising, these women reported participating in less intense and fewer minutes of exercise (Duncombe et al., 2009, Clarke and Gross, 2004). Mudd (2009) reported the findings of an interview study carried out on 298 healthy women in the first trimester in the USA. A correlation between uncertainty about safety and low levels of PA was demonstrated: women who did not participate in MVPA were more likely to report exercise as unsafe (OR 2.0, 95% CI 1.0-3.8) (Mudd et al., 2009). A study examining the beliefs of 57 healthy nulliparous women regarding PA found that 'a good night's sleep' and 'rest and relaxation' were perceived as being more important than regular exercise or having an active lifestyle (Mudd et al., 2009, Clarke and Gross, 2004).

A review of health beliefs of women with previous gestational diabetes demonstrated a significant knowledge/behaviour gap and a lack of knowledge regarding possible lifestyle modifications (Jones et al., 2009). Pregnancy should be an ideal time to impart health promoting advice and information as women tend to be more receptive (Lawlor and Chaturvedi, 2006). During pregnancy women are influenced by knowledge and advice given by health professionals; however, Clarke, (2004), found that women get most of their advice and information about PA prior to 16 weeks from books and magazines. These findings are consistent with those from other studies, suggesting that health professionals give no or inappropriate advice regarding PA in pregnancy (Lobelo et al., 2009a, Cogwell et al., 2001).

Women need consistent, clear advice from health care professionals, who only have a small window of opportunity to influence behaviour in pregnancy (Gross and Bee, 2004, Lawlor and Chaturvedi, 2006). Women's responses depend on the importance the individual woman places on an active lifestyle in pregnancy and the trustworthiness of the information source (Levy, 1999, Weir et al., 2010, Gross and Bee, 2004).

Ultimately, a woman must be motivated, ready and willing to change (Oteng-Ntim et al., 2010). This will be dependent on her expectations, knowledge, personal barriers, preferences and goals. She must want, and be supported, to find cognitive and behavioural strategies to overcome her own personal barriers (Jenkins et al., 2006).

1.12 Health professionals views, knowledge and attitudes

Evidence indicates that in general women receive little or no advice from health care professionals regarding activity. In comparison, time and effort is spent discussing healthy eating, smoking cessation and alcohol intake. Any advice women do receive appears to lack clarity and consistency (Weir et al*.,* 2010). The resulting evidence-practice gap may mean that women do not achieve the best health outcomes (Godin et al., 2008). This is possibly due to a lack of knowledge regarding current PA recommendations, lack of training, confidence or inability to give advice on the subject (Cogwell et al., 2001, Lobelo et al., 2009a). Pre-natal health care providers in a qualitative study in the USA, and primary care nurses in a UK study, both reported that staff acknowledged the importance of nutrition and PA counselling, the impact of overweight and obesity as a serious health issue, and that weight management was part of their role (Stotland et al., 2010, Brown et al., 2007a). However, concerns were raised about the inadequacy of counselling skills and uncertainty about their effectiveness (Stotland et al., 2010). A small randomised trial conducted in the UK investigating strategies to increase PA in 50 – 70 year olds, found that brief advice from motivated GPs resulted in an increase in PA levels in the intervention group. This suggests doctors, at least, can influence behaviour through short interventions embedded in the consultation (Armit et al., 2009). Previous qualitative studies have confirmed that GPs do see it as part of their role to advise and educate patients regarding healthy lifestyles but the degree to which advice was given on a particular subject, for example activity, was dependent upon the individual doctor's attitude, personal interest, time constraints and perceptions of their own effectiveness (Ampt et al., 2009). This is reinforced by the findings of Lobelo, (Lobelo et al., 2009b) who found that doctors who were more personally motivated were more likely to give advice regarding PA. Conversely those who were ambivalent about the effectiveness of interventions were less likely to (Ogden and Flanagan, 2008).

This evidence indicates that health care professionals' attitudes, as well as lack of knowledge and motivation, may impact on their ability to give suitable support and advice regarding activity during pregnancy. Health care professionals need appropriate training regarding the barriers women encounter, the cultural norms and attitudes, as well as current PA recommendations if they are to impact on pregnant women's PA behaviour.

Little information is known about midwives' knowledge, beliefs and attitudes about PA advice during pregnancy. As midwives have regular direct contact with women throughout pregnancy they are ideally placed to support and encourage healthy lifestyle choices. Therefore more in depth knowledge regarding midwives' views would seem essential if training and resource allocation is being addressed.

1.13 Summary and study rationale

In non-pregnant individuals PA is known to improve physiological, metabolic and psychological parameters and decrease the risk of chronic diseases such as cardiovascular disease and hypertension. Conversely physical inactivity is known to be the most significant cause of insulin resistance. It would seem plausible that PA in pregnancy may have similar benefits. Appropriate levels of PA have the potential to help maintain energy balance, reduce excessive GWG and improve pregnancy outcomes. This may be especially important for obese women, whose pregnancy complications are often associated with poor glycaemic control, insulin resistance and metabolic syndrome.

However, results from observational studies that have examined the associations between PA and pregnancy outcomes such as GDM and pre-eclampsia have been inconclusive and often contradictory. Many of these studies were small and used various self-report measures. In some studies PA was measured retrospectively and/or at only one time point. Studies investigating the relationship between PA and GDM show the most promising results. The prospective studies, larger studies and a small study which used objective PA measurement reported positive associations between PA and the development of GDM.

Similarly, intervention studies, systematic reviews and meta-analyses have shown that currently there is no definitive evidence that improving PA levels during pregnancy may be possible, help to control GWG and/or improve pregnancy outcomes for obese women and their infants. This may be due to poor methodological design, measurement methods, sample size, compliance and acceptability of the research methods or intervention. The PA component of the interventions varied substantially, from supervised exercise classes to unsupervised home based activities, counselling sessions, lifestyle education and printed educational materials. Delivery of the interventions also varied in intensity, some were delivered individually others as group sessions, most being based on theoretical behaviour change models. Many of the PA interventions were delivered in conjunction with a dietary intervention and some cases only comprised a small component of the complete package. In the systematic review by Thangaratinam (2012), dietary and PA components of interventions are analysed separately. The authors conclude that whilst dietary interventions were likely to improve GWG and obstetric outcomes, PA interventions were only successful within subgroups of participants. The authors acknowledge that the methodological quality of many of the studies was low. Closer examination of protocols also highlights that in many cases successful delivery of the PA intervention was not reported and behaviour change not measured. It therefore becomes impossible to conclude whether the lack of positive outcomes was due to the fact that the components of the intervention do not influence the outcome, or that the intervention delivery failed to instigate a behaviour change.

Before attempting to change behaviour- that is, increase PA levels, it is essential to know what the current patterns of behaviour are. To date, there is limited good quality evidence, (produced using robust measurement methods), relating to the amount, type and intensity of PA carried out in overweight and obese pregnant women or the longitudinal changes that occur as pregnancy progresses. Therefore the first aim of this study is to describe PA patterns in overweight and obese pregnant women and how this changes as pregnancy progresses.

Many barriers to women increasing PA levels during pregnancy have been identified. These include lack of knowledge of what is safe, beneficial and appropriate, and lack of support and information from health care providers. Midwives are in a privileged position and have a key public health role and responsibility to advise and support women throughout pregnancy. It would follow that they are ideally situated to advise women about PA, yet qualitative data suggests that this is not the case. Whilst the maternity experiences of obese pregnant women, (Smith and Lavender, 2011), and studies about the interactions between midwives and obese pregnant women have been reported, (Nyman et al., 2010, Mulherin et al., 2013, Merrill and Grassley, 2008), there have been no studies specifically examining the discussions midwives may, or may not, have regarding PA. Lack of clarity in the advice given may be a result of lack of knowledge, inadequate training or lack of confidence. Midwives may have concerns regarding counselling skills or may have uncertainties about the effectiveness of the advice that they give. The advice given by other health care professionals has been shown to be affected by motivation, attitude, interest in the topic, time constraints and perceptions of effectiveness. However, the possible link between these factors, psychological theories of behaviour change and subsequent links to interventions to change midwives behaviour have never been investigated Therefore, the second aim of this research is to investigate the views, knowledge and attitudes of midwives regarding PA during pregnancy, more specifically, in obese pregnant women, thereby identifying any factors which may be influencing the advice they give. These findings could then potentially be mapped back to appropriate behaviour change techniques to use in interventions aimed at changing midwives conduct.

1.14 Objectives:

- To describe PA in overweight and obese pregnant women and how this changes as pregnancy progresses.
- To identify any factors which may influence the PA carried out by overweight and obese pregnant women.
- To assess the feasibility and acceptability of using different PA measurement methods in this population.
- To investigate the perceived practices, knowledge, attitudes and views of midwives towards discussing PA in pregnancy, with specific focus on advising obese women.
- To identify possible barriers to changing midwives' behaviour with regard to giving this advice appropriately.
- To identify gaps in current knowledge and training needs.

2 Physical activity levels in pregnancy

2.1 Introduction

Increasing PA levels in overweight and obese pregnant women may have a positive effect on reducing obesity-related pregnancy complications, such as diabetes, hypertension and macrosomia. Successful interventions, guidelines and protocols designed to increase PA levels in obese pregnant women need to be based on the best evidence available. To inform such studies researchers and practitioners need to understand the amount, intensity and type of activity overweight and obese pregnant women are already performing, how this changes as pregnancy progresses and what factors influence PA levels. To investigate this accurate, reliable and acceptable PA measurement methods are needed.

2.1.1 Aims and objectives

- To describe the amount, type and intensity of PA carried out by overweight and obese pregnant women, using objective and self-report methods.
- To investigate how PA changes as pregnancy progresses.
- To investigate factors which influence PA levels in overweight and obese pregnant women.
- To compare objectively measured and self-reported activity levels.
- To assess the feasibility and acceptability of objective and self-report measurement methods.

2.2 Methodology

The aims of the project were achieved by conducting, and analysing the data, from two separate studies. A quantitative approach was adopted as one of the main aims of the work was to investigate the actual amount of PA carried out by overweight and obese pregnant women and how this changes as pregnancy progresses.

1. MAPS (Measuring Activity in Pregnancy Study), a longitudinal single centre study examining the amount, type, frequency and intensity of PA carried out by overweight and obese women (BMI≥25kg/m^2) during

pregnancy (Weir et al., 2010, McParlin et al., 2010, Bell et al., 2013) (Appendix L).

2. UPBEAT (UK Pregnancy Better Eating and Activity Trial), a multicentre randomised controlled trial testing a dietary and PA intervention for obese (BMI ≥30kg/m^2) pregnant women (www.medscinet.net/upbeat), (Poston et al., 2013, Hayes et al., 2015).

MAPS was conducted initially, at the Newcastle upon Tyne Hospitals NHS Foundation Trust. A sample size calculation was not performed as this study was testing the feasibility and acceptability of PA measurement, and recruitment continued for as long as was practicable. Given that this was an exploratory study, it was decided to include overweight as well as obese pregnant women. By doing so it was hoped that the number of participants and therefore number of valid PA measurements would be maximised.

Recruitment to UPBEAT began after MAPS had finished. Again, no formal power calculation was made, as is usual for pilot studies, and the figure of 100 was decided upon because it was considered to be achievable, and thought large enough to show a difference in behaviour should there be one (as stated in the original UPBEAT NIHR grant application). The UPBEAT cohort provided a second sample of women having longitudinal objective and subjective PA measurement using a similar measurement protocol and measurement tools as described in the methods section. Therefore, although a slightly different population, obese as opposed to overweight and obese, and from different sites around the UK, it was thought that comparing and combining datasets would increase the diversity, sample size and the potential to detect important trends in PA.

2.2.1 Choice of measurement methods

Both objective and subjective measurement methods were used to collect PA data. Accelerometers were chosen because they were small, lightweight and unobtrusive and their acceptability was found to be good in several large studies in non-pregnant populations (Hagstromer et al., 2007, Pate et al., 2006, Troiano et al., 2008). Accelerometers have also been used successfully in several other studies in pregnant women (Chasan-Taber et al., 2004a, Schmidt et al., 2006b, Poudevigne and O'Connor, 2006, Stein et al., 2003, Rousham et al., 2006, Oostdam et al., 2013, Symons Downs and Hausenblas, 2007)

Accelerometers provide details regarding time spent in different PA intensities and subsequently whether participants are meeting PA recommendations of at least 30 minutes of MVPA per day or achieving bouts of moderate PA during the day.

The RPAQ was chosen to measure subjective PA as, although not validated for use in pregnancy, it asks about PA over the preceding month within four main domains: (at home, during work, whilst commuting and during leisure [recreation] time), and its validity has been described in detail in the non-pregnant population (Besson et al., 2010). The 'Pregnancy Physical Activity Questionnaire' (PPAQ) (Chasan-Taber et al., 2004b), was not used because of poor correlation with objectively measured PA (as described in the introduction). Recall interviews were considered as a method of capturing self-reported PA however, as these are usually carried out in person or over the telephone it was considered too burdensome for participants.
Both the RPAQ and acceptability questionnaires for MAPS were given to participants to complete at home so as to minimise inconvenience and so that completed forms and monitors could be picked up or dropped off with minimal disruption to daily life. Whilst the participants were given the RPAQ to take home in UPBEAT, they had to return for a follow up appointment in the hospital one week after the initial appointment, therefore, if participants choose not to complete the form at home, or forgot, it was easy to complete this at the follow-up appointment.

Previous studies involving the longitudinal measurement of PA during pregnancy have reported decreased compliance with wearing the monitor as pregnancy progressed (Rousham et al., 2006). This results in a reduced number of valid, longitudinal, paired comparisons. The resulting missing data can reduce the representativeness of the sample of participants, potentially lead to bias and possible reduction in power to detect a difference in the results. For this reason it was planned to carry out a missing data analysis to assess if greater compliance of wearing the monitors by the participants would potentially influence the results.

2.2.2 Ethical considerations

Recruitment to both studies involved the identification of women with a BMI either ≥25 or ≥30 kg/m^2. Potential participants were then approached and participation in the respective study discussed, with an explanation of why they were eligible. Knowing that this discussion could be uncomfortable for woman and potentially cause offence or distress, potential participants were invited into a private room before the subject was broached. The dialogue and explanation of each study was carefully considered and practiced in an attempt to reduce any feelings of stigma, blame or concern. Arrangements were made so that any women who did become anxious, (for example, as a result of being informed of their increased risk of certain pregnancy complications), they could be referred to see an obstetrician or the study Principle Investigator.

2.2.3 Methods study 1: MAPS (Measuring Activity in Pregnancy Study)

Design

This was a longitudinal, study of the amount, type and intensity of PA undertaken by overweight and obese pregnant women, and also investigated the feasibility and acceptability of measuring PA in this population.

Ethical approval

Ethical approval was obtained from Durham and Tees Valley 2 Research Ethnics Committee, (REC. Ref. number: 07/H0908/53. Appendix J)

Recruitment

Recruitment for the study took place between September 2007 and January 2008. All women booking for pregnancy care at the Newcastle upon Tyne Hospitals NHS Foundation Trust were considered for inclusion in the study and sent a Participant Information Leaflet with their first trimester ultrasound appointment (Appendix A).

Inclusion/Exclusion criteria

All pregnant women with a BMI over 25 kg/m^2 (calculated from height and weight recorded at the first booking appointment with the community midwife), a singleton pregnancy and a normal 11-14 week ultrasound scan were eligible for inclusion. Women were excluded if they were less than 16 years old, had a pre-existing medical condition, required an interpreter or were unable to give informed consent in English.

Eligibility was assessed from medical records when women attended for their ultrasound appointment. Eligible women were approached following their scan to discuss participation. After obtaining written, informed consent women were randomly allocated to subsequently have their activity monitored at either two or three time points during pregnancy (12-14, 26 and/or 36 weeks) using a Microsoft Excel random number generating formula. Depending on the number they were placed into one of three groups; A, B or C;

Group A had PA measured at 12-14 and 26 weeks gestation.

Group B had PA measured at 12-14 and 36 weeks gestation.

Group C had PA measured at 12-14, 26 and 36 weeks gestation.

By asking some women to complete measurement at either 26 or 36 weeks gestation, it was hoped that fewer would withdraw.

Measurement tools

Information regarding women's PA was obtained by objective assessment using the GT1M Actigraph accelerometer and by self-report using the 'Recent Physical Activity Questionnaire' (RPAQ) Appendix F.

As pregnancy is a time of rapid change, the usual reference time frame of the RPAQ (four weeks) was reduced to one week for this study. This also enabled direct comparison with accelerometry data.

Participants were asked to wear the accelerometer for a period of seven days and then complete the RPAQ to correspond with the same seven days that the monitor was worn. The accelerometer was initialised to start recording at 7am on the following morning and set to record activity counts in 5 second epochs. The accelerometer was attached to an elastic belt worn around the waist with the monitor positioned over the right hip. Women were instructed to start wearing the monitor as soon as possible in the morning and to wear it for as much of the day as feasible, removing it for washing, swimming and for bed at night and documenting 'on' and 'off' times and the reasons for removal in a simple diary (Appendix E). Participants were also asked to complete a simple demographic questionnaire (Appendix C) and a questionnaire assessing convenience, comfort, ease of wearing the accelerometer and ease of completing the questionnaire at the end of the seven day period (Appendix D).

The accelerometer and all the questionnaires were then collected at a convenient time and location for the participant.

Longitudinal follow up

At 24 and/or 34 weeks of pregnancy, two weeks prior to the planned measurement time points, the participants' hospital records were reviewed to ascertain if any medical or obstetric complications had developed since recruitment. If this was the case the women were excluded from any further participation. Otherwise women were contacted prior to either 26 weeks and/or 36 weeks, according to their group allocation, to complete their subsequent data collection in the same manner as the first trimester.

A small sub-set of women were contacted in the third trimester and invited to participate in qualitative semi-structured interviews conducted by a postgraduate public health student investigating the attitudes and views of overweight and obese women to PA in pregnancy. This work has subsequently been published (Weir et al., 2010) (Appendix L).

2.2.4 Methods study 2: UPBEAT (UK Pregnancies Better Eating and Activity Trial)

Background to the UPBEAT study

The UPBEAT study is a National Institute for Health Research, (NIHR UK), funded programme aimed at improving pregnancy outcomes for obese women (BMI ≥30kg/m^2) and their babies, (Applied Research Programme RP-0407-10452). The study aims to deliver a complex dietary and PA behaviour change intervention to obese pregnant women who are recruited and allocated to the intervention arm of the study. The Chief Investigator for UPBEAT is Professor L. Poston from St.Thomas' Hospital, who act as Sponsor's for the study. Ethical approval was obtained from St Thomas' Hospital Research Ethics Committee, (REC Ref. no. 09/HO802/5, Appendix K). As I was the research midwife conducting the UPBEAT study in Newcastle Professor Poston has granted permission for PA data from women in the control arm of the pilot study to be used for the purposes of this thesis.

The study consists of three phases; phase one, (April 2008-March 2009), was primarily concerned with the development of the study protocol, the measurement methods and tools that would be used to conduct the study and collect data, and the complex intervention. This was carried out by research teams in London and Newcastle, with the Newcastle team having responsibility for developing the PA measurement methods, tools and intervention advice. Phase two, (April 2009-March 2011), was a pilot randomised controlled trial, (RCT), which tested the deliverability of the intervention and whether a difference in behaviour change, (nutritional intake and PA levels), could be demonstrated between the two arms of the study (Poston *et al.,* 2013). Phase three, (March 2011-ongoing) (Briley *et al.,* 2014), is a multicentre RCT, the primary outcomes of which are differences in the incidence of impaired glucose tolerance of women and infant macrosomia. This thesis presents PA data from phase 2 of the study (pilot RCT).

Design

The pilot RCT was carried out in four centres in the UK, Newcastle upon Tyne Hospitals NHS Foundation Trust, Guy's and St Thomas' NHS Foundation Trust (London), King's College Hospital Foundation Trust (London) and The Southern General Hospital and Princess Royal Maternity Hospital (Glasgow).

Obese (BMI ≥30 kg/m^2 at study entry) pregnant women who had a normal 11-14 week ultrasound scan, had a singleton pregnancy and no other pre-existing medical conditions, were eligible to participate. Women who were less than 16 years old, required an interpreter or were unable to give informed consent were excluded.

Recruitment and data collection

In Newcastle, eligible women were identified from the antenatal booking proforma which was completed by the community midwife, and I subsequently approached women in the antenatal ultrasound department or clinic. A brief overview of the study was given in a private location, along with a study Participant Information Leaflet (Appendix G). At St. Thomas's Hospital the research midwives identified eligible women in the antenatal ultrasound department. They then approached and discussed the study with identified women, providing them with the study information leaflet following their first trimester ultrasound scan. Recruitment at King's College Hospital took place in the community. Initially the research midwives relied on community midwives to refer eligible women to them, however, they also had separate ethical approval to the main study which allowed them to telephone eligible women who had booked for pregnancy care at the King's College Hospital. In Glasgow the obstetric service is based in the community and only high risk women attend one of the two hospitals. The research midwives therefore attended the 12 clinics in rotation to identify and approach eligible women.

Potential participants were then contacted by telephone approximately one week later to ascertain if they wished to participate in the study. Women who agreed to participate were then recruited and consented at approximately 15 weeks gestation. They were then randomly allocated to either the intervention arm, (referral to the study health trainer for dietary and PA advice and support), or the control arm (routine ante-natal care). All participants had their PA measured objectively using GT1M Actigraph accelerometers, and subjectively via the RPAQ at recruitment, 28 and 36 weeks gestation. Women were asked to wear the accelerometers in the same way for the same length of time as in the MAPS study and complete the RPAQ for the same 7 days. The raw accelerometer data was loaded onto the UPBEAT study database. Ideally accelerometry data should be recorded using the smallest epoch length possible as this ensures that PA variables are recorded in as much detail as feasible. However, due to the large data files produced when 5 second epochs are used and limitations of storage space on the database, the accelerometers were initialised to record activity in 15 second epochs. The MAPS data was not stored on a web based database and therefore did not have the same size limitations on the accelerometer files.
As it was anticipated that participation in the intervention arm of the study would impact on the PA levels of the women at later time points, this thesis only presents data from women in the control arm of the study.

2.2.5 Data preparation (both studies)

The RPAQ underwent double data entry, directly onto a Microsoft Excel spread sheet in MAPS and onto the web based database in UPBEAT. Data was subsequently exported into an SPSS spreadsheet for statistical analysis.
For MAPS, estimates of PA energy expenditure (PAEE) for the four different domains of the RPAQ were calculated by multiplying participation (hours/day) by the metabolic cost of each activity, expressed in METs, obtained from the

Physical Activity Compendium (Ainsworth et al., 2000b). Total PAEE was calculated by summing PAEE in each domain (home, work, during transport and during recreational activities). In UPBEAT data analyst provided overall estimates of the minutes per day women reported spending in sedentary, light, moderate and vigorous PA. Therefore it required further manipulation to produce PAEE data, so making it comparable with MAPS RPAQ output. The time spent in specific PA intensities within each domain was multiplied by the average MET value which corresponds to the intensity. The appropriate MET value for each recreational activity was multiplied by the amount of time spent in that activity. Total PAEE was then calculated in the same manner as MAPS.
The questionnaire also provided descriptive information regarding the participants' recreational activities at each data collection time point. Some of the activities, such as jogging and dancing, were only carried out by a small number of participants; therefore, activities with the same metabolic energy expenditure were combined for the purposes of further descriptive presentation and analysis.
Accelerometry data from MAPS recorded PA in 5 second epoch lengths, as opposed to UPBEAT which used 15 second epoch lengths. Therefore, the data from MAPS was compressed to make it comparable to UPBEAT data using the Actilife V5 software, (www.Actigraphcorp.com). Raw accelerometer data was then processed using MAHuffe analysis software, (http://www.mrc-epid.cam.ac.uk/Research/PA/Downloads.html). This software was programmed to produce data which describes average minutes per day that participants spent in sedentary, (less than 100 counts per minute), light, (100-1951 counts per minute), moderate, (1952-5725 counts per minute) and vigorous (over 5726 counts per minute) PA (Freedson et al., 1998). As the amount of vigorous activity recorded was very low the minutes of moderate and vigorous activity were combined to make one variable, 'moderate or vigorous PA' (MVPA). Runs of zero counts lasting more than 60 minutes were excluded, as it was considered the monitor must have been removed for this time. A valid day of recording was defined as one in which more than 500 minutes of monitored on-time were recorded in a 24 hour period; only women recording at least three valid days of accelerometry were included in further analysis and only valid

days were analysed. Average PA counts per minute, counts per day and step counts were also recorded.

Postcodes were matched to two national indices of deprivation database, the Indices of material deprivation, (IMD), for English addresses and the Scottish IMD for address in Scotland. These were grouped into quintiles for further analysis.

2.2.6 Statistical analysis

Objectively measured accelerometer data

Accelerometer data produced by the MAHuffe software was analysed using SPSS version 17 (SPSS, Inc., Chicago, Il, USA), to produce descriptive statistics for each study population. Variables were checked for normal distribution using the Shapiro-Wilk test. Age was found to be normally distributed and therefore this was compared using t tests; ordinal and nominal data was examined using cross tabulations and chi-squared analysis. BMI and the activity variables were not normally distributed, even after log transformation. The data were therefore examined using the Mann Whitney U test, whilst paired longitudinal changes between time points were assessed using Wilcoxon Signed Ranks and Friedman test to compare repeated measures over time. Summary data for non-normally distributed data are presented as median values with inter quartile ranges (IQR).

The median values for all accelerometry derived PA variables were calculated for both individual studies and the paired longitudinal changes as pregnancy progressed calculated. Variables were compared between the two studies at each time point, then data from both studies was combined and longitudinal changes in PA levels calculated for the whole dataset.

Comparison of participants according to MVPA category

The characteristics of participants who achieved an average of more than 30 minutes of MVPA per day, the target recommended by NICE (NICE, 2010), were compared to those who did not. Again, both studies were analysed separately before the participant characteristics between the two studies were compared then combined.

Associations and influencing factors

Pearson's correlation coefficients were calculated between demographic variables and PA variables, and between subjective and objectively measured PA variables to identify any possible relationships.

Factors which could potentially influence PA levels were examined using linear regression, with MVPA acting as the dependant variable at each respective time point for both studies independently and for the combined dataset. Variables found to be associated with MVPA in univariate analysis, ($p<0.2$), were included in multiple linear regression models. Several different models were tested with various combinations of potential predictor variables. Dummy variables were also created between step count at each time point, MVPA at baseline, BMI and study allocation to ascertain if results were inherently different between MAPS and UPBEAT. The goodness of fit of a model was measured using the residual sum of squares (RSS), together with the number of degrees of freedom (df). The residual mean square (RMS) was calculated as the ratio of the RSS to the df. An F-test was used to compare the superiority of a more complex model fitted to the data relative to a simpler model (based on some but not all of the predictors in the more complex model). Specifically, the difference in RSS between the simpler and the more complex model was divided by the product of the RMS of the more complex model and the difference in df between the two models (referred to as df1). This ratio was then compared with the F-distribution on df1 and df2, where df2 is the degrees of freedom of the more complex model. If the p-value from this test was less than 0.05, then the more complex model was deemed to provide a significantly better fit to the data than the simpler model.

The number of valid recordings decreased with increasing gestation. Missing data can reduce the representativeness of study sample and potentially lead to bias. To test this theory a missing data analysis was performed by creating a second database with five different imputations for the missing data points. The regression analysis was then repeated for the influential predictor variables and the adjusted findings from the pooled imputations were compared to the original data.

Participation in MAPS or UPBEAT was tested as a potential predictor variable on the whole dataset but was not found to be associated with MVPA at any time point. On this basis, and the fact there were no differences between corresponding PA variables in the two studies at any time point, the descriptive PA analysis from the combined dataset is presented, described and discussed during this chapter.

Self-reported PA levels

Total self-reported PAEE and PAEE within different domains were calculated and longitudinal changes compared. The RPAQ asks questions about 35 different recreational activities, a large number of which none of the participants carried out (Appendix F). Similar activities with the same MET values were therefore combined, (for example, dance+run+jog+tennis), and changes as pregnancy progressed presented. Participants were divided into quartiles depending on their PAEE at the baseline measurement and characteristics of participants compared between quartiles to ascertain if any relationships were apparent.

Associations and comparisons between self-reported PA, participant characteristics and objectively measured PA

Pearson's correlation coefficients were calculated between total PAEE and the different domains of PAEE, demographic and objectively measured PA variables; again to identify any relationships.

Spearman's rank correlation coefficients were calculated between subjectively obtained PAEE and sedentary, light, MVPA and counts per minute obtained via accelerometer to ascertain if the questionnaire could be used to rank participants by activity levels.

Acceptability of measurement method

Acceptability data were analysed using cross tabulations, and accelerometry derived data from participants who complied with at least three valid days of recording were compared to those who did not. Descriptive information from the MAPS acceptability questionnaire was produced and presented along with free text comments.

2.3 Results

2.3.1 Participant information MAPS and UPBEAT

The demographic characteristics of all participants at baseline are shown in table 6. There were no differences between mean age, parity, education level or mean hours worked between MAPS and UPBEAT participants. However, whilst a higher proportion of women participating in MAPS were in paid employment, a higher proportion of UPBEAT participants worked full time compared to part time.

The recorded median BMI for UPBEAT women was higher than for MAPS women, (34.2 compared to 28.8, $p<0.001$). This was expected as the inclusion criteria for the MAPS study was a BMI over 25 kg/m^2, whilst for UPBEAT it was over 30 kg/m^2, therefore 54% of MAPS women were overweight as opposed to obese. The ethnic mix between the two studies also differed, 87% of the MAPS women reported being of white European origin compared to 55% in UPBEAT. This is likely to reflect the ethnic mix of the North East of England compared to South London where more than half of UPBEAT recruitment was carried out. Women in MAPS were less likely to live in deprived areas, but more likely to live with their partners and to smoke.

Table 6 Demographic comparisons of participants

Characteristic	MAPS n=68 total	UPBEAT n=58 total	p value
Age mean(SD)	31.1 (5.4)	29.9 (5.1)	0.831
BMI median (IQR)	28.8 (26.6-33.6)	34.2 (32.4-38.6)	<0.001
Overweight	37 (54%)		
Obese	31 (46%)	58 (100%)	
Hours worked mean (SD)	32.0 (9.1)	33.6 (10.1)	0.455
Paid employment			
No	17 (25.0%)	24 (41.4%)	
yes	51 (75%)	32 (58.6%)	0.049
full/part time			
<35 hours wk	25 (37%)	8 (13%)	
>35 hours wk	26 (38%)	26 (42%)	0.018
Parity			
Nulliparous	29 (43%)	18 (29%)	
Multiparous	39 (57%)	40 (64%)	0.174
Ethnicity			
White European	59 (87%)	34 (55%)	
Black	0	19 (31%)	
Asian	1 (1%)	0	
Other	1 (1%)	5 (8%)	<0.001
Education level			
Less than degree level	49 (72%)	33 (60%)	
Degree or above	19 (28%)	25 (40%)	0.779
Living with partner			
No	5 (7%)	15 (24%)	
yes	55 (81%)	43 (69%)	0.011
Smoking status			
No	40 (59%)	53 (85%)	
yes	20 (29%)	5 (8%)	0.001
IMD quintile			
1 (least deprived)	19 (28%)	4 (6%)	
2	17 (25%)	7 (11%)	
3	6 (9%)	18 (29%)	
4	12 (18%)	12 (19%)	
5 (most deprived)	10 (15%)	13 (21%)	0.001

*some missing values result where less than 100% of participant characteristics reported

Table 7 compares some of the demographic characteristics of study participants with those of either women with live births or women of childbearing age in

England and Wales. Not surprisingly the BMI of women aged between 25-34 years was lower than that of study participants, however, interestingly 27% of women were reported to be overweight and 21% obese in this cohort. The proportion of women who reported smoking in MAPS was higher than in the general population but the most notable differences were in the ethnicity and IMD of participants compared to the general population. Only one participant out of a total of 126 reported being of Asian origin and while a higher number of participants reported being of black ethnicity in UPBEAT compared to the national average, none of the MAPS participants were of this ethnic origin. Over half of the post code areas in the North East of England fall into the most deprived two IMD quintiles. In comparison to this general population data, participants in MAPS had the opposite trend, with over half of participants post codes falling into the two least deprived quintiles. The IMD of the UPBEAT participants appeared to be a better reflection of the combined London plus North East IMD data.

Table 7 Comparison of study participants to the general population comparison of study participants to the general population

Characteristic	MAPS n=68	UPBEAT n=58	General population: women with live births# or women of childbearing age‡	
Mean Age/yrs	31.1	29.9	29.8 # (2012**)	
Ethnicity				
White European	59 (87%)	34 (55%)	70.1%	
Black	0	19 (31%)	5.1%	
Asian	1 (1%)	0	9%	
Other	1 (1%)	5 (8%)	6.2%	
Not stated			9.6% # (2012 π)	
Living with partner	55 (81%)	43 (69%)	84% # (2012**)	
Smoking status				
Yes	20 (29%)	5 (8%)	12% # (2012¥)	
IMD quintile			North East*	London+ N. East*
1 (least derived)	19 (28%)	4 (6%)	13%	10%
2	17 (25%)	7 (11%)	15%	15%
3	6 (9%)	18 (29%)	16%	19%
4	12 (18%)	12 (19%)	24%	28%
5 (most deprived)	10 (15%)	13 (21%)	32%	28%

*Proportion of post code areas falling into each quintile from English IMD (only 4 participants from Scotland) Data from English Indices of Deprivation 2010. http//data.gov.uk/dataset/index-of-multiple-deprivation
**Data from ONS 2012, Live births in England and Wales by characteristics of mother
¥Data from Health and Social care Information Centre, statistics on smoking in England 2012
∞Data from Health Survey for England 2012, women aged 25-34yrs.
πData from ONS, Live births England and Wales by ethnicity by area of usual residence of mother, 2005-2008, published 2011

2.3.2 Study populations

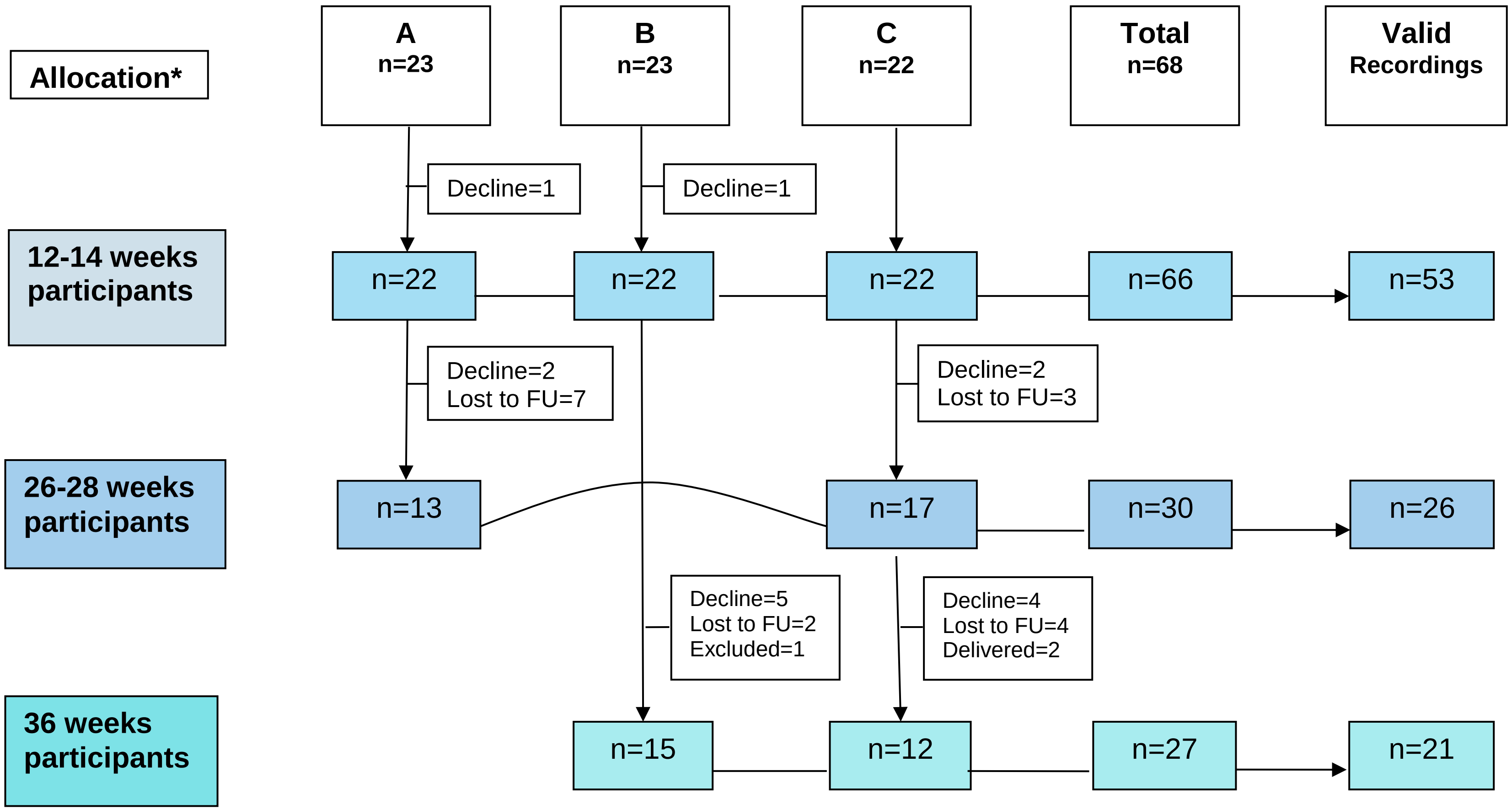
2.3.3 MAPS

177 eligible women were approached regarding participation during the recruitment time period. Of these, 68 (38.4%) consented to participate in the study. Fifty six, (82%), women completed an RPAQ and 53 (78%) completed three or more valid days of accelerometry measurement (median seven days) at the first data collection point (median 13 weeks of pregnancy, range 11-15). Of these 55 women, 26 (47%) were nulliparous and 22 (40%) were obese at booking.

At the second data collection point (median 26 weeks, range 25-28), 43 women were eligible and 30 (70%) agreed to participate, of whom 27, (63%), completed an RPAQ and 26 (61%) recorded three or more valid days of accelerometry data (median six days). Forty women remained eligible for the third data collection point (median 36 weeks, range 34-37). Twenty eight (68%) women agreed to participate and 21 (53%) completed an RPAQ and recorded three or more valid days of accelerometry data (median six days). Ten of these women had also participated in the second data collection time point.

The flowchart in figure 1 highlights the allocation of participants to the groups and their subsequent data collection points.

Figure 1. MAPS participant group allocation and subsequent data collection



** Allocation to groups A, B and C relates solely to the MAPS study and refers to the time points the participants were invited for PA*

2.3.4 UPBEAT

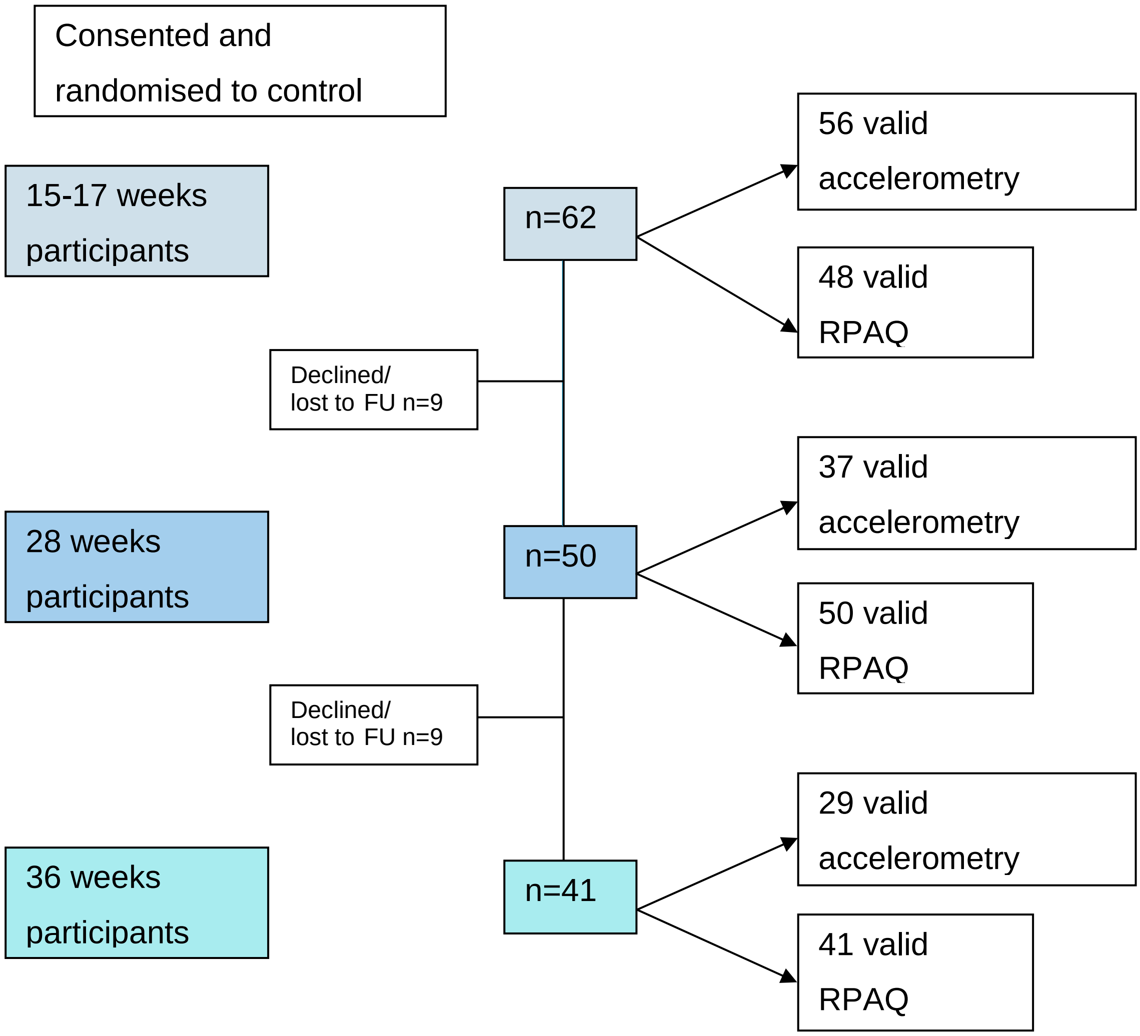
The overall recruitment rate for the UPBEAT pilot study was 27.9%. Sixty two participants consented and were allocated to the control arm of the pilot trial. Subsequently 48 (77%) completed an RPAQ and 56 (82%) completed three valid days of accelerometry, (median 7 days) at baseline.

All of the participants were eligible at the second time point (27-28+6 weeks) and 50 (81%) agreed to participate. All of these women completed an RPAQ and 37 (60%) completed three valid days of accelerometry (median 6 days).

At the third collection time point (34-36+6 weeks) all participants were eligible and 41 (66%) agreed to participate. All of these women completed an RPAQ and 29 (47%) recorded at least three valid days of accelerometry (median 6 days).

The flowchart in figure 2 highlights the number of participants at each time point and their subsequent data collection.

Figure 2. Flowchart highlighting data collection at each respective time point for UPBEAT participants



The first data collection time point in the MAPS study was performed at 11 to 15 weeks gestation, in comparison to the UPBEAT time point which was at 15 to 17 weeks. For the purposes of the remainder of this thesis this time point will be referred to as the ‘baseline’ measurement.

The second data collection time point in MAPS was performed at 25-28 weeks, in comparison to UPBEAT which was at 27-28+6 weeks. This time point will be referred to as the ‘28 week’ measurement.

The third data collection time point in MAPS was performed at 34-37 weeks, in comparison to UPBEAT which was at 34-36+6 weeks. This time point will be referred to as the ’36 week’ measurement.

The proportion of participants completing the RPAQ at 28 weeks was higher in the UPBEAT cohort, (p=0.045). It is probable that this is because midwives had face to face contact with the participants whilst performing the required measurements at this UPBEAT time point. They were, therefore, able to encourage women to complete the questionnaire whereas in MAPS the women often left the questionnaire and monitor in a safe, designated drop off point. Otherwise, there were no differences in the proportion of women consenting or completing data collection at different time points between the two studies.

Table 8 highlights the study participation at the three data collection time points.

Table 8: Comparison of participant compliance at the 3 data collection time points.

	MAPS Consent n=68	UPBEAT Consent n=62	p value	MAPS Consent n=68	UPBEAT Consent n=62	p value
	Accelerometry			RPAQ		
Baseline ≥ 3 valid days/ completed questionnaire	55 (80.9%)	56 (90.3%)	0.120	56 (82.4%)	48 (77.4%)	0.120
Eligible 28 weeks	43	ALL		43	ALL	
Consented 28 weeks	30 (69.8%)	50 (80.6%)	0.207	30 (69.8%)	50 (80.6%)	0.207
28 weeks ≥ 3 valid days/ completed questionnaire	26 (60.5% of those eligible)	37 (59.7% of those eligible)	0.935	27 (62.8% of those eligible)	50 (80.6% of those eligible)	0.045
Eligible 36 weeks	40	ALL		40	ALL	
Consented 36 weeks	28 (70%)	41 (66.1%)	0.681	28 (70%)	41 (66.1%)	0.681
36 weeks ≥3 valid days/ completed questionnaire	21 (52.5% of those eligible)	29 (46.8% of those eligible)	0.572	21 (52.5% of those eligible)	41 (66.1% of those eligible)	0.170

2.3.5 Objective longitudinal measurement of physical activity in pregnancy using accelerometry

Time spent wearing the monitor, in sedentary, light and MVPA along with average counts per minute, counts per day and average steps per day were calculated for each study individually and are presented in table 9. As the absolute values may be affected by the time the monitor was worn, sedentary, light and MVPA were calculated as a percentage of wear time, table 10. When all PA variables for both studies were compared directly at each time point no statistically significant differences were found. Similarly there were no differences in the proportion of recorded time participants spent in sedentary, light and MVPA between MAPS and UPBEAT. Due to similarities in PA levels, and the known lack of influence of study participation on MVPA from the regression analysis, (table 16), the datasets were combined.

Table 9. Comparison of accelerometry derived PA data between MAPS and UPBEAT at all three time points

	Baseline UPBEAT n=56	Baseline MAPS n=53	p-value	28 wks UPBEAT n=37	28 wks MAPS n=26	p- value	36 wks UPBEAT n=29	36 wks MAPS n=21	p-value
Proportion completing ≥3 valid days	90.3%	77.9%	0.120	59.7%	60.5%	0.935	46.8%	52.5%	0.572
Total Days	7 (6-7)	7 (5-7)	0.103	6 (4.75-7)	6 (5-7)	0.443	6 (5-7)	6 (5-7)	0.927
Recorded time/min	810.93 (750.73-875.01)	798.39 (740.77-835.38)	0.230	789.09 (713.12-859.35)	733.63 (689.84-790.48)	0.059	790.54 (711.33-880.81)	777.79 (727.04-840.02)	0.776
Sedentary time/min	605.83 (542.30-648.56)	585.30 (523.31-633.48)	0.183	572.93 (503.66 650.37)	538.42 (474.48-584.45)	0.071	600.38 (521.36-645.64)	542.38 (456.03-595.50)	0.602
Light PA/min	175.66 (131.87-218.58)	177.43 (139.21-223.15)	0.767	169.26 (124.94-196.40)	163.43 (147.46-207.86)	0.494	165.95 (118.78-217.64)	166.62 (147.04-232.64)	0.473
MVPA/min	36.50 (23.84-44.05)	27.75 (21.64-41.98)	0.266	34.50 (22.16-4172)	28.78 (20.28-44.83)	0.753	23.92 (18.90-36.82)	27.39 (21.11-29.38)	0.761
Steps	5816 (4529-7351)	5380 (4268-6913) ***n=30***	0.587	4963 (3416-6243)	5289 (4469-7541)	0.128	4201 (3084-5392)	4390 (3768-5107)	0.455
Counts/day	213511 (167293-274834)	199748 (163506-264141)	0.540	210847 (140776-265969)	197822 (168247-233811)	0.891	186106 (142152-256573)	193700 (168933-216832)	0.836
Counts/min	254.63 (201.73-319.34)	261.04 (208.66-317.58)	0.931	255.88 (211.21-314.90)	273.43 (227.45-338.03)	0.460	244.69 (182.86-281.27)	247.36 (210.36-286.67)	0.716

Values = median (IQR)

Table 10, Comparison of recorded time spent in sedentary, light and MVPA between the studies at the three data collection time points.

	ALL	MAPS	UPBEAT	p-value
Baseline	n=109	n=53	n=56	
Sedentary	74.42% (69.36-78.52)	74.85% (68.53-77.76)	73.75% (69.58-79.05)	0.616
Light	21.48% (17.71-26.47)	21.61% (18.65-27.67)	21.50% (16.94-25.26)	0.254
MVPA	4.08% (2.64-5.49)	3.83% (2.64-5.39)	4.37% (2.65-5.80)	0.505
28 weeks	n=63	n=26	n=37	
Sedentary	74.10% (69.33-77.26)	73.56% (68.35-76.77)	75.22% (68.64-80.52)	0.328
light	20.97% (18.33-26.32)	23.06% (20.16-27.66)	20.16% (15.95-25.71)	0.090
MVPA	4.23% (2.87-5.31)	3.94% (2.88-6.14)	4.29% (2.85-5.22)	0.944
36 weeks	n=50	n=21	n=29	
Sedentary	74.31% (70.20-79.58)	74.33% (67.50-78.88)	73.85% (70.50-80.45)	0.293
Light	22.38% (17.58-25.88)	23.30% (18.91-29.05)	21.23% (16.88-25.44)	0.227
MVPA	3.36% (2.49-3.95)	3.51% (2.55-3.92)	3.14% (2.48-4.23)	0.883

Values= median (IQR)

Paired longitudinal data were compared between each time point and the combined dataset is presented in table 11.The total number of valid days recorded decreased as pregnancy progressed between baseline and 28 weeks and baseline and 36 weeks. Average total daily recorded wear time of the monitors, average daily sedentary time, light PA and step count, decreased between baseline and 28 weeks. Between baseline and 36 weeks there was a significant decrease in all PA variables except light PA. In contrast there were no differences between the 28 and 36 weeks’ time points.

As the absolute values may be affected by the time the monitor was worn, sedentary, light and MVPA were calculated as a percentage of wear time. There were no differences in the proportion of recorded time participants spent in sedentary, light and MVPA between MAPS and UPBEAT. Paired longitudinal changes were calculated for the whole dataset and are shown in table 12. The only significant difference was the median percentage of wear time spent in MVPA between baseline and 36 weeks (4.18% compared to 3.36%).

Table 11: Combined datasets, (MAPS+UPBEAT), paired longitudinal changes in valid recordings between time points

	Baseline n=62	28 wks n=62	p- value	Baseline n=50	36 wks n=50	p- value	28 wks n=35	36 wks n=35	p-value
Total Days	7 (6-7)	6 (5-7)	<0.001	7 (6-7)	6 (5-7)	0.003	6 (5-7)	6 (5-7)	0.777
Recorded time	13hr 29min (12hr27min-14hr25min)	12hr 34min (11hr44min-13hr48min)	0.002	13hr 42min (12hr54min-14hr33min)	12hr 59min (11hr 59min-14hr9min)	<0.001	12hr 54min (11hr54min-13hr51min)	12hr 42min (11hr47min-14hr3min)	0.318
Sedentary time	10hr 8min (9hr5min-10hr43min)	9hr 15min (8hr15min-10hr19min)	0.004	10hr 19min (9hr10min-10hr48min)	9hr 46min (8hr33min-10hr33min)	0.031	10hr 16min (9hr-10hr47min)	9hr 32min (8hr20min-10hr32min)	0.743
Light PA	3hr (2hr20min-3hr38min)	2hr 42min (2hr9min-3hr19min)	0.006	3hr 13min (2hr28min-3hr 45min)	2hr 46min (2hr25min-3hr38min)	0.098	2hr 40min (2hr15min-3hr19min)	2hr 38min (2hr3min-3hr38min)	0.726
MVPA/min	34.9 (21.8-47.9)	33.6 (20.3-43.1)	0.108	35.8 (23.9-50.8)	26.3 (19.8-30.1)	<0.001	33.6 (19.8-43.5)	26.6 (20.2-37.4)	0.112
Steps	5314 (4303-7376)	5025 (3661-6731)	0.013	5762 (4681-7468)	4390 (3394-5202)	<0.001	5061 (3717-6426)	4455 (3342-5373)	0.008
Counts/day	220171 (162517-283033)	207732 (157457-259599)	0.081	223201 (182361-294930)	191457 (147988-230848)	<0.001	206920 (153703-265918)	186107 (145802-256324)	0.196
Counts/min	261.6 (202.0-359.3)	261.0 (220.2-319.9)	0.820	275.7 (218.5-346.8)	245.5 (206.6-281.0)	0.004	256.1 (218.0-316.2)	246.4 (200.2-297.7)	0.179
Proportion ≥30mins MVPA	35 (56.4%)	34 (54.8%)	0.857	28 (56%)	13 (26%)	0.001	18 (51.4%)	12 (34.3%)	0.141

Values= median (IQR)

Table 12: Paired longitudinal changes in proportion of recorded time spent in sedentary, light and MVPA

	Baseline	28 weeks	p-value	Baseline	36 weeks	p-value	28 weeks	36 weeks	p-value
Sedentary	74.0% (70.1-78.9)	74.3% (69.0-77.5)	0.738	72.3% (69.7-77.2)	74.3% (70.2-79.6)	0.289	74.1% (69.3-77.2)	74.3% (70.3-80.0)	0.413
Light	21.6% (17.5-25.2)	20.7% (17.9-26.1)	0.534	23.7% (17.9-26.5)	22.4% (17.6-25.9)	0.732	21.3% (18.6-25.7)	21.2% (17.0-25.4)	0.980
MVPA	4.2% (2.5-5.9)	4.3% (2.8-5.4)	0.729	4.2% (2.7-6.1)	3.4% (2.5-4.0)	0.001**	4.2% (2.8-5.6)	3.6% (2.6-4.5)	0.105

2.3.6 Determinants of physical activity

Comparison of women achieving/not achieving ≥30 minutes MVPA per day

At baseline 53% of participants achieved the target of 30 minutes of MVPA per day. This remained fairly stable at 28 weeks (56%), but decreased at 36 weeks (24%). The characteristics of women who did and did not achieve at least 30 minutes of MVPA per day are shown and compared in table 13. There were no significant differences between the groups at any time point. There were no differences between the proportions of participants in MAPS and UPBEAT who achieved 30 minutes of MVPA at any time point (data not presented).

Table 13: Characteristics of participants who did/did not achieve 30 minutes of MVPA per day at different time points

	Baseline			28 weeks			36 weeks		
Variable	<30 min MVPA	≥30 min MVPA	p value	<30 min MVPA	≥30 min MVPA	p value	<30 min MVPA	≥30 min MVPA	p value
Number of participants (%)	56 (47%)	62 (53%)		32 (44%)	40 (56%)		41 (76%)	13 (24%)	
Age (yrs)	30.1 (5.2)	30.5 (5.2)	0.693	31.3 (5.6)	30.3 (5.5)	0.455	31.1 (4.5)	32.6 (6.1)	0.357
BMI (kg/m^2)	31.5 (27.1-35.6)	32.9 (30.0-35.8)	0.207	32.4 (28.1-37.0)	33.5 (31.7-36.4)	0.223	32.7 (28.5-36.4)	34.3 (32.6-42.8)	0.053
Parity: Nulliparous	21	26		8	18		15	3	
Multiparous	35	36	0.623	24	22	0.079	26	10	0.368
Paid employment: No	21	16		7	13		11	2	
Yes	35	46	0.218	25	27	0.317	30	11	0.400
Ethnicity: White European	44	45		25	30		32	10	
All other	12	17	0.183	7	10	0.904	9	3	0.932
Education: <degree level	35	31		22	20		22	4	
≥degree level	17	26		9	17		19	7	
unknown	4	5	0.169	1	3	0.153	0	2	0.308
Smoking status: No	41	48		26	33		34	10	
Yes	13	11		6	6		7	2	
unknown	2	3	0.461	0	0	0.707	0	1	0.974
Living with partner: Yes	42	40		24	23		28	8	
No	11	17		7	14		12	3	
unknown	1	2	0.484	1	2	0.365	1	1	0.632
IDM quintile 1	12	9		6	4		7	1	
2	10	12		7	4		8	2	
3	6	17		4	12		7	3	
4	15	8		6	7		9	3	
5	9	11		3	11		3	3	
unknown	4	5	0.092	6	2	0.096	7	1	0.588

Paired longitudinal changes in MVPA according to PA category at baseline

Changes in the amount of MVPA carried out by participants who did, and did not, reach the recommended 30 minutes of MVPA per day at baseline were examined. Participants were categorized into two groups, (not meeting/meeting ≥30 minutes MVPA), and their longitudinal changes in MVPA were compared (table 14). Women who did not achieve 30 minutes of MVPA at baseline showed no change in MVPA as pregnancy progressed. Conversely, participants who did achieve 30 minutes of MVPA at baseline showed a decrease between both baseline and 28 weeks (44.1 minutes to 40.3 minutes, p=0.016), and baseline and 36 weeks (48.8 minutes to 27.6 minutes, p<0.001).

Table 14*:* Paired longitudinal changes in MVPA compared according to MVPA category at baseline

	Baseline MVPA paired with 28 weeks	**28 weeks MVPA**	**p-value**	**Baseline MVPA paired with 36 weeks**	**36 weeks MVPA**	**p-value**
Median MVPA women achieving < 30 min MVPA baseline	20.3 (15.6-25.9) [n=27]	20.2 (16.2-26.8) [n=27]	0.597	22.5 (16.5-26.9) [n=22]	22.7 (16.9-28.1) [n=22]	0.808
Median MVPA women achieving ≥ 30 min MVPA baseline	44.2 (36.9-55.9) [n=35]	40.3 (33.6-49.4) [n=35]	0.016	48.8 (39.6-56.4) [n=28]	27.6 (21.2-39.9) [n=28]	<0.001

Comparison of MVPA between overweight and obese women

As some participants were overweight (as opposed to obese) median amounts of MVPA were compared between groups, however there were no differences (table 15).

Table 15*:* Comparison of MVPA between overweight and obese women

	Overweight	Obese	p-value
Baseline MVPA median min/day (IQR)	**n=32** 26.8 (22.0-41.1)	**n=76** 36.6 (22.6-44.3)	0.199
28 weeks MVPA median min/day (IQR)	**n=12** 21.7 (19.8-42.2)	**n=51** 34.0 (23.4-43.0)	0.161
36 weeks MVPA median min/day (IQR)	**n=13** 25.9 (17.8-28.9)	**n=36** 26.5 (20.0-36.4)	0.441

p-value calculated via Mann-Whitney U test, only participants completing 3 valid days at specific time point included in analysis.

Relationship between objectively measured PA and participant characteristics

At baseline monitor wear time correlated with sedentary and light PA but not MVPA. Light PA correlated with MVPA, step counts, total counts and counts per minute, whilst MVPA was strongly correlated with step count (r=0.738), total counts (r=0.921), and counts per minute (r=0.895).

At 28 weeks the relationship between wear time, sedentary and light PA remained, and there was no correlation with MVPA. MVPA continued to be correlated with step count, total counts and counts per minute.

By 36 weeks wear time continued to correlate with sedentary and light PA, whilst MVPA and counts per minute correlated strongly with all PA variables except sedentary time. Counts per minute was inversely correlated with sedentary time.

Factors which could potentially influence MVPA were investigated using linear regression. Initially all demographic variables were individually examined with MVPA as the dependant variable for each study and then for the combined data set at the three time points (Appendix I). All significant predictors are presented in table 16.

The average daily step count was found to be a significant predictor of MVPA at all three time points. At baseline BMI was also a significant predictor of MVPA, increasing BMI having a positive influence on MVPA. MVPA at baseline was found to be a significant predictor of MVPA at 28 weeks and 36 weeks, that is, by increasing MVPA at baseline it is likely that an increase of MVPA at 28 and 36 weeks can be predicted. Participation in MAPS or UPBEAT also appeared to be having a weak influence on MVPA at 28 weeks, although this was not significant ($p=0.066$).

The number of recordings decreased at each time point due to withdrawal from participation, thus resulting in missing data. Missing data can reduce the representativeness of the sample of participants, potentially lead to bias and possible reduction in power to detect a difference in the results. When a missing data analysis was performed there was little impact on the relationship between step count or BMI at baseline, however allowing for missing values weakened the impact of the other predictors.

Table 16: Significant influencing predictors at 3 time points

i. BASELINE (dependent variable minutes MVPA at baseline)

	β	Std error	p
MAPS			
Steps	0.007	0.001	<0.001
UPBEAT			
BMI	0.684	0.299	0.026
steps	0.007	0.001	<0.001
ALL			
BMI	0.608	0.215	0.006
steps	0.007	0.001	<0.001

ii. 28 WEEKS (dependent variable minutes MVPA at 28 weeks)

	β	Std error	p
MAPS			
Steps	0.004	0.001	0.003
MVPA baseline	0.414	0.129	0.004
UPBEAT			
Steps	0.008	0.001	<0.001
ALL			
Steps	0.007	0.001	<0.001
MVPA baseline	0.194	0.081	0.019
Study	-5.373	2.868	0.066

iii. 36 WEEKS (dependent variable minutes MVPA at 36 weeks)

	β	Std Error	p
MAPS			
Steps	0.003	0.001	0.015
MVPA Baseline	0.137	0.067	0.058
Age	0.546	0.335	0.122
BMI	0.583	0.305	0.075
UPBEAT			
Steps	0.007	0.001	<0.001
MVPA baseline	0.212	0.109	0.064
ALL			
Steps	0.006	0.001	<0.001
MVPA baseline	0.185	0.072	0.013

Units of measurement: steps = median step count per day, BMI = kg/m^2, MVPA = median minutes per day, age in years.

The unstandardised beta (β) coefficient indicates the type of relationship between the dependent variable, (MVPA) and the specific predictor variable. A positive β indicates a positive relationship, that is, as the predictor variable increases the dependent variable will increase. The β coefficient also indicates the extent to which each predictor affects MVPA if all the other predictors are held constant. For example, at baseline for the complete dataset, (Table 16,i), β for BMI = 0.684, if the median BMI of participants were to increase by 1 unit, then the median MVPA would be expected to increase by 0.684 minutes. In a more useful way, with a β for steps of 0.007 an extra 1 step per day would equate to an additional 0.007 minutes of MVPA, and an extra 1000 steps per day would equate to an extra 7 minutes of MVPA. Conversely to attain an extra 10 minutes of MVPA a day approximately 1430 extra steps would be required. This calculation presumes that additional steps performed will be carried out at the intensity of MVPA, this may not be the case for every individual. The standard error can be used to calculate an approximate confidence interval for the β coefficient, (plus or minus standard error x 1.96) which can be used to estimate the precision of the results. The range can subsequently be used to interpret how clinically or practically important the results are. In the above example with a β = 0.007 and a standard error =0.001:

1 step would equate to an extra 0.007 minutes of MVPA, (95% CI 0.005, 0.009);

1000 steps would equate to 7 minutes of MVPA, (95% CI 5 mins, 9 mins).

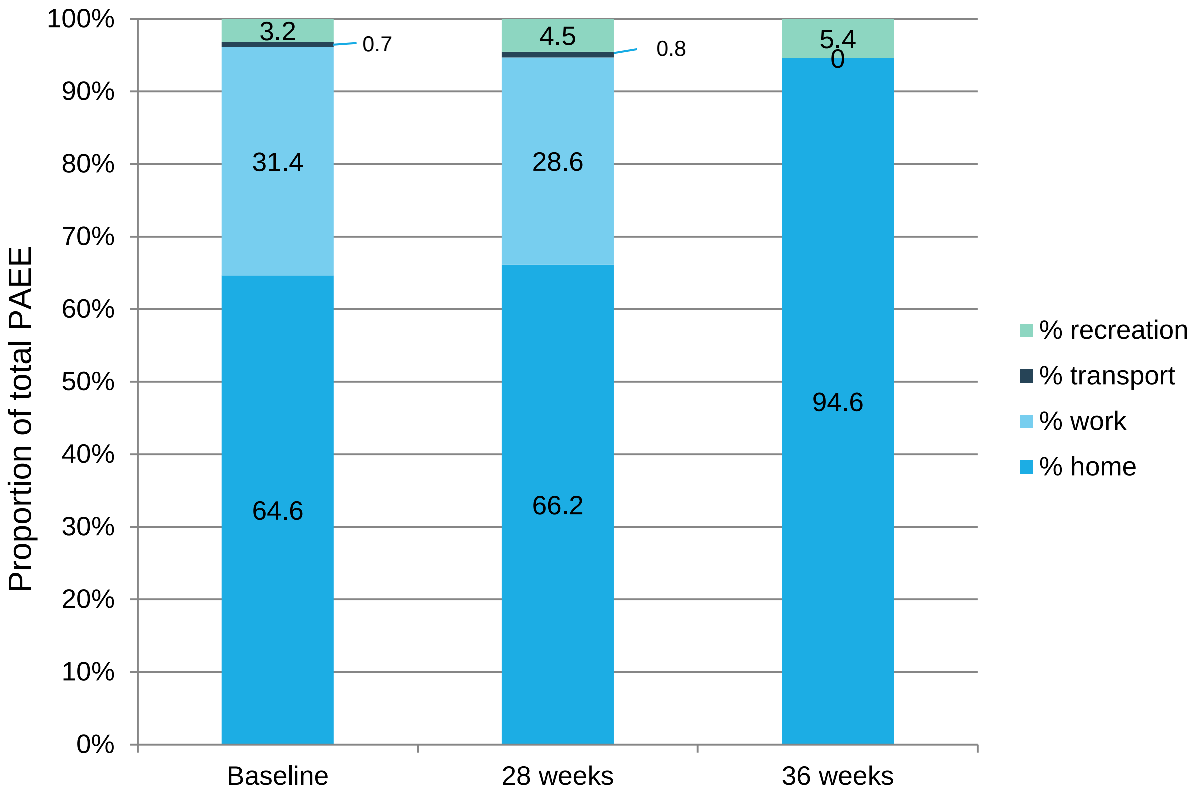
This confidence interval is narrow; even if an extra 1000 steps resulted in five minutes of MVPA, this may mean that a women achieves, or comes close to the daily recommendations of ≥30 minutes, which may subsequently prove to be of clinical importance.

The results in Table 16 (iii) are not so compelling. MVPA at baseline appears to be a significant predictor of MVPA at 36 weeks, β=0.212 and the standard error is 0.109. Therefore, an increase of one minute of MVPA at baseline should equate to an extra 0.212 minutes at 36 weeks, (95%CI -0.002, 0.426). Thus, increasing MVPA at baseline may have no effect but conversely an extra minute may result in an extra 0.43 minutes at 36 weeks. Therefore the clinical and practical implications of these results are less convincing.

2.3.7 Self-reported physical activity in pregnancy via RPAQ

At baseline participants self-reported expending an average of 27.2 MET hours per day in total. The proportion of energy expended in the different domains and how this changes as pregnancy progresses is charted in figure 3.

Figure 3: Chart showing distribution of total PAEE between different domains at three time points



Longitudinal changes in energy expenditure within different activity domains

When self-reported data from the two studies were compared differences were present at baseline: UPBEAT subjects reported carrying out more PA in the home, [19.6 METS (15.3-24.2) compared to 17.0 METS (13.7-20.4), p=0.007], whilst MAPS women report more PA commuting to work, [0.2 METS (0.1-0.6) compared to 0.0 METS (0-0.4), p=0.019]. At other time points there were no differences between the studies. This difference probably reflects the differing number of women in paid employment between the studies and the fact that women usually stop working during the third trimester of pregnancy.

When both data sets were combined, (table 17), no differences were found between baseline and 28 weeks. However, between baseline and 36 weeks and between 28 and 36 weeks there were differences in self-reported PA within all domains except recreational activity. PAEE within the home increased, while PAEE at work, commuting and total PAEE decreased.

Table 17: **Paired longitudinal comparisons**

	Base-line n=67	**28 wks n=67**	**p value**	**Base-line n=57**	**36 wks n=57**	**p value**	**28 wks n=50**	**36 wks n=50**	**p value**
Home	18.1 (14.2-21.2)	17.8 (13.2-21.0)	0.803	18.1 (14.0-21.1)	21.0 (17.4-23.5)	<0.001	17.4 (13.0-21.0)	20.9 (16.8-23.6)	0.001
Work	8.6 (0-11.4)	7.1 (0-10.7)	0.759	9.1 (0-10.9)	0 (0-6.9)	<0.001	8.0 (1.5-10.8)	0 (0-8.6)	<0.001
Transport	0.2 (0-0.6)	0.2 (0-0.7)	0.576	0.2 (0-0.8)	0 (0-0)	<0.001	0.2 (0-0.6)	0 (0-0.0)	<0.001
Recreation	0.8 (0.2-1.9)	0.9 (0.3-2.2)	0.701	0.9 (0.4-2.1)	1.2 (0.2-3.2)	0.233	1.5 (0.5-2.7)	1.2 (0.5-2.9)	0.662
Total	27.2 (24.4-29.4)	26.8 (23.7-29.5)	0.446	26.9 (24.9-29.1)	24.9 (22.8-27.8)	0.008	28.0 (23.6-29.9)	24.9 (23.0-28.4)	0.012

All values are MET/hrs/Day, median (IQR). Comparisons via Mann-Whitney U test

Demographic comparisons of participants according to self-reported PAEE quartiles

Participants were categorised into quartiles depending on their self-reported PAEE at each time point, (1=least active 25% of participants, 4=most active 25%, (table Comparisons were then made between different demographic characteristics and the allocated quartiles. Age, BMI, being in paid employment, ethnicity or living with a partner did not have any influence on the activity category. More nulliparous women were categorized into the two lower PA quartiles at baseline and this trend continued throughout pregnancy. However, the numbers of multiparous women were evenly spread between all quartiles at each time point. Whilst education at baseline and 36 weeks was not related to PAEE quartile, participants with a degree appeared more likely to fall into the two most active quartiles at 28 weeks' time point (p=0.020). Smokers were more likely to fall into the least two active quartiles at baseline but not at other time points.

Table 18: Demographic comparison of women according to self-reported PAEE quartile at baseline

	1 (25%)	2 (50%)	3 (75%)	4 (100%)	p value
Age yrs (mean [SD])	29.7 (5.7)	28.6 (4.6)	32.0 (3.7)	31.3 (4.8)	0.063
BMI kg/m^2 (median [IQR])	31.8 (27.0-35.6)	31.0 (26.6-33.6)	31.6 (28.5-35.4)	33.9 (32.2-38.6)	0.065
Parity					
Nulliparous	18	13	6	3	
Multiparous	14	13	16	19	0.006
Paid employment					
No	14	8	3	4	
Yes	18	19	19	18	0.064
Ethnicity					
White European	23	23	20	16	
All Other	7	4	2	5	0.489
Education					
Below degree level	22	15	12	9	
Degree or above	9	10	9	10	0.409
Smoking					
No	22	18	20	19	
Yes	9	9	2	1	0.034
Living with Partner					
Yes	19	23	17	16	
No	12	4	5	4	0.177
IMD quintile					
1	6	3	3	7	
2	4	6	7	4	
3	6	7	3	3	
4	7	5	1	5	
5	4	4	6	2	0.426

Correlations between PAEE and participant characteristics

Pearson's correlation coefficient was calculated to identify any other relationships between total self-reported PAEE, demographic variables and objectively measured sedentary and MVPA. At baseline there was a small but statistically significant positive correlation with age (r=0.210), parity (r=0.327), and objectively measured MVPA (r=0.242), and a negative correlation with smoking (r=-0.259). Age had a negative correlation with PAEE in the home (r=-0.325), but positive with work (r=0.412), conversely parity had a positive correlation with PAEE in the home (r=0.583), and negative correlation with work (r=-0.250). Self-reported recreational PAEE had a positive correlation with total PAEE (r=0.495).

At 28 weeks the same weak relationship still existed between age and parity with PAEE at work and in the home. PAEE at work and in commuting had strong positive correlations with total PAEE (r=0.676, and r=0.632) and strong negative correlations with PAEE in the home, (r=-0.639).

By 36 weeks, total self-reported PAEE was correlated with parity (r=0.363), work (r=0.351) and recreational PA (r=0.472).

Self-reported PAEE did not correlate well with accelerometry measured sedentary and MVPA. However, the questionnaire may be useful to rank participants according to their PA levels. Spearman's rank correlations coefficients were therefore calculated for self-reported EE and objectively measured sedentary, light, MVPA and average counts per minute at the three time points (this compared paired sets of data from the same individuals). At baseline PAEE was weakly correlated with light PA and counts per minute (ρ= 0.272 and ρ=0.222) whilst at 28 and 36 weeks there were no correlations with PAEE. When the proportion of time spent in sedentary, light and MVPA are compared to PAEE at baseline, again a weak positive correlation was found with light PA (ρ=0.268) and negative correlation with sedentary PA (ρ=-0.284).

Self-reported leisure time activities and changes over pregnancy

The self-reported recreational activities at the three time points for all study participants are presented in table 19, along with the longitudinal changes during pregnancy.

The most popular recreational activity was walking, with at least 60% of the participants reporting doing this at each of the time points. A smaller proportion of women reported swimming (16.3%) and conditioning/floor exercises (20.2%). There was no change in the proportion of participants carrying out these activities as pregnancy progressed. An even smaller number of participants reported aerobic activities such as aerobics classes, dancing, jogging and tennis. This number decreased as pregnancy progressed but only achieved statistical significance between baseline and 28 weeks. Activities in the home and garden (such as DIY, mowing the lawn, weeding) increased between baseline and 36 weeks and between 28 and 36 weeks. One participant reported cycling once at baseline and once at 28 weeks only.

A smaller proportion of MAPS participants reported walking at baseline compared with UPBEAT, and no MAPS participants reported aerobic activities at 28 weeks; otherwise there were no differences between the two data sets.

Table 19 Self-reported recreational activity

	Baseline All n=104	28 weeks All n=79	36 weeks All n=68	p values
Swimming	17 [16.3%]	18 [22.8%]	16 [23.5%]	Base-28 =0.279 Base-36 =0.254 28-36 =0.915
Walking for pleasure	63 [60.6%]	53 [67.1%]	41 [60.3%]	Base-28 =0.361 Base-36 =0.970 28-36 =0.393
Home & garden	18 [17.3%]	12 [15.2%]	24 [35.3%]	Base-28 =0.699 Base-36 =0.009 28-36 =0.004
Aerobic activities (class, dance, run, jog, tennis)	13 [12.5%]	3 [3.8%]	7 [10.3%]	Base-28 =0.025 Base-36 =0.653 28-36 =0.128
Conditioning & floor exercise	21 [20.2%]	12 [15.2%]	12 [17.6%]	Base-28 =0.375 Base-36 =0.675 28-36 =0.689

Numbers represent number of participants, [% of total sample],

2.3.8 Acceptability of PA measurement

Comparison of women recording/not recording 3 valid days of accelerometry

It is reasonable to assume that women who agreed to take part in the study and complied with wearing the monitor did not find it unacceptable. The demographic characteristics of participants who did, and did not, complete three valid days of recording at the different time points are shown in table 20. The mean age of participants who did not complete three valid days at baseline and 36 weeks was lower than those who did. Participants in paid employment were much more likely to record three or more valid days at each time point, and a higher proportion of participants who did not record three valid days at baseline and 36 weeks were educated to below degree level. Otherwise, there were no differences in BMI, parity, ethnicity, smoking status or IMD quintile between participants who did and did not record three valid days.

At baseline women who completed three or more valid days recorded more sedentary, light and MVPA but also had the monitor on for longer. There was no difference in the proportion of wear time the two sets of participants spent in sedentary, light and MVPA at baseline, (table 21). It can only be concluded that for some reason the women who recorded less than three valid days of activity wore the monitor for a shorter time on the days they did record over 500 minutes. There were no differences between the two sets of participants at 28 weeks but data at 36 weeks highlighted differences in light, MVPA and wear time. When these variables were examined as a proportion of wear time it was found that participants who recorded less than three valid days recorded a higher proportion of sedentary time and a lower proportion of light and MVPA than participants with more than three days of valid recording.

Table 20: Comparison of characteristics of participants who did/did not complete 3 valid days of accelerometer recording.

Variable	Baseline			28 weeks			36 weeks		
	<3 valid days	≥3 valid days	p value	<3 valid days	≥3 valid days	p value	<3 valid days	≥3 valid days	p value
Age, mean (SD)	26.8 (4.9)	30.6 (5.1)	0.004	29.0 (4.8)	30.8 (5.7)	0.122	28.8 (5.0)	31.5 (4.9)	0.007
BMI, median (IQR)	33.2 (28.4-38.3)	32.4 (28.5-35.7)	0.481	33.4 (31.0-36.5)	32.4 (29.3-38.4)	0.584	32.4 (30.1-35.4)	33.4 (29.0-36.9)	0.402
Parity									
Nulliparous	4	44		17	21		19	17	
Multiparous	15	64	0.103	23	43	0.318	35	33	0.899
Ethnicity									
White	12	82		25	50		34	39	
All other	1	21	0.271	9	13	0.513	11	11	0.778
Paid employment									
Yes	8	78		22	46		32	38	
No	11	32	0.014	20	18	0.041	24	12	0.041
Education level									
< Degree	11	59		23	37		34	23	
≥ Degree	1	43	0.023	12	23	0.693	14	25	0.022
Smoking									
Yes	5	20		7	12		8	8	
No	7	86	0.067	29	51	0.962	41	41	1.000

Table 20 cont.

Living with partner									
Yes	9	77		25	43		35	34	
No	3	29	0.862	11	20	0.064	14	15	0.398
IMD quintile									
1	4	19		4	10		9	8	
2	3	21		11	9		9	9	
3	4	20		10	13		12	9	
4	4	20		7	31		10	10	
5	3	20	0.984	8	11	0.583	13	6	0.769
Sedentary time Median (IQR)	8hr45min (7h36m-9h39m)	9hr51min (8h50m-10h39m)	0.023	8hr56min (8h24m-9h27m)	9hr15min (8h11m-10h21m)	0.274	8hr52m (8h6m-9h31m)	9hr46min (8h33m-10h33m)	0.188
Light PA, median (IQR)	2hr31min (1h26m-2h50m)	2hr56min (2h18m-3h40m)	0.019	2hr47min (2h11m-3h18m)	2hr24min (2h11m-3h17m)	0.363	1hr50min (1h19-2h5m)	2hr46min (2h25m-3h38m)	0.009
MVPA, median (IQR)	21.8 (16.1-30.0)	31.4 (22.1-43.0)	0.039	32.79 (20.8-42.6)	38.5 (21.8-46.1)	0.616	13.0 (9.2-16.0)	26.3 (19.8-30.1)	0.006
Steps, median (IQR)	4849.2 (3770.2-5592.0)	5742.4 (4402.8-7198.8)	0.273	5063.2 (3703.4-6655.7)	5583.5 (2912.0-7398.9)	1.000	1964.5 (1608.1-3508.5)	4389.9 (3394.2-5202.1)	0.015
Average 'wear' time, min/day, median (IQR)	11hr16min (10h10m-12h54m)	13hr26min (12h23m-14h10m)	0.001	11hr39min (11h8m-12h3m)	12hr34min (11h42m-13h48m)	0.062	11hr2min (10h17m-11h3m)	12hr56min (11h59m-14h9m)	0.008

Table 21: Differences in the amount of recorded PA as a proportion of wear time

	<3 valid days	≥3 valid days	p-value
% sedentary Baseline	75.7 (69.9-81.8)	74.4 (69.4-78.5)	0.267
% Light PA Baseline	21.8 (14.8-24.5)	21.5 (17.7-26.5)	0.338
%MVPA Baseline	3.5 (2.1-4.6)	4.1 (2.6-5.5)	0.271
% sedentary 36 weeks	80.3 (78.8-86.2)	74.3 (70.2-79.6)	0.032
% light PA 36 weeks	17.5 (12.0-19.3)	22.4 (17.6-25.9)	0.039
% MVPA 36 weeks	2.0 (1.4-2.6)	3.4 (2.5-4.0)	0.021

In MAPS, participants were asked to complete a simple questionnaire regarding acceptability of the measurement methods at each time point, and they were also encouraged to comment on their experience of having their PA measured (Appendix D). No acceptability data was collected regarding PA measurement in the UPBEAT study; however, a process evaluation was carried out alongside the pilot trail. Twelve women within the control arm of the study and 9 within the intervention arm participated in semi-structured interviews. Overall, both groups found the research process ‘acceptable’ (Poston et al., 2013).

The results from MAPS are shown graphically in figure 4 according to question with the subsequent change in response as pregnancy progressed. At baseline almost 70% of the women felt that wearing the monitor was comfortable or very comfortable. However, this changed by the third time point, with less than 40% of the women expressing this feeling, p=0.016. Convenience and ease of wear also decreased as pregnancy progressed, but not significantly so. Ease of completing the questionnaire remained stable at all time points. Free text comments from participants are presented in table 22.

Figure 4: Changes in acceptability questions amongst the MAPS cohort at 3 time points

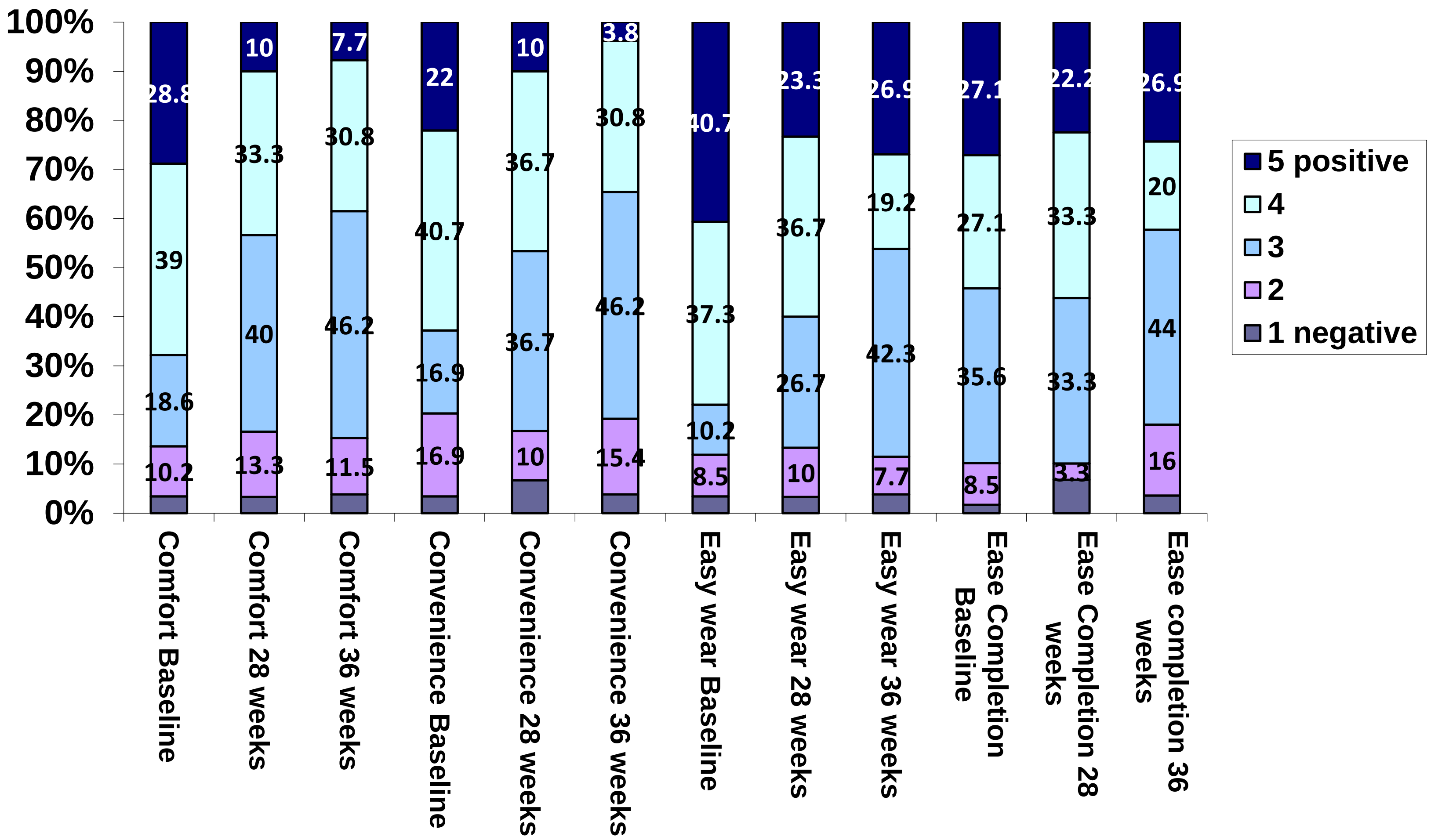


Table 22: **All participant comments**

Baseline *Better reflection if worn 2 weeks* *Has support belt so uncomfortable to wear both* *Would have preferred clip on monitor* *Uncomfortable to wear as bump got bigger* **26wks** *Found belt uncomfortable to wear as it kept slipping.* *Buckle a lot more uncomfortable now I am bigger* *Sometimes forgot to wear belt as soon as I could* *Maybe an alarm attachment that can be set to remind to put on* *Questions would be easier to answer on a daily basis to keep a record each night.* **36wks** *Easier to wear belt at 37wks than 15.* *Easier to wear belt at 37wks than 12, stays in correct place under bump.* *RPAQ section C inappropriate for pregnancy, length of elastic annoying* *Not managed to answer many questions, not relevant at this gestation* *Worth finding another way to wear monitor, not on belt eg clip to waistband* *Belt much more uncomfortable to wear due to size* *Would be easier to log activities at end of day* *Only uncomfortable as was unwell*

The majority of comments were regarding comfort of the belt. Some women found it easier at later gestations but most found it more uncomfortable. The elastic on the belt appeared to cause issues, ‘too long’, ‘kept slipping’, and the use of a clip was also suggested. Forgetfulness was cited as another problem; both forgetting to put the monitor on and forgetting what activities had been performed throughout the week.

2.4 Discussion

2.4.1 Key Findings

The amount, type and intensity of physical activity measured by accelerometry and self-report

This chapter describes and compares the longitudinal PA behaviour in overweight and obese pregnant women from two different studies using both objective and subjective measurement methods.

Almost all objectively measured PA variables, with the exception of light PA, decreased between baseline and 36 weeks. Recorded sedentary time also decreased with increasing gestation, which was contrary to what was expected. However, total wear time of the monitor also decreased as pregnancy progressed, therefore the amount of time spent in sedentary, light and MVPA was examined as a proportion of total accelerometer wear time. When this was done the only change was a fall in MVPA between baseline and 36 weeks, light and sedentary PA remained stable. Effectively this results in a higher proportion of the participant’s day not being recorded at later gestations. Whilst the women may have been active during the time the monitor was removed, many women verbally stated that they were inclined to remove the monitor in the evening when they were relaxing or when they were having a rest during the day. This suggests that the activity not recorded was likely to be sedentary in nature; if this had been recorded the results could possibly show increased sedentary time as pregnancy progresses.

At baseline over half of the participants achieved 30 minutes of objectively measured MVPA. This proportion was maintained at 28 weeks but fell by 36 weeks to 24%. The PA of women who were more active at baseline decreased as pregnancy progressed while less active women remained so. None of the demographic characteristics of participants appeared to influence whether or not they achieved MVPA recommendations, however regression analysis found that the average daily step count was independently associated with MVPA at all time points and that higher MVPA at baseline was predictive of higher MVPA later in pregnancy.

As described in the methodology section, power calculations were not carried out prior to commencing data collection for MAPS or the UPBEAT pilot study. It is therefore possible that some of the non-significant results may have been different if a larger sample size of participants was achieved. Some researchers and journal editors advocate the use of post-hoc power calculations to ascertain if inadequate power is affecting the internal validity of the findings (O'Keefe, 2007). Others argue that this is inappropriate and misleading and after results have been obtained confidence intervals should be used to estimate the magnitude of the effects or difference in findings (Hoenig and Heisey, 2001, Levine and Ensom, 2001). Researchers can then interpret findings to ascertain the potential clinical importance of results. Therefore, whilst performing a post-hoc power calculation was considered, following discussions with a statistician this was not done. Instead, the standard error was used to calculate the 95% confidence intervals which in turn give an indication of the precision of the results and was thought to be a more appropriate method of determining statistical power.

With the PA data from MAPS and UPBEAT it was thought that the amount of MVPA carried out by participants was most likely to have the greatest impact on health and it could also be compared with national PA recommendations. Therefore, when linear regression was performed, MVPA was used as the predictor variable. Step count was found to be a statistically significant, independent predictor of MVPA at each time point. Being statistically significant implies that the probability of obtaining the results seen in the sample would be low if there were no underlying effect. However the ‘p value’ simply demonstrates the strength of the evidence that there is, or is not, a real difference. It does not tell the researcher or clinician if this difference is of any clinical importance, or clinically significant; indeed, just because a result is statistically significant it does not follow that it is clinically significant. A clinically significant change or difference needs to be decided by health care professionals and needs to have a positive relationship or impact on participants or patients health or well-being.

If women could increase or maintain their PA levels during pregnancy, resulting in levels of moderate PA meeting national recommendations, this would be a clinically significant outcome. The results of MAPS and UPBEAT show that such an outcome might be achieved if step count could be increased.

Some results from this research indicated that BMI may be related to MVPA. Although not statistically significant, the median BMI of women who achieved the target of 30 minutes or more of MVPA per day was higher than that for those women who did not (Table 10). Regression analysis also highlighted that BMI appeared to be predict MVPA; however, the standard error for the regression coefficients were relatively large, indicating that the confidence intervals would be wide and therefore the precision of these results was low. Recently reported findings from the whole UPBEAT pilot cohort found no significant difference in the decrease in PA levels by the third trimester between participants with a BMI between 30-35 and those with a BMI over 35 (Hayes et al., 2015), whilst a greater decline in self-reported PA has been reported in women with a higher BMI (Sui et al., 2013a). Both of these findings support the theory that findings from my analyses occurred by chance.

Self-reported total PAEE and PAEE at work fell during pregnancy whilst the proportion of PAEE in the home increased. Multiparous women were found to self-report higher PAEE levels than nulliparous women, otherwise no other significant associations with personal characteristics were found. A weak positive correlation was found between total PAEE and MVPA at baseline, otherwise none of the other self-reported activity variables correlated with objectively measured PA variables at any other time point.
Recreational PAEE accounted for a very small proportion of total PAEE and remained fairly stable throughout pregnancy. Walking and swimming were the most popular leisure time activities carried out by women, with over half of participants reporting walking for pleasure.
Both MAPS and UPBEAT used accelerometry and RPAQ at three time points during pregnancy but differed slightly in inclusion criteria. However, there were no differences in PA variables between the studies at any of the time points. When regression analysis was performed and ‘study’ was entered as a predictor variable it was found not to influence MVPA at any time point. For these two reasons and the purposes of simplifying presentation, the data from both studies was combined and presented as a one whole dataset. This provided a larger, more diverse sample of participants.

Acceptability

The number of valid days of accelerometry recordings, the actual time per day worn, as well as the number of women consenting and completing the

measurement, decreased as pregnancy progressed. This is in line with women reporting that comfort of wearing the belt decreased over pregnancy. Increasing discomfort may relate to increasing size, tiredness or pregnancy-related problems such as symphysis pubis dysfunction, a problem which is three times more common in obese pregnant women (Reynolds et al., 2013).
Although participants in UPBEAT were in the control group and therefore were not invited to participate in health trainer sessions, they still had extra hospital visits and data collection measurements with the research midwives as part of the study. This increased burden may have influenced their decision to withdraw from further data collection. Barriers such as lack of time, the cost or impracticality involved in travelling to appointments, getting time off work and assistance with child care have been cited as reasons why women disengaged with services (Olander and Atkinson, 2013). Conversely previous qualitative research reported that obese women disengaged from weight management services if they felt that the service did not meet their needs (Atkinson et al., 2013). It is therefore possible that women may have been disappointed that they were not allocated to the intervention group and were not receiving the extra support they were hoping for, and thus subsequently lost the motivation to participate.

2.4.2 Strengths and Limitations

The main strength of this chapter is that it presents the paired results of both objectively and subjectively measured PA at three time points during pregnancy in overweight and obese women from two different cohorts. This provided informative, descriptive information about amount, intensity and type of PA carried out by this population of pregnant women, and how this changed as pregnancy progressed.

Another strength is that in both cohorts participants underwent a randomisation process. As previously described, only women from UPBEAT were allocated to the control arm of the pilot trial were included in the analysis. The randomisation process reassures us that women in the control arm were not intrinsically different from those in the intervention arm. The process occurred via a secure internet based data management system, this computer generated randomisation process was stratified according to ethnicity, parity, age, BMI and study centre. This is considered the gold standard for randomly allocating participants in an intervention study, so producing comparable groups at baseline and substantially reducing the risk of selection bias and confounding. MAPS was not an intervention study but there was a need to allocate women to one of three groups which subsequently meant participants had PA measurements performed at two or three time points. It was felt that asking women to carry out three measurement time points might prove to be too much of a burden and increase the risk of withdrawal. By asking some women to measure PA at baseline and 28 weeks, some at baseline and 36 weeks and some at all three points it was hoped that as many paired sets of data as possible would be obtained. This random allocation was carried out using a simple Microsoft Excel random number generating program. This was appropriate to the study resources and was thought to be adequate as allocation was not to an intervention. In hindsight using another independent researcher to carry out the randomisation procedure, or allocation using sealed opaque envelopes would have reduced the risk of potential selection bias even further.

After carrying out each measurement participants were asked to complete an acceptability questionnaire. This comprised four questions about comfort, convenience, ease of wearing and ease of completion of the RPAQ. Participants were also asked to add any additional comments about wearing the monitor or completing the questionnaire. Only 17 comments were made during the course of MAPS. Whilst this provided important information about comfort and forgetfulness little other information was gleaned about the experience of participation. In retrospect a limitation of the study was that participants could have been more actively encouraged to complete this section, and more emphasis could have been placed upon the importance of participants' views. Alternatively, semi-structured interviews carried out after all measurement time points were completed could have provided useful in-depth information about participants opinions, views and experience of wearing accelerometers at different time points and completing the RPAQ. This could have subsequently been used to help select the most appropriate measurement methods for future intervention studies.

Another potential way to increase response rate, acceptability and possibly recruitment rate would have been to have patient and/or public involvement in the design of MAPS and the PA measurement component of UPBEAT. Members of the public, such as patients, potential patients, carer or service users, can provide a different perspective on the research question, the design or conduct of a study. As members of the study steering group or as interested advisors, public involvement can enhance the research process. In the case of PA measurement, having public involvement at the design stage of the study may have influenced the choice of measurement methods and time points by advising on potential acceptability. They could have been involved in the writing, formatting and production of the participant information leaflets and other data collection materials, potentially making them more user friendly. Lay representatives may also have been able to provide useful advice about how to engage with potential participants, how to discuss the study and broach the sensitive subject of BMI. Lay representatives from minority ethnic groups may also have been able to give advice on how to engage with, and possibly recruit, women with differing ethnicities, so making the results more generalisable to the wider population. This was especially noticeable as only one participant reported being of Asian ethnic origin, compared to at least nine percent of women having live births in England and Wales during a comparable time period. Recruitment may also have been hindered due to lack of access to interpreting services and translated documents. In summary, public representation and involvement in the design and conduct of the study may have improved recruitment, retention and acceptability (INVOLVE, 2012).

The IMD of MAPS participants were markedly different from that of the general North East population. Over half of MAPS participants were in the least deprived two quintiles, as calculated from their post code, whilst over half of post codes in the North East fall into the two most deprived quintiles. This may affect the generalisability of the results to the rest of the population of the North East, but it is difficult to say exactly how. Little evidence exists about the influence of socioeconomic status on PA levels in pregnant women. However, higher PA levels have been associated with higher family income (Ning et al., 2003, Domingues and Barros, 2007) and higher post-secondary education (Mottola and Campbell, 2003, Evenson et al., 2004a). In non-pregnant populations individuals with higher socioeconomic status self-report more PA and a stronger intention to exercise compared to individuals of lower socioeconomic status (Scholes and Mindell, 2013, McFadden et al., 2008, Chinn et al., 1999). It is therefore plausible that the study participants were more active than the wider North East population. As with minority ethnic groups, future research should aim to engage with, and aim to recruit hard to reach groups who may have a significant influence on results.

Several factors may have influenced the PA data that was recorded. Relatively small numbers of participants took part in the studies and, given the high decline rate in both studies, may not be representative of the general overweight and obese pregnant population. Women who participated in the research may have been more motivated, and possibly more active, so increasing the chance of self-selection, response and participation bias. The effect of wearing a monitor may have influenced participants' usual routine, so affecting recorded PA levels. As a consequence the results may not be a true reflection of everyday life. Previous studies have shown that after 3 days of recording any abnormally high PA levels return to usual habitual levels, therefore only data from participants having at least 3 valid days of recording was analysed (Trost et al., 2005, Corder and Ekelund, 2007, Warren et al., 2010).

Whilst objectively measured PA provides the most reliable information regarding PAEE it does have limitations. Compliance with recording decreased as pregnancy progressed, agreeing with findings from previous studies, (Harrison et al., 2011, Rousham et al., 2006). A major problem with obtaining valid recordings is that monitors must be removed for sleeping, washing and swimming. Researchers therefore have to rely on study participants to reattach the monitor in a timely manner. Forgetfulness was cited by women as a reason for not wearing the monitor, and whilst many participants stated they were relaxing and sedentary when not wearing the monitors it is not possible to prove this. It is likely that 24 hour recording methods would provide a more accurate measure of daily PA (Matthews et al., 2012).
Accelerometers are good at distinguishing sedentary time from active time and are good at monitoring walking, however, they are unable to provide any

information about other types of activity (Lubans et al., 2011). To encourage behaviour change it is essential to know what activities women undertake so that good or bad habits can be targeted. Since our population were not very active, accelerometry may not provide enough information to aid intervention development. The importance of this information is reinforced by the knowledge that in non-pregnant individuals breaks in prolonged periods of sedentary time have been shown to have a significant influence on the risk of developing metabolic syndrome (Healy et al., 2008) which leads to an increased risk of heart disease, diabetes and stroke. Therefore being able to accurately measure this and account for what participants are actually doing (for example TV viewing, gaming, working on a computer) may prove to be of increasing importance.

Another potential problem with accelerometers is that movement not involving accelerations or decelerations may not be recorded; movements involving muscle contraction, especially involving the upper body, such as carrying, lifting and pushing or activities such as cycling and rowing, may not be accurately registered and important information may be missed (Ekelund et al., 2002, Matthews et al., 2012). In the case of pregnant women this is likely to include household activities and childcare and therefore may result in under reporting of accelerometry-measured PA. The position of the monitor can also affect accuracy of the accelerometer (Corder and Ekelund, 2007): inaccurate positioning or tilting of the monitor, (for example, on a pregnant abdomen), is likely to affect the quality of recording.

The monitors used in MAPS and UPBEAT were only set to record activity in one axis, the vertical plain. Tri-axial models and accompanying analysis software may improve accuracy of estimates. The assignment of appropriate cut points and epoch lengths causes some debate. The cut-points used for these studies were established by Freedson, 1998, and are the most commonly used values for adults. However it has been suggested that these cut points are set too high for moderate PA and are therefore not sensitive to small changes in habitual activity. This may be especially relevant for obese pregnant women who have a smaller range of activity variability, the majority of their recorded activity being sedentary or light in nature (Strath et al., 2012, Evenson and Wen, 2010a, Macfarlane et al., 2006, Chasan-Taber et al., 2004c, Chasan-Taber et al., 2007) suggested that this problem can be overcome by using total counts or counts per minute, however total counts are dependent on compliance and wear time and counts per minute give an indication of average intensity, providing no information about duration and bouts of time in different intensity levels. The epoch length is the time interval at which digital accelerometer signals are recorded in the monitor memory so producing an activity count. A longer epoch length, for example one minute, will produce less detailed information than a shorter length which can pick up short bursts and changes in activity intensity. This is more relevant to PA measurement in children who carry out short bursts of PA at different intensities. If the epoch length is too long the detail of changes from moderate to vigorous to very vigorous PA are lost and total PA underestimated (Trost et al., 2005). With overweight and obese pregnant participants this is unlikely to be a problem as they carried out little or no vigorous PA. Therefore the use of 15 second epochs in MAPS and UPBEAT should not influence the reliability of the results.

To obtain the most reliable results self-report measurement tools should, ideally, be validated within the specific population in which they are being used. Although the RPAQ has not been validated for use in pregnancy it asks questions about everyday life, in the home, domestic tasks and caring responsibilities, as well as work, commuting and recreational activity. It was therefore considered suitable for use with pregnant women.

All questionnaires using self-report PA are likely to be influenced by response bias, random and systematic errors, so resulting in over reporting which in turn is partly caused by social desirability (Adams et al., 2005, Prince et al., 2008, Matthews et al., 2012). Participants respond to questions in a manner that they feel is appropriate and viewed as acceptable by the researcher or health care professional, rather than give an accurate response. A more specific problem with self-reporting activity is that the researcher has to rely on an individual's own perception of their PAEE and ability to assess the intensity of effort (Evenson and Wen, 2010b, Lagerros and Lagiou, 2007, Evenson and Wen, 2010a). As questionnaires attempt to capture all non-sedentary PA related to childcare and household tasks it has been suggested that the home domain and overall PAEE may be susceptible to over reporting as women often multi task (Collins et al., 2007).

Another problem is that MET values have been calculated for use within the general population where EE attributed to PA is dependent on weight, age, sex, efficiency of activity and environmental conditions. Values may be different and not appropriate for pregnant individuals (Evenson and Wen, 2010a, Lagerros and Lagiou, 2007).

2.4.3 Comparison with literature

Objectively measured physical activity in pregnancy, amount, types and trends

The baseline proportion of participants achieving more than 30 minutes of MVPA is higher than previously reported in non-pregnant populations; only 34% of older UK women (mean age 40.7 years) achieved more than 30 minutes of MVPA (Ekelund et al., 2007), whilst in the Health Survey for England 2008, obese women aged 16 to 34 years achieved an average of 27 minutes per day (Department of Health, 2009). In comparison, the Health Survey for England reported that women of higher socio-economic status were more likely to meet PA recommendations (Department of Health, 2009). Lack of consensus here is likely to be due to differences in protocols, populations, selection bias and possibly measurement methods, such as different monitors and cut points. Similar to our findings, Evenson (Evenson and Wen, 2011) also reported a fall in accelerometer measured MVPA between second and third trimesters in a cross sectional study of 359 pregnant American women using Actigraph accelerometers. Whilst direct comparison with our dataset is not possible as different PA intensity ‘cut points’ were used, the proportion of measured time spent in MVPA fell from 1.9% in the second trimester to 1.1% in the third. Rousham (Rousham et al., 2006) used Actiwatches to measure longitudinal changes in PA in 57 low risk, healthy, nulliparous pregnant women in the UK. They reported accelerometry counts per minute as opposed to MVPA but also found a decrease in PA between second and third trimester. Likewise, PA has also been reported to fall in obese pregnant women between first and third trimester when measured via pedometer step counts (Harrison et al., 2011, Renault et al., 2010).

The PA of women in our study who were more active at baseline decreased as pregnancy progressed in contrast to those who were less active where PA remained stable. Whilst this has not been reported previously during pregnancy it is similar to the findings of Hinton, (Hinton and Olson, 2001), who found that women who exercised more frequently prior to pregnancy moderated their activity once pregnant, whilst sedentary women maintained their levels of PA.

Self-reported physical activity

Other studies have reported comparable results to the RPAQ findings using different questionnaires. Derbyshire (Derbyshire et al., 2008) reported the proportion of PAEE in the home steadily increased as pregnancy progressed whilst work related PAEE decreased in the third trimester. Using a semi structured interview Clarke (Clarke et al., 2005) found that total PAEE decreased by the third trimester, occupational and recreational PAEE decreasing whilst PAEE within the home remained stable. Similarly, an intervention study which used the Baecke questionnaire to measure changes in PA found a decrease in PAEE levels by the third trimester (Guelinckx et al., 2010).

Objectively measured physical activity compared to self-report

The current findings confirm those of Oostdam (Oostdam et al., 2013), who used an accelerometer and the Active Australia Questionnaire (AQuAA), at three time points during pregnancy in 55 overweight and obese women. They reported poor correlation between measurement methods; the questionnaire tending to overestimate MVPA and underestimate sedentary time. Similarly, Harrison et al (2011) compared the IPAQ and accelerometer measurement in 48 pregnant women at 26-28 weeks gestation and found that the IPAQ overestimated MVPA and underestimated light PA (Harrison et al., 2011). A systematic review examining differences between objectively and subjectively measured PA in non-pregnant individuals concluded that, depending on the method used, self-reported PA could either be higher or lower than objectively measured PA (Prince et al., 2008). Unlike Adams (Adams et al., 2005) who reported that body size in non-pregnant women had no influence on over reporting, the systematic review concluded that overweight/obese individuals were much more likely to over report, and in comparison, male participants self-report PA more accurately than females (Prince et al., 2008, Ferrari, 2007). In a study of non-pregnant individuals completing the IPAQ it was found that overreporters tended to have a lower educational level (Fogelholm et al., 2006). Concerns have been raised that, by creating more complex questionnaires that aim to tease out a more detailed picture of PA levels, the risk of misclassification due to misinterpretation will increase (Lagerros and Lagiou, 2007).

Factors influencing PA in pregnancy

None of the measured demographic characteristics correlated strongly with PA variables. Previous studies have reported an association between higher PA levels during pregnancy and pre pregnancy exercise level, being older, higher education achievement and higher household income, (Hinton and Olson, 2001, Evenson et al., 2004a, Evenson and Wen, 2011, Foxcroft et al., 2011), being a non-smoker, of non-Hispanic white origin and having insurance cover (Ning et al., 2003, Petersen et al., 2005, Evenson and Wen, 2010b, Evenson and Wen, 2011). A greater decrease in PA in early pregnancy has been reported in women who were aged less than 35, multiparous, had not attended university and those with a BMI≥30kg/m^2 (Mottola and Campbell, 2003, Fell et al., 2009).

2.4.4 Implications

Measuring physical activity in pregnancy

Despite the need for accurate, valid and reliable estimates of PA, data collection methods also need to be feasible. Self-report measures are less accurate but tend to be more acceptable and have a better response rate than objective measures. Some women stated a diary might be easier to complete, however research has shown that to be accurate and reliable this type of ‘momentary time assessment’ must be completed in 15 minute intervals and this is very onerous (Biddle et al., 2009).

Given the potential problem of compliance with wearing accelerometers future research aimed at measuring PA should consider using monitoring devices that can provide continuous 24 hour recording, for example, Actiheart. Some of these devices, (such as those containing heart rate monitors), need individual calibration. Therefore, despite potential flaws, accelerometers remain a convenient method for objectively measuring PA as they have been pre-calibrated against doubly labelled water (Westerterp, 2009). Pedometers are a simpler form of motion sensor and have been used in many research studies.

As with accelerometers, they do not pick up upper body activity, nor do they measure intensity, duration or habitual PA associated with household tasks and care giving (Corder and Ekelund, 2007, Aittasalo et al., 2010). However they are cheaper than accelerometers, acceptable to participants and can also be used as motivational tools. Whilst correlation with self-report measures are low to moderate at best, (Harrison et al., 2011, Aittasalo et al., 2010), correlation between pedometer steps and accelerometry is more promising (Kinnunen et al., 2011, Harrison et al., 2011). Agreement between the monitors in categorising participants in terms of PA levels was moderate to good and despite wide limits of agreement correlation between the two monitors has been reported as consistently high, (Tudor-Locke et al., 2002) and thus the monitors could be interchangeable if only relative values of step count are required. A study by Connolly (2011) measured PA in pregnant women between 20-34 weeks gestation using three different brands of pedometers and an accelerometer, (mean BMI at time of measurement=31 kg/m^2). The investigation was carried out under controlled conditions on a treadmill and step counts were manually counted and compared to the monitor results. The study found that two of the pedometers, (Omron HJ-7201TC and New Lifestyle NL2000), were more accurate than the Yamax Digiwaker SW-200 and the GT3X Actigraph accelerometer, especially at slower speeds (Connolly et al., 2011). Therefore given the apparent relationship between steps and MVPA found in our study and the difficulties with using and analysing accelerometer data, good quality pedometers could offer a cheaper alternative in large epidemiological studies.

The results suggest that the RPAQ is a poor tool for determining self-reported PA in overweight and obese pregnant women, both in terms of absolute PA and in ranking individuals. It does, however, give researchers an indication of the distribution of PAEE within domains of everyday life and how this changes as pregnancy progresses. It also provides valuable information about the recreational activities pregnant women participate in. Walking and swimming proved the most popular throughout pregnancy, in line with the results of other studies, (Zhang and Savitz, 1996, Da Costa et al., 2003, Evenson et al., 2004a, Pereira et al., 2007). An understanding of preferred recreational activities provides a useful insight for developing interventions to increase PA levels in pregnant women.

Increasing physical activity levels

The results from the study indicate that it is possible for obese pregnant women to achieve more than 30 minutes of MVPA per day and that MVPA at the beginning of pregnancy influences MVPA later in pregnancy. This is an important finding in terms of health promotion, encouraging an increase in PA pre-conceptually or in the first trimester may boost MVPA early in pregnancy, potentially re-enforcing the likelihood of higher levels of MVPA later in pregnancy. Following on from this, it was found that PA in more active women falls as pregnancy progresses, therefore women should be encouraged to try and maintain recommendations throughout pregnancy. Previous studies have reported reasons for low or declining PA levels, citing illness, pain, discomfort, concerns about safety and exercise self-efficacy (Duncombe et al., 2009, Hinton and Olson, 2001, Foxcroft et al., 2011, Poston et al., 2013). Promotion of acceptable activities has a better chance of being successful, however these results show that only a small proportion of total PAEE is expended in recreation and self-reported levels remain stable through pregnancy. Short bouts of intermittent PA in non-pregnant individuals have been shown to improve cardiovascular fitness and are likely to be associated with other health benefits. Therefore, the promotion of small changes in everyday life, such as walking to work or shops, walking up stairs, playing actively with children, should also be promoted and encouraged (Lagerros and Lagiou, 2007). Future intervention studies should perhaps offer individualised support, information and focus on the promotion of uncomplicated everyday lifestyle changes and the use of simple motivational monitoring tools. A range of options may be required to meet the needs of, and be acceptable to different women. Increasing daily step count is likely to help women achieve the recommended 30 minutes of MVPA throughout pregnancy and is hopefully acceptable and feasible for most obese women.

3 Midwives knowledge, attitudes and beliefs about physical activity during pregnancy

3.1 Background and rationale

> *"The midwife has an important task in health counselling and education, not only for the woman, but also within the family and the community. This work should involve antenatal education and preparation for parenthood and may extend to women's health, sexual or reproductive health and child care."*
>
> (NMC, 2009)

Despite standards regarding midwives' education, role, current evidence and national guidelines regarding PA (NICE, 2010)(Chapter 1, Table 4), qualitative research indicates that women receive little or no advice from health care professionals regarding PA during pregnancy (Smith et al., 2012). Midwives have regular direct contact with women throughout pregnancy and are therefore ideally placed to support and encourage healthy lifestyle choices. However, advice pregnant women receive regarding PA appears to lack clarity and consistency (Weir et al., 2010).

3.1.1 Guideline implementation

Clinical practice is affected by many variables; political, economic and organisational factors are likely to impact as much as an individual health professional's characteristics. Adoption of evidence-based guidelines therefore requires behaviour change by clinicians, managers and possibly specific health care institutions (Michie et al., 2007). Previous interventions designed to change clinical practice have included education via workshops, conferences and written material, audit, feedback, reminders, support systems and opinion leaders, (Dyson et al., 2011), but their success is often variable. Passive strategies are usually ineffective, and whilst more active interventions have more success they are often more costly (Grimshaw et al., 2001). Getting research evidence into practice is, therefore, often slow, difficult and problematic. Studies examining implementation in the USA and Netherlands found that a third of patients did not receive care according to the best evidence, whilst a quarter received care that they did not need (Eccles et al., 2005).

Implementation of NICE guidelines has been shown to vary by Trust and topic (Sheldon et al., 2004) and is influenced by professional support, quality of evidence, costs and procedures for auditing adherence. A systematic review of guideline dissemination and implementation strategies found that the majority of interventions only lead to modest to moderate improvements in care by health care staff (Grimshaw et al., 2004). Effective and appropriate change strategies need to be based on why specific staff ‘do’ or ‘do not’ perform behaviour already.

It is possible that attempts to implement guidelines have had limited and varied effects due to the lack of an explicit theory or rationale for the intervention, failure to identify barriers and facilitators to implementation, or poor methodological design (Grimshaw et al., 2004, French et al., 2012). A systematic review examining health care staff behaviour concluded that health professionals’ intentions were a good proxy measure for subsequently performing a specific behaviour (Eccles et al., 2006), and that intention and behaviour are influenced by psychological variables that can be measured.

3.1.2 Encouraging health care staff to change their behaviour

A complicating factor in the process of changing the behaviour of a health care professional is that the new behaviour does not always directly benefit the person making the changes, therefore a major motivating factor is removed. Previous research has found that professionals are unwilling to make changes to their behaviour unless they can see direct benefits to their patient and their own practice (Michie and Abraham, 2004).

An understanding of why advice is not given, or guidelines followed, is essential if behaviour change strategies are to be implemented. Research in Finland investigating the smoking cessation advice given by dental care providers reported that providers lacked confidence in assisting patients to quit (Amemori et al., 2011). This lack of confidence was thought to be a consequence of lack of knowledge, skills, doubts about effectiveness of counselling and busy schedules. Evidence from the Finnish study indicates that attitudes, as well as lack of knowledge and motivation, may impact on the ability of staff to give appropriate support and advice.

Therefore, interventions designed to influence behaviour change in midwives need to be based on the barriers that midwives face when discussing PA with obese pregnant women and advising them appropriately.

3.2 Theoretical Domains Framework

Behaviour change interventions should be guided by theory to assist with replication and to provide an understanding of the influencing components involved in the change process. There are a number of psychological behaviour change theories which have been developed to help guide intervention development and explain how behaviour change occurs, (for example**:** Social Learning/Social Cognitive theory, Theory of Reasoned Action, Theory of Planned Behaviour, Transtheoretical/Stages of Change Model and Health Action Process Approach (Michie et al., 2005)). Many of these have similar or overlapping concepts and can be challenging for non-psychologists to implement.

Michie developed a theoretical, psychological framework which can be used to evaluate evidence-based practice and study the implementation of guidelines by health care professionals. It can also inform the development of theory-based interventions that will support implementation of evidence-based practice and aid the communication of constructs, (the factors which may influence behaviour of the health care professionals) to an interdisciplinary audience (Michie et al., 2004, Michie et al., 2005). In this research, groups of psychological theorists, health service researchers and health psychologists deconstructed 33 psychological behaviour change theories and identified 128 explanatory constructs. These were grouped into 12 domains (table 23).

The first 11 domains contain constructs that influence the behaviour under investigation, the final domain (nature of behaviour), relates more to an understanding and description of the actual behaviour.

Table 23: Theoretical domains and their constructs

Domain	Meaning	Constructs
Knowledge	*Familiarity gained by experience, theoretical or practical understanding.*	Knowledge- condition, scientific rationale, procedural schemas, mindsets and illness representations.
Skills	*Ability/proficiency acquired through practice*	Competence, ability, assessment, practice, interpersonal skills, coping strategies
Social professional role and identity	*A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting*	Identity, professional, boundaries, role. Group/social identity. Social/group norms. Alienation/organisational commitment.
Beliefs about capabilities	*Acceptance of the truth, reality, or validity about an ability, talent, or facility that can be put to constructive use*	Self-efficacy, control, perceived competence, self/professional confidence, empowerment, self-esteem, perceived behavioural control, optimism/pessimism.
Beliefs about consequences	*Acceptance of the truth, reality or validity about outcomes of a behaviour in a given situation*.	Outcome expectations, (physical, social, emotional) Anticipated regret, appraisal, attitudes, incentives/rewards/sanctions, unrealistic optimism, salient events, sensitization/critical incidents.
Motivation and goals	*Mental representations of outcomes or end states that an individual wants to achieve*	Intention, (stability/certainty), goals (autonomous, controlled), target and priority setting, intrinsic motivation, commitment, distal and proximal goals, Transtheoretical model and stages of change.
Memory, attention and decision processes	*Ability to retain information, focus selectively and choose between alternatives*	Memory, attention, control, decision making
Environment context and resources	*Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour.*	Resource, material resource, environmental stressors, environment interaction, knowledge of task environment.
Social influences	*Interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours.*	Social support and pressure, social/group norms/identity, leadership, team working, organisational culture, power/hierarchy, professional

		boundaries/roles, management commitment, supervision, comparisons, feedback, competing/ conflicting demands. Learning and modeling.
Emotion	*A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event.*	Affect, stress, anticipated regret, fear, burn-out, cognitive overload/tiredness, threat, positive/negative affect, anxiety/depression
Behavioural regulation	*Anything aimed at managing or changing objectively observed or measured actions.*	Goal/target setting, implementation intention, action planning, coping, self-monitoring, goal priority, generating alternatives, feedback, moderators of intention-behaviour gap, project management, barriers and facilitators.
Nature of the behaviour	*What is the actual behaviour?*	Routine/automatic habit, breaking habit, direct experience/past behaviour, representation of tasks, stage of change model

(Michie et al., 2005)

This 'Theory Domains Framework' (TDF) was originally designed to be used in qualitative research, for example, performing semi-structured interviews or focus groups involving health care professionals to assess difficulties in implementing a specific guideline (Michie et al., 2007, Bussieres et al., 2012, Dyson et al., 2011, Boscart et al., 2012, McSherry et al., 2012, Patey et al., 2012, Francis et al., 2012, French et al., 2012). It has subsequently been used in a questionnaire format, with each item, or question, relating to one of the 11 specific domains, (Amemori et al., 2011, Beenstock et al., 2012). By scoring each response it is possible to obtain an overall mean value for each domain. Domains which score highly have a positive influence on the behaviour being carried out, that is, there are constructs within the domain which act as facilitators. Conversely, domains with low scores have a negative influence on the behaviour being carried out, that is, constructs within the domain act as barriers to action and implementation. These theoretical constructs can then be mapped back to relevant behaviour change techniques (Michie et al., 2008). The TDF could therefore be a useful tool to investigate the implementation of NICE guidelines regarding PA in pregnancy by midwives.

3.3 Aims and objectives

The main aim of the study was to describe prior knowledge, attitudes and current practice of midwives surrounding PA and obesity in pregnancy.

3.3.1 Objectives of questionnaire:

- To ascertain whether or not midwives discuss PA with obese pregnant women and advise them in accordance with national guidelines.
- To identify key domains which may impact upon midwives' behaviour, facilitating or acting as barriers to discussing/ advising PA.
- To identify any personal characteristics which are associated with midwives' behaviour.
- To make recommendations to inform subsequent training needs of midwives.

3.4 Methodology

This study was a cross sectional, quantitative, paper based, self-completion questionnaire with additional sections for free text comments. The aim was to explore barriers and facilitators to the specific behaviour:

> ***'Midwives discuss PA with obese pregnant women and advise them accordingly'***

The use of qualitative interviews was considered as a potential method to collect data regarding midwives views, attitudes and beliefs. However, it was felt that the use of a questionnaire would be more appropriate as it would ensure that a greater breadth of responses would be elicited. Data from midwives with differing experiences and backgrounds working in different locations, such as ward, clinic, community, across all three Trusts could be collected. Space was provided for free text comments from the respondents in an attempt to overcome some of the limitations with using pure quantitative survey research. This would allow midwives to further describe their perspectives on the subject area.

A theoretical approach was used to ensure the questions incorporated into the questionnaire were systematically developed. The use of the TDF is a novel and emerging approach to designing questionnaires which inform theory and behaviour change interventions by methodically questioning theoretical constructs. Thus, using the TDF provided a structured and uniform approach to questionnaire design and data collection in order to help quantify barriers and facilitators to performing the specific behaviour. I also had the support of a senior lecturer in health psychology who had experience in using the framework.

Midwives were chosen to participate in the survey as they have contact with women throughout pregnancy, from the pregnancy booking appointment through to the post-natal period. Therefore they have the greatest potential and more opportunities to influence and advise women. The inclusion of other health care professionals, such as obstetricians, was considered, they also have direct contact with pregnant women, although this is not so frequent as midwives and often at a later stage of pregnancy. However, it was felt that other health care professionals were likely to face different barriers and facilitators to discussing PA with obese pregnant women and therefore their inclusion in the survey might mask or skew the results given by the midwives.

No formal sample size calculation was performed for the survey, three diverse NHS Trusts were targeted and all employed midwives were invited to participate. Efforts were made to maximise response rate in several ways. Midwives were informed in advance that they would receive the questionnaire, a statement within the questionnaire attempted to explain the importance of the topic and it was anonymised. A letter from the respective Head of Midwifery/Women's Services and Principle Investigator for each site was sent with each questionnaire, endorsing the questionnaire and encouraging staff to participate. Reminder e-mails were sent to staff with internet access, flyers were posted in Trust newsletters and sent to each community midwife base. Finally, a second questionnaire was posted out one month after the first so that midwives who may have mislaid, lost or forgotten about the first questionnaire could still participate if they so wished.

Questionnaire development

The questionnaire was designed using the TDF suggested by Michie (Michie et al., 2005). Table 24 lists the 12 domains and describes them in the context of the behaviour under investigation.

Table 24*:* Description of the domains in the context of this research

Domain	Description
Knowledge	Do midwives know what to advise obese pregnant women with regard to PA
Skills	Do midwives feel able and have the correct training to advise obese pregnant women about PA
Social Professional Role	Do midwives feel that advising obese pregnant women about PA is part of their professional responsibility
Beliefs about Capabilities	Do midwives feel capable, confident and comfortable to advise obese pregnant women about PA
Beliefs about consequences	What do midwives think will be the result if they advise obese pregnant women about PA
Motivation and Goals	How much do midwives aim to, or want to, discuss and advise obese pregnant women about PA
Memory, attention, decision	Do midwives remember to discuss, or remember that they should discuss, PA with obese pregnant women
Social Influences	Do other health professionals or individuals influence whether or not midwives discuss and advise obese pregnant women about PA
Emotion	Do emotions/feelings influence whether or not midwives discuss and advise obese pregnant women about PA
Behaviour Regulation	Are there guidelines or is there a care pathway in place to support midwives when they discuss PA with obese pregnant women
Environment, Context, Resources	Do midwives have enough resources, such as time, to discuss PA with obese pregnant women
Nature of the Behaviour	Do midwives discuss PA with obese pregnant women an advise them in accordance with national guidelines

Research literature reporting the views, knowledge and attitudes of pregnant women and health service professionals towards PA and obesity was examined and recurring themes, comments and questions identified. The issues identified were then used to inform and develop appropriate questions for the questionnaire. Evidence to support the questions was derived from the evidence-based guidelines and systematic reviews listed below and presented in table 25. All evidence statements relating to PA in pregnancy were abstracted from the reports and used where appropriate. (The questionnaire is presented in Appendix M)

1. NICE guidelines ‘Dietary interventions and physical activity interventions for weight management before, during and after pregnancy’ (NICE, 2010).

2. The joint CEMACE/RCOG guidelines ‘Management of Women with Obesity in Pregnancy’ (Modder and Fitzsimons, 2010).
3. ‘Systematic review of dietary and/or physical activity interventions for weight management in pregnancy’ (Campbell et al., 2009).

Table 25*:* Evidence statements from guidelines and systematic reviews and related questions

Domain	Relationship to the 'Behaviour'	Evidence	Interpretation of evidence	Statements/Questions
Knowledge	Do midwives know what to advise obese pregnant women regarding physical activity during pregnancy?	**NICE public health guideline 27, 'Dietary interventions and physical activity interventions for weight management before, during and after pregnancy'**. (NICE, 2010) • Advise that moderate intensity PA will not harm her or her unborn child. At least 30 minutes per day of moderate intensity activity is recommended. • Give specific and practical advice about being physically active during pregnancy. • Recreational exercise such as swimming or brisk walking and strength conditioning exercise is safe and beneficial	It is safe for obese women to be physically active during pregnancy. NICE guidelines recommend that all pregnant women should aim to achieve 30 minutes of moderate intensity activity per day. Women who have never carried out moderate activity can safely and gradually build up to this goal. It is safe for women who are already moderately active to maintain activity levels. There are many different ways that women can achieve recommendations	1. I know what the recommendations are in the NICE guidelines, ***(****Weight Management Before, During and After Pregnancy****),*** regarding PA during pregnancy. 2. If obese women have not exercised prior to pregnancy they should not attempt to start during pregnancy. 3. It is acceptable for obese pregnant women who find physical activity difficult to rest and remain more sedentary during pregnancy. 4. Experts don't really know if physical activity is beneficial or harmful for obese pregnant women. 5. Attending exercise classes is the only way obese pregnant women can meet activity recommendations.

		• The aim of recreational exercise is to stay fit, rather than to reach peak fitness. • If women have not exercised routinely they should begin with no more than 15 minutes of continuous exercise, three times per week, increasing gradually to daily 30 minute sessions. • If women exercise regularly before pregnancy, they should be able to continue with no adverse effects. Explain to those women who would find this level of PA difficult that it is important not to be sedentary, as far as possible. Encourage them to start walking and to build PA into daily life, e.g., by taking	and build activity into everyday life.	

		the stairs instead of the lift, rather than sitting for long periods.		
Skills	Are midwives able to advise obese pregnant women about being physically active during pregnancy? Do midwives feel they have adequate and appropriate training to communicate the information?	**Systematic Review of dietary and/or physical activity interventions for weight management in pregnancy'. (Campbell *et al.,* 2009)** **Evidence Statement 19:** Evidence from 3 UK based qualitative studies (Gross and Bee, 2004, Heslehurst et al., 2007a, Wiles, 1998) suggests that weight management information and advice from professionals is not received or assimilated by many women during pregnancy. Available information is often vague, confusing, contradictory, and is not linked to weight management.	Midwives appear to have problems communicating the correct information regarding activity to pregnant women	6. I feel competent discussing activity levels with obese pregnant women. 7. I am able to implement the recommendations regarding PA and obese pregnant women. 8. I am trained to give obese pregnant women appropriate advice regarding PA in pregnancy.
Social Professional role/ Identify	Do midwives feel it is part of their role and responsibility to advise obese pregnant women	**Joint CEMACE/RCOG guidelines, 2010, p6:** 'Women should be made aware of the importance of healthy eating and	It is part of the role of the midwife who is providing ante-natal care to advise all pregnant women	9. It is part of my role as a midwife to advise obese pregnant women about the appropriate type and amount of PA they should do during pregnancy.

	about physical activity during pregnancy?	appropriate exercise during pregnancy in order to prevent excessive weight gain and gestational diabetes.' **Systematic review Evidence statement 4:** 'There is weak evidence from two studies (Wolff et al., 2008, Claesson et al., 2008b) amongst obese women that interventions promoting healthy eating and/or moderate physical activity leads to a reduction in weight retained post-partum when compared with controls.' **Systematic review Evidence statement 11:** 'There is evidence from two USA based observational studies (Olson and Strawderman, 2003, Gunderson et al., 2004) that women, including overweight women, who decreased physical activity in pregnancy experienced significantly greater	about the importance of diet and activity in relation to health, wellbeing and minimise excessive gestational weight gain.	10. It is part of my role as a midwife to discuss PA as part of routine ante-natal care with obese pregnant women. 11. It is the responsibility of the GP or Obstetrician to discuss PA with pregnant women.

		gestational weight gain. Higher activity levels were associated with reduced weight gain.’		
Beliefs about Capabilities	Do midwives feel confident and comfortable when advising obese pregnant women about activity during pregnancy? Do midwives feel capable and competent when advising obese pregnant women about activity?	**Systematic review Evidence statement 26:** ‘Qualitative evidence from two UK based studies (Heslehurst et al., 2007b, Warriner, 2000) suggests there are communication difficulties between overweight women and health professionals. One study of health professionals found that they are often embarrassed to discuss issues of weight with overweight women, and that the women themselves were also embarrassed. One study (Heslehurst et al., 2007b), explored the views of health professionals, some of which found it difficult to raise this issue sensitively. They reported a lack of guidance on this issue, thought were aware of the risks and benefit of	Midwives may lack confidence in their ability to advise obese pregnant woman about activity. Midwives may find discussing weight related issues difficult and embarrassing. Midwives may be concerned that when they give advice it will cause offence and not have the desired beneficial effects.	12. I find it easy to discuss activity levels with obese pregnant women. 13. I feel confident giving obese pregnant women advice about PA during pregnancy. 14. I feel optimistic that if I give PA advice to obese pregnant women they will follow it.

		raising the issue. They were concerned that some women may stop attending antenatal appointments if they felt victimised.		
Beliefs about consequences/ Anticipated outcomes/ Attitudes	Do midwives feel that by giving advice about activity during pregnancy it will have a beneficial effect on the health and wellbeing of obese pregnant women?	**NICE PH guideline 27, p11:** 'Advise that a healthy diet and being physically active will benefit both the woman and her unborn child during pregnancy and will also help her to achieve a healthy weight after giving birth. Advise her to seek information and advice on diet and activity from a reputable source.' **Systematic review, Evidence statement 6:** 'Three RCT's conducted in the USA, Denmark and Canada, (Polley et al., 2002, Wolff et al., 2008, Hui et al., 2006), and 2 non randomised studies conducted in Finland and a Cree community in Canada, (Kinnunen et al., 2007a, Gray-Donald et al., 2000),	Carrying out moderate intensity activity is safe for obese pregnant women and the fetus. Encouraging women to be active during pregnancy is likely to improve their health and wellbeing. Women who are more active may achieve a healthier weight gain during pregnancy.	15. It is safe for obese pregnant women to try and follow the recommendations of at least 30 minutes of moderate intensity activity per day. 16. Obese pregnant women will feel guilty if I discuss PA with them but they find it difficult to be more active. 17. Advising obese women to be more physically active during pregnancy may put their baby at risk of harm. 18. It is beneficial for obese women to increase their physical activity levels during pregnancy.

		found no evidence to suggest that interventions among women who are a healthy weight or obese, focusing on healthy eating and moderate physical activity, adversely affect infant outcomes including birth weight, gestational age at birth and the incidence of macrosomia.' **Evidence statement 7:** 'There were no reported adverse effects associated with moderate physical activity and /or dieting during pregnancy.'		
Motivation and goals	Do midwives aim to, or want to, discuss and advise obese pregnant women about PA?	**Systematic review Evidence statement 19:** 'Evidence from 3 UK based qualitative studies (Gross and Bee, 2004, Heslehurst et al., 2007b, Wiles, 1998) suggests that weight management information and advice from professionals is not received or assimilated by many women during pregnancy. Overweight women may feel	Midwives may feel that any advice they give to women regarding weight management is not well received by women and so do not focus on this. Midwives may not feel able to provide an individualised approach to giving advice.	19. I have more important things to discuss with obese women during ante-natal appointments than their PA levels. 20. I aim to discuss PA with obese pregnant women as part of my routine ante natal care. 21. I am keen to implement the guidelines regarding PA for obese pregnant women.

		they are not receiving relevant, tailored information about appropriate diet and weight gain during pregnancy (Wiles, 1998)' **Evidence statement 22;** 'Evidence from 2 UK based qualitative studies (Gross and Bee, 2004, Fox and Yamaguchi, 1997), suggests that even relatively active women reduce their PA during pregnancy (although they are more likely to continue to be active at some level). One study, (Gross and Bee, 2004) found that pregnant women decreased their activity levels based on advice from health professionals, or more commonly, on information they had read in books and magazines. Family members, friends and even health trainers tended to discourage PA. Women balanced their fears of injury to themselves or harm to the baby with aims	Midwives may not be aware of the importance and need to give ongoing support and encouragement regarding activity to obese pregnant women.	

		toward weight management. Women also reported reduced motivation, physical limitations due to larger size and tiredness during pregnancy and a lack of facilities. Another study reported that pregnant women may feel self-conscious when carrying out PA (Fox and Yamaguchi, 1997)’		
Memory, attention and decision process	Do midwives remember to discuss, or remember that they should discuss, PA with obese pregnant women?	Giving advice about PA during pregnancy has been rated as a low priority by health care professionals (Chang 2013). Discussions about PA may be influenced by lack of awareness, familiarity or agreement with guidelines. Discussing weight related issues during pregnancy is a difficult and sensitive topic, midwives may be reluctant to broach the issue (Phelan, 2010). Many health care professionals lack	Midwives may forget to discuss PA with obese pregnant women because other issues take priority. This decision may be influenced by the lack of awareness of the benefits, especially to obese women. Midwives may feel that they do not possess adequate counselling skills or that the topic may	22. I do not discuss PA with obese pregnant women because • I usually forget • I don’t really know what to advise. 23. If women are obese I am more likely to discuss PA 24. I only discuss PA with obese women who ask me for advice about it.

		confidence in their ability to council patients on lifestyle related issues and therefore avoid the topic (Howe, 2010).	cause offence and so consciously or sub-consciously do not discuss it.	
Environment context and resources	Do midwives have appropriate resources, (time, information, referral pathways), to discuss PA with obese pregnant women	**Systematic review, Evidence statement 21:** 'There is evidence from UK based qualitative research (Heslehurst et al., 2007b), that health professionals working in maternity units may feel they have insufficient time to discuss weight issues with women during pregnancy and consider that it is too late to give advice on weight management once a woman is pregnant. Health professionals themselves report that women's access to the information and advice on weight management is often ad hoc.'	Midwives may feel they do not have enough time to discuss activity with obese pregnant women. Midwives may feel that it is too late to give advice that will impact on a woman's weight and therefore not prioritise the discussion. Midwives may feel that further access to information for women is limited.	25. I am usually too busy to discuss PA with obese pregnant women. 26. If I have any questions regarding PA in obese pregnant women there is no one readily available to give me the support and answers I need. 27. If I had a leaflet to give to obese pregnant women I would feel more comfortable about discussing PA.

Social influences	Are midwives influenced by other health professionals or individuals when deciding whether or not to discuss and advise obese pregnant women about PA?	**NICE PH guidelines 27, p11:** 'WHO SHOULD TAKE ACTION? Obstetricians, midwives, GP's and practice nurses. Dieticians and public health nutritionists. Managers and health professionals in children's centres Midwifery assistants, support workers and other healthcare practitioners. WHAT ACTION SHOULD THEY TAKE? At the earliest opportunity, eg, during a pregnant woman's first visit to a health professional, discuss her eating habits and how physically active she is. Find out if she has any concerns about diet and the amount of PA she does and try to address them.'	It is the responsibility of all health care providers to encourage pregnant women to have a healthy diet and be physically active. If midwives feel that their peers are not giving this advice, rather than adopt the same attitude, they should encourage this behaviour within their peer group.	28. Other midwives in my NHS Trust do not discuss PA routinely with obese pregnant women. 29. Obese pregnant women expect me to discuss PA with them during pregnancy. 30. GP's expect me to discuss PA with obese pregnant women. 31. Obstetricians expect me to discuss PA with obese pregnant women.
Emotion	Do emotions or feelings influence whether or not midwives discuss	**Systematic review Evidence statement 20:** There is evidence from UK based qualitative research	Discussing weight related issues with obese pregnant women is difficult as	32. I am more concerned about other pregnancy related issues than giving advice about PA to obese pregnant women.

	and advise obese pregnant women about PA?	(Heslehurst et al., 2007b, Levy, 1999) that women may be unaware of the potential effects of obesity during pregnancy. However, they may avoid information about their health if they find it distressing and will only action it when they feel the time is right for the well-being of themselves, their unborn baby and their partners.	it can be a very sensitive topic and cause distress. Midwives may be concerned that they will cause offence or anxiety and may either feel very uncomfortable or may avoid the discussion.	33. I worry about making obese pregnant women anxious by advising them about activity. 34. I worry that discussing PA with obese pregnant women may harm my relationship with the woman, 35. I feel uncomfortable talking to women who are obese about their PA levels.
Behavioural regulation	Do midwives have guidelines or care pathways to provide support and advice when discussing PA with obese pregnant women?	**NICE PH guideline 27, p11:** 'Give specific and practical advice about being physically active during pregnancy.' *Defined as:* 'Anything aimed at managing or changing objectively observed or measured actions', this could involve goal/target setting, implementation, intention, action planning, coping and self-monitoring'.	Midwives need to be aware of appropriate and practical advice and have a plan as to when, how and where they will deliver this advice.	36. I have a clear plan of how to address PA issues with obese pregnant women. 37. I know when to address PA with obese pregnant women. 38. I have a clear plan of what to recommend to obese pregnant women regarding PA 39. If I encounter a problem when discussing PA with obese pregnant women I know how to solve it.
Nature of Behaviours	Do midwives discuss PA with obese pregnant	Evidence indicates that in general women receive little or no advice from health	Need to examine direct experiences and past behaviour	OPEN question: How do you view giving physical activity advice to obese pregnant women?

	women an advise them in accordance with national guidelines?	care professionals regarding activity. Any advice women do receive appears to lack clarity and consistency (Weir *et al.,* 2010).	of midwives, what is the routine automatic habit and how can this be changed.	Would you like to make any other comments?

A total of 40 closed questions were devised, with between 3 and 5 questions relating to each domain. These questions were then randomly arranged in the questionnaire and respondents were asked to rate their replies on a 5 point Likert scale, where 1=strongly agree and 5=strongly disagree. Some of the questions were negatively phrased to avoid acquiescence bias.

The domain ‘nature of the behaviour’ differs from the other 11 domains in that it does not relate directly, mediate or influence the behaviour, that is, it is not a key determinant of behaviour change. It relates more to a description and understanding of the actual behaviour that needs to be changed (Michie et al., 2008, Michie et al., 2005, Francis et al., 2012). For this reason there were no direct questions related to this domain within the questionnaire, in accordance with the methods explained in previous studies (Amemori et al., 2011, Michie et al., 2011). It was felt that using an open question may elicit information about what the midwives think about the behaviour and what they feel needs to be changed, thus, possibly providing some guidance or insight into why implementation of the desired behaviour varies (Michie et al., 2005).

One direct question was also asked, whether the individual participant performed the behaviour under investigation, (that is, discuss and advise obese pregnant women regarding PA), with the reply on a 5 point scale from ‘Always’ to ‘Never’. The domain questions were followed by a small number of basic demographic questions, (Appendix M), with space for free text comments about the subject and the actual questionnaire itself. The length of the questionnaire was designed to maximise the amount of information obtained, so improving the validity of the results, whilst trying not to be too onerous for the midwives to complete. The questionnaire was piloted with 5 midwifery colleagues and was found to take less than 10 minutes to complete and was therefore thought to be of an acceptable length.

3.5 Methods

3.5.1 Ethical approval

Ethical approval was obtained from Sunderland Research Ethics Committee, Rec. Reference number 11/NE/0152 (Appendix O).

Newcastle upon Tyne Hospitals NHS Foundation Trust acted as sponsors of the research (Research and Development reference number 5748).

3.5.2 Data Collection

Population/sample

The questionnaire was distributed initially to all hospital and community midwifery staff employed by Newcastle upon Tyne Hospital NHS Foundation Trust and South Tyneside District Hospital NHS Foundation Trust between June 2011 and September 2011, and then subsequently to all community midwives employed by Northumbria Health Care Trust in the North of Tyne Primary Care Trust area between July 2012 and September 2012. In total 375 questionnaires were distributed and with an estimated 50% return rate it was anticipated that this would provide meaningful results.

By selecting a tertiary referral centre, (Newcastle upon Tyne Hospital NHS Foundation Trust), and a District General Hospital in the same region it was hoped that a broad cross section of staff views, attitudes and practices would be obtained. The North of Tyne community midwives were subsequently added after initial analysis of responses from the hospital midwives indicated that many of them did not have contact with women in the antenatal period.

A covering letter was written to accompany each questionnaire (Appendix N). This was signed by the head of midwifery in the respective Trusts and either the Principle Investigator for that location or the Obstetric Consultant involved with the research.

The questionnaire was designed to be returned anonymously. A list of staff members was obtained from the maternity administration departments of the participating Trusts. Each staff member was allocated a coloured, numbered label which was attached to the front of the questionnaire. Participants were instructed to complete the questionnaire then detach the label and return both the questionnaire and label separately to the designated collection boxes within the maternity departments. Community midwives from the North of Tyne area were provided with 2 pre-addressed envelopes, one for the questionnaire, and one for the label. By doing this it was possible to ascertain which staff members had returned their questionnaire, but impossible to know which questionnaire individuals had actually completed. This was done so that a second ‘reminder’ questionnaire could be sent out to staff members who had not returned their first one.

Completion and return of the questionnaire was taken as consent to participate in the study. Staff who failed to return the second questionnaire were deemed to have declined participation.

3.5.3 Data processing and statistical analysis

Returned questionnaires were given a sequential identification number for the purposes of data entry. All topic questions were coded 1-5; demographic questions were given appropriate codes. Coded data from the questionnaires was entered directly onto an SPSS spreadsheet for subsequent analysis, (SPSS Inc., Chicago, Il, USA), by one operator then checked by a second independent operator to ensure accuracy.

Participant characteristics

Descriptive information regarding participant characteristics and place of work was produced and compared using cross tabulations and t tests.

Domain questions

As questions were coded as strongly agree = 1 to strongly disagree = 5, scores from positively phrased questions were inverted so that the higher score related to a more favourable response, thus keeping the coding consistent throughout. Mean domain scores were calculated from each set of domain-specific questions, a high score indicating that the constructs within the domains were *not* acting as barriers to performing the behaviour (discuss and advise PA with obese pregnant women). A low score indicated that it was more likely the constructs within the specific domains were acting as barriers to performing the behaviour. The internal consistency of the questions within each domain was assessed by calculating Chronbach's alpha; a cut-off of 0.5 was deemed sufficient for preliminary research, as previously described (Amemori et al., 2011). Effectively, an alpha of less than 0.5 was deemed to be an indication that there was variability in how individual midwives had responded to the different questions within that domain. Where this was the case the domains were examined to see how alpha improved if individual questions were removed from the analysis. Subsequently, 9 questions were excluded from further analysis. Removal brought Chronbach's alpha up to a more robust value for most domains. The 'environment, context resource' domain was an exception to this. Despite removal of one of the questions α remained low. Results for this domain are still presented in the tables, however they are not interpreted and no conclusions are drawn from them.

The mean domain scores for each Trust and staff groups were calculated and compared using t tests and analysis of variance.

Associations

Associations between respondent characteristics and mean domain scores were initially investigated using cross tabulations. Further associations between the 'behaviour' (discuss and advise PA with obese pregnant women), the domains and demographic characteristics were calculated using Pearson's correlation coefficient and defined as low (0.0 to 0.39), moderate (0.40 to 0.69) and high (0.70 to 1.0).

Influencing factors

Factor analysis was performed to identify and describe the underlying components influencing the behaviour. Categorical principle component analysis (CATPCA) was used to perform data reduction as the variable of interest, (discuss and advise PA with obese pregnant women), was reported on a categorical scale of 1-5. The analysis was performed in SPSS with different combinations of domains until a meaningful solution, with clearly defined dimensions, was obtained based on goodness of fit.

The question response distributions were tested for normality and the behaviour was found to be positively skewed, i.e. high scores for the behaviour 'discuss and advise PA with obese pregnant women' were more probable than low scores. Since the outcome variable of interest was categorical the probability of midwives scoring 1, 2, 3, 4 or 5 for this question was investigated using an ordinal regression model with a complementary log-log link (McCullagh and Nelder, 1989). The complementary log-log link was chosen since it is better suited than other standard link functions to situations in which the data are skewed towards higher values. Ordinal regression produced estimated coefficients for the predictor variables; these in turn were used to produce the Wald statistic, (the square of the ratio of the coefficient to its standard error). A significant result means that the null hypothesis, (that this value will be equal to zero), can be rejected, indicating that covariates with a significant value are associated with the behaviour (discuss/advise PA with obese pregnant women).

The analysis was repeated systematically using every combination of the covariates

A test for parallel lines was performed; this tests the assumption that the relationships between the covariates and log odds of being in a given category for ‘behaviour’, (that is, scoring 1, 2, 3, 4 or 5), or the category above is the same for all categories. This would mean that the results are a set of parallel lines, one for each category of the behaviour. The difference between the -2 Log likelihood values for Staff Group 1, (community and antenatal midwives), was found to be 2.04, p=0.879, indicating that there was no difference between the slope coefficients of the parallel lines.

As part of the ordinal regression analysis SPSS performs a ‘goodness of fit measure’ for the model. The observed and expected cell counts are used in this calculation; if these are similar with no significant difference then the model fits well. For Staff Group 1 Pearson’s chi-squared = 111.15, on 142 degrees of freedom, p=0.974, indicating the model fitted well. These calculations were repeated for the whole sample and the other sub-divided groups and the same patterns and conclusions were found.

The regression model was then used to estimate the effect on the behaviour, (discuss and advise obese pregnant regarding PA), if the scores for the influencing domains were increased, so mimicking the effect of a successful training intervention or policy/practice change, (that is, decrease barriers and increase the facilitating factors that encourage the midwives to perform the behaviour).

Free text comments

Free text responses were typed verbatim directly onto an Excel spreadsheet. These comments were then coded thematically using the TDF domains by two independent reviewers (CMcP and RB). Once each comment was aligned to one or more domains the link was either categorised as facilitating the behaviour or acting as a barrier against performing the behaviour. The number of barriers related to each domain was subtracted from the number of facilitators to give an overall score which is presented graphically and compared to the quantitatively produced question mean domain scores.

3.6 Results

3.6.1 Demographic characteristics of participants

A total of 365 questionnaires were distributed and 192 returned, giving a response rate of 52.6%. The numbers obtained from each of the participating Trusts are shown in table 26, along with years qualified and self-reported activity levels. Both South Tyneside and North of Tyne midwives returned more questionnaires than staff at the Newcastle Hospitals NHS Foundation Trust. A higher proportion of North of Tyne respondents had been qualified for over 10 years. South Tyneside respondents reported lower PA levels than midwives from the other Trusts.

Table 26*: Demographic characteristics of participants*

	All	Newcastle	South Tyneside	North of Tyne	p value
Number issued	365	258	77	30	
Number returned	192 (52.6%)	111 (43.0%)	51 (66.2%)	30 (100%)	Newcastle v other <0.001 N v S Tyne= 0.314
Years Qualified **<2** **3-5** **5-10** **>10**	 17 (8.8%) 22 (11.4%) 32 (16.7%) 121 (63.0%)	 11 (9.9%) 15 (13.5%) 19 (17.1%) 66 (59.4%)	 6 (11.8%) 7 (13.7%) 10 (19.6%) 28 (54.9%)	 0 0 3 (10.0%) 27 (90.0%)	0.049
Self-reported activity level ***Mean (SD)***	6.53 (1.73)	6.70 (1.70)	5.91 (1.67)	6.93 (1.72)	0.010

Table 27 highlights the differences in main place of work of respondents in each Trust. The differing staff distribution reflects the different nature of the hospitals, Newcastle Trust being a much larger referral centre with a fetal medicine unit, birth centre and team of research midwives.

Table 27: Respondents place of work; number and % by Trust

Place of work	Newcastle	South Tyneside	North of Tyne	All
Community	15 (13.6%)	9 (17.6%)	30 (100%)	54 (28.3%)
Day assessment	2 (1.8%)	2 (3.9%)	0	4 (2.1%)
ANC or FMU	14 (12.7%)	2 (3.9%)	0	16 (8.4%)
Delivery Suite	17 (15.4%)	26 (51.0%)	0	43 (22.5%)
Inpatient ward	10 (9.1%)	6 (11.8%)	0	16 (8.4%)
Rotational	36 (32.7%)	6 (11.8%)	0	42 (22.0%)
Integrated Team	3 (2.7%)	0	0	3 (1.6%)
Birth Centre	3 (2.7%)	0	0	3 (1.6%)
Research	7 (6.4%)	0	0	7 (3.7%)
Other	3 (2.7%)	0	0	3 (1.6%)
Total	110*	51	30	191

*1 participant failed to answer question

3.6.2 Reliability and validity of questions

The mean response for each individual question and mean domain scores were calculated for the whole sample (table 28) and the internal consistency within each domain was tested using Chronbach's alpha (table 29).

Table 28*: Individual question mean scores*

Knowledge	Mean	SD
1. I know what the recommendations are in the NICE guidelines, *(Weight Management Before, During and After Pregnancy),* regarding physical activity during pregnancy.	3.06	0.98
2. If obese women have not exercised prior to pregnancy they should not attempt to start during pregnancy.	3.89	0.62
3. It is acceptable for obese pregnant women who find physical activity difficult to rest and remain more sedentary during pregnancy.	4.30	0.66
4. Experts don't really know if physical activity is beneficial or harmful for obese pregnant women.	3.75	0.62
5. Attending exercise classes is the only way obese pregnant women can meet activity recommendations.	3.42	0.76
Skills		
6. I feel competent discussing activity levels with obese pregnant women.	3.21	1.03
7. I am able to implement the recommendations regarding physical activity and obese pregnant women.	2.91	0.86
8. I am trained to give obese pregnant women appropriate advice regarding physical activity in pregnancy.	2.23	0.87
Social Professional Role		
9. It is part of my role as a midwife to advise obese pregnant women about the appropriate type and amount of physical activity they should do during pregnancy.	3.97	0.65
10. It is part of my role as a midwife to discuss physical activity as part of routine ante-natal care with obese pregnant women.	3.98	0.63
11. It is the responsibility of the GP or Obstetrician to discuss physical activity with pregnant women.	3.16	0.90
Beliefs about capabilities		
12. I find it easy to discuss activity levels with obese pregnant women.	3.07	1.02

13. I feel confident giving obese pregnant women advice about physical activity during pregnancy.	3.16	1.00
14. I feel optimistic that if I give physical activity advice to obese pregnant women they will follow it.	2.59	0.89
Beliefs about consequences		
15. It is safe for obese pregnant women to try and follow the recommendations of at least 30 minutes of moderate intensity activity per day.	3.75	0.78
16. Obese pregnant women will feel guilty if I discuss physical activity with them but they find it difficult to be more active.	3.11	0.88
17. Advising obese women to be more physically active during pregnancy may put their baby at risk of harm.	4.06	0.64
18. It is beneficial for obese women to increase their physical activity levels during pregnancy as it will reduce their risk of getting gestational diabetes.	3.77	0.82
19. It is beneficial for obese women to increase their physical activity levels during pregnancy as it will reduce their chances of excessive weight gain.	3.97	0.65
Motivation and goals		
20. I have more important things to discuss with obese women during ante-natal appointments than their physical activity levels.	3.32	0.83
21. I aim to discuss physical activity with obese pregnant women as part of my routine ante natal care.	3.47	0.74
22. I am keen to implement the guidelines regarding physical activity for obese pregnant women.	3.98	0.74
Memory, attention, decision process		
23. I do not discuss PA with obese pregnant women because • I usually forget	3.69	0.85
• I don’t really know what to advise.	3.34	1.02
24. If women are obese I am more likely to discuss physical activity	2.92	0.89
25. I only discuss PA with obese women who ask me for advice about it.	3.25	0.93
Environment, context, resources		
26. I am usually too busy to discuss physical activity with	3.21	1.00

	obese pregnant women.		
27.	If I have any questions regarding physical activity in obese pregnant women there is no one readily available to give me the support and answers I need.	2.63	1.00
28.	If I had a leaflet to give to obese pregnant women I would feel more comfortable about discussing physical activity.	1.79	0.65
Social Influences			
29.	Other midwives in my NHS Trust do not discuss physical activity routinely with obese pregnant women.	2.69	0.68
30.	Obese pregnant women expect me to discuss physical activity with them during pregnancy.	2.76	0.89
31.	GP's expect me to discuss physical activity with obese pregnant women.	3.24	0.80
32.	Obstetricians expect me to discuss physical activity with obese pregnant women.	3.56	0.74
Emotion			
33.	I am more concerned about other pregnancy related issues than giving advice about physical activity to obese pregnant women.	3.09	0.86
34.	I worry about making obese pregnant women anxious by advising them about activity.	3.21	0.99
35.	I worry that discussing physical activity with obese pregnant women may harm my relationship with the woman.	3.33	0.94
36.	I feel uncomfortable talking to women who are obese about their physical activity levels.	3.40	0.95
Behaviour Regulation			
37.	I have a clear plan of how to address physical activity issues with obese pregnant women.	2.76	0.83
38.	I know when to address physical activity with obese pregnant women.	3.33	0.88
39.	I have a clear plan of what to recommend to obese pregnant women regarding physical activity.	2.64	0.90
40.	If I encounter a problem when discussing physical activity with obese pregnant women I know how to solve it.	2.84	0.86

Table 29: Domain mean scores and Chronbach's alpha

Domain	Mean score (SD)	Chronbach's α
Knowledge	3.86 (0.40)	0.381
Skills	2.79 (0.74)	0.725
Social Professional role	3.71 (0.52)	0.473
Beliefs about capabilities	2.94 (0.76)	0.676
Beliefs about consequences	3.72 (0.42)	0.441
Motivation and goals	3.59 (0.58)	0.627
Memory, attention, decision process	3.32 (0.66)	0.683
Environment, context, resource	2.54 (0.58)	0.285*
Social Influence	3.05 (0.53)	0.598
Emotion	3.26 (0.67)	0.681
Behaviour regulation	2.88 (0.48)	0.267

*α remains low, impossible to interpret or draw conclusions

The questions that were removed and the resulting effect on the domain means and alpha are presented in table 30. All subsequent analysis was carried out on this reduced set of questions.

Table 30*: *Removal of questions to improve internal consistency of domain context

(Questions highlighted removed from further analysis, leaving new mean domain score and alpha.)

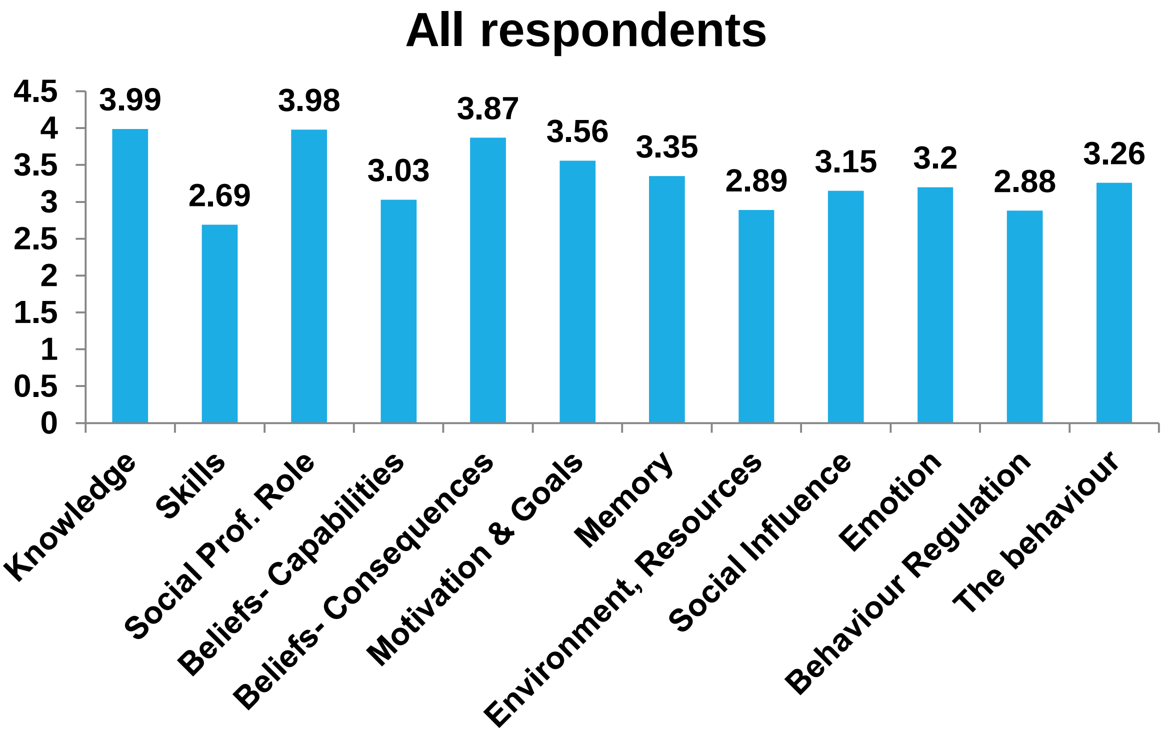
Knowledge	**mean (SD)**
1. I know what the recommendations are in the NICE guidelines, ***(Weight Management Before, During and After Pregnancy*)**, regarding30physical activity during pregnancy.	
5. Attending exercise classes is the only way obese pregnant women can meet activity recommendations.	
New Domain mean (SD)	**3.98 (0.46)**
Domain α	**0.576**
Social Professional Role	
9. It is the responsibility of the GP or Obstetrician to discuss physical activity with pregnant women.	
New Domain mean	**3.98 (0.57)**
Domain α	**0.748**
Beliefs about capabilities	
12. I feel optimistic that if I give physical activity advice to obese pregnant women they will follow it.	
New Domain mean	**3.11 (0.94)**
Domain α	**0.835**
Beliefs about consequences	
14. Obese pregnant women will feel guilty if I discuss physical activity with them but they find it difficult to be more active.	
New Domain mean	**3.88 (0.48)**
Domain α	**0.564**
Memory, attention, decision process	
24. If women are obese I am more likely to discuss physical activity	
New Domain mean	**3.45 (0.75)**
Domain α	**0.727**
Environment, context, resources	
28. If I had a leaflet to give to obese pregnant women I would feel more comfortable about discussing physical activity.	
New Domain mean	**2.92 (0.78)**
Domain α	**0.380**
Social Influences	
29. Other midwives in my NHS Trust do not discuss physical activity routinely with obese pregnant women.	
New Domain mean	**3.18 (0.63)**
Domain α	**0.641**
Behaviour Regulation	
40. If I encounter a problem when discussing physical activity with obese pregnant women I know how to solve it.	
New Domain mean	**2.90 (0.72)**
Domain α	**0.769**

3.6.3 Mean domain scores

The mean domain scores were highest for ‘knowledge’, ‘social professional role’ and ‘beliefs about consequences’ and lowest for ‘skills’, ‘behaviour regulation’ and ‘beliefs about capabilities’ (figure 5).

Higher domain scores indicate that the constructs within the domains facilitate respondents to carry out the behaviour and lower scores indicate that constructs within the domains act as barriers. Therefore, the results indicate that the domains ‘knowledge’, ‘social professional role’ and ‘beliefs about consequences’ contain fewer constructs that act as barriers to performing the behaviour than the other domains. Conversely, the ‘skill’, ‘beliefs about capabilities’ and ‘behaviour regulation’ domains contain more constructs that are acting as barriers to performing the behaviour. The domain ‘environment, context, resources’ also had a low score, however, as previously discussed, the results from this domain must be treated with caution as Chronbach’s α was below 0.5.

Figure 5*: Mean domain scores, all respondents.*



Comparison of Trusts and place of work

The mean domain scores between Trusts are presented in table 31. The two hospital Trusts were initially compared to ascertain if there was any difference between the large tertiary and small district hospitals, but this was found not to be the case for any of the domain means.

Table 31*: Comparison of mean domain values of the 3 participating sites*

Domain	Newcastle	S. Tyneside	p-value	Newcastle	N of Tyne	p-value	S Tyneside	N of Tyne	p-value
Knowledge	4.02 (0.44)	3.92 (0.57)	0.276	4.02 (0.44)	3.97 (0.37)	0.555	3.92 (0.57	3.97 (0.37)	0.673
Skills	2.69 (0.72)	2.69 (0.75)	0.993	2.69 (0.72	3.29 (0.62)	<0.001	2.69 (0.75)	3.29 (0.62)	0.001
Social Prof. Role	4.01 (0.54)	3.91 (0.71)	0.357	4.01 (0.54)	3.97 (0.45)	0.660	3.91 (0.71)	3.97 (0.45)	0.689
Beliefs about Capabilities	2.94 (0.90)	3.23 (0.95)	0.067	2.94 (0.90)	3.57 (0.88)	0.001	3.23 (0.95)	3.57 (0.88)	0.121
Beliefs about consequences	3.89 (0.49)	3.84 (0.46)	0.570	3.89 (0.49)	3.90 (0.48)	0.891	3.84 (0.46)	3.90 (0.48)	0.578
Motivation & goals	3.58 (0.56)	3.51 (0.67)	0.542	3.58 (0.56)	3.77 (0.50)	0.094	3.51 (0.67)	3.77 (0.50)	0.073
Memory, decision	3.32 (0.74)	3.43 (0.75)	0.384	3.32 (0.74)	3.92 (0.58)	<0.001	3.43 (0.75)	3.92 (0.58)	0.003
Environment & Resources	2.93 (0.77)	2.80 (0.82)	0.349	2.92 (0.77)	3.09 (0.78)	0.321	2.80 (0.82)	3.09 (0.78)	0.132
Social Influence	3.17 (0.65)	3.10 (0.54)	0.459	3.17 (0.65)	3.37 (0.66)	0.161	3.10 (0.54)	3.37 (0.66)	0.053
Emotion	3.22 (0.63)	3.14 (0.78)	0.491	3.22 (0.63)	3.57 (0.53)	0.007	3.14 (0.78)	3.57 (0.53)	0.011
Behaviour regulation	2.82 (0.71)	2.84 (0.74	0.837	2.82 (0.71)	3.32 (0.57)	0.001	2.84 (0.74)	3.32 (0.57)	0.004
The Behaviour	3.19 (1.32)	3.41 (1.34)	0.347	3.19 (1.32)	4.13 (0.74)	0.001	3.41 (1.34)	4.13 (0.74)	0.019

All values are = mean (SD)   *p value calculated via t test.

Whilst there are no differences between the Newcastle and South Tyneside respondents, there are several differences between the two hospitals and the North of Tyne community midwives. It is possible that community and hospital staff who work in specific areas, such as an inpatient ward, encounter differing barriers and facilitators to implementing the behaviour. For this reason community midwives and hospital based staff with core roles in the ante natal clinic and assessment unit were placed into one group and compared to staff providing predominantly intrapartum and post-natal care, as illustrated below.

Group 1: predominantly ante natal care	Community, ante-natal clinic/fetal medicine, day assessment unit, integrated team, research midwives
Group 2: predominantly delivery suite and post-natal care	Delivery suite, inpatient ward, rotational staff, birth center, risk management and audit midwives.

3.6.4 Comparison of different staff groups

The characteristics of participants in Groups 1 and 2 varied by employing Trust, years qualified and place of work. Comparison data is presented in table 32.

Table 32*:* Demographic characteristics of Group 1 versus Group 2

	Group 1 N=84	Group 2 N=108	p value
Trust			
Newcastle	41 (48.4%)	70 (64.8%)	
S. Tyneside	13 (15.5%)	38 (35.2%)	
N. Tyneside	30 (35.7%)	0	<0.001
Years Qualified			
<2	2 (2.4%)	15 (13.9%)	
3-5	3 (3.6%)	19 (17.6%)	
5-10	8 (9.5%)	24 (22.2%)	
>10	71 (84.5%)	50 (46.3%)	<0.001
Place of work			
Community	54	0	
Day assessment	4	0	
ANC/FMU	16	0	
Integrated Team	3	0	
Research	7	0	
Delivery suite	0	43	
Inpatient ward	0	16	
Rotational	0	42	
Birth Centre	0	3	
Other	0	3	<0.001
Self-reported activity level *Mean (SD)*	6.56 (1.65)	6.50 (1.79)	0.829

Group 1 scored higher than Group 2 in all domains except in the ‘knowledge’ and ‘social professional role’ (table 33).

A similar pattern was seen between community staff versus all other staff, with no significant differences in ‘knowledge’,’ social professional role’, ‘beliefs about consequences’ and ‘environment, context and resources’, (data not presented).

Table 33*: Comparison of mean domain scores between Groups*

Domain	ALL	Group 1	Group 2	p value
Knowledge	3.98 (0.46)	4.01 (0.42)	3.96 (0.50)	0.534
Skills	2.79 (0.74)	3.00 (0.75)	2.62 (0.69)	<0.001
Social Professional Role	3.98 (0.57)	4.04 (0.54)	3.93 (0.60)	0.222
Beliefs Capabilities	3.11 (0.94)	3.36 (0.90)	2.92 (0.92)	0.001
Beliefs Consequences	3.88 (0.48)	3.96 (0.50)	3.82 (0.46)	0.040
Motivation, Goals	3.59 (0.58)	3.75 (0.56)	3.46 (0.58)	0.001
Memory, attention, decision	3.45 (0.75)	3.68 (0.75)	3.25 (0.70)	<0.001
Environment, context, resources	2.92 (0.78)	3.09 (0.84)	2.78 (0.71)	0.007
Social Influence	3.18 (0.63)	3.32 (0.64)	3.07 (0.60)	0.006
Emotion	3.26 (0.67)	3.38 (0.63)	3.16 (0.69)	0.023
Behaviour Regulation	2.90 (0.72)	3.14 (0.70)	2.71 (0.67)	<0.001
Discuss/advise obese pregnant women re:PA	3.39 (1.29)	3.97 (0.98)	2.95 (1.33)	<0.001

**All values = mean (SD)*

The community staff in Group 1 were then compared to all other staff in group 1 to ensure that the community staff and antenatal staff were homogeneous with respect to their attitudes, knowledge and beliefs (table 34). A difference was seen in the ‘emotion’ domain; otherwise all other domains were not different. Therefore for the purposes of final reporting Group 1 was considered to provide the most appropriate results.

Table 34*: comparison of community staff versus other participants in Group 1*

	Community n=54	All other in Group1 n=30	p value
Knowledge	3.97 (0.39)	4.07 (0.47)	0.334
Skills	3.07 (0.71)	2.88 (0.82)	0.267
Social Prof. role	3.96 (0.54)	4.17 (0.53)	0.098
Beliefs Capabilities	3.40 (0.86)	3.30 (0.98)	0.643
Beliefs Consequences	3.94 (0.47)	4.01 (0.54)	0.531
Motivation & Goals	3.79 (0.55)	3.67 (0.57)	0.317
Memory, attention, decision	3.80 (0.68)	3.47 (0.83)	0.058
Environment, context, resources	3.06 (0.84)	3.15 (0.86)	0.636
Social influence	3.38 (0.58)	3.23 (0.73)	0.323
Emotion	3.52 (0.58)	3.14 (0.66)	0.008
Behaviour Regulation	3.22 (0.60)	3.01 (0.84)	0.192
Trust employed **Newcastle** **S.Tyne** **N.Tyne**	 15 9 30	 26 4 0	<0.001
Years midwife **<2 yrs** **2-5 yrs** **5-10 yrs** **>10 yrs**	 1 1 4 48	 1 2 4 23	0.479
Scale Active *Mean (SD)*	6.61 (1.74)	6.47 (1.50)	0.703
Discuss/advise obese pregnant women re:PA	4.16 (0.78)	3.65 (1.20)	0.062

3.6.5 Associations between domains and respondent characteristics

The most experienced group (measured by years qualified) and recently qualified midwives were more likely to report that they discussed and advised obese pregnant women regarding PA. Only three domains were significantly associated with midwives' experience, these are presented in table 35. More experienced midwives scored the highest for 'beliefs about capabilities', 'emotion' and 'behaviour regulation', and were more likely to say that they discuss and advise PA with obese pregnant women.

Table 35*: Comparison of domain mean scores according to midwives experience*

Years qualified	< 2	2-5	5-10	>10	p value
Discuss/advise obese pregnant women re:PA	3.44 (1.21)	2.60 (1.39)	2.93 (1.28)	3.69 (1.19)	0.001
Beliefs-capabilities	2.79 (0.87)	2.57 (0.90)	3.09 (1.03)	3.27 (0.89)	0.005
Emotion	3.15 (0.62)	2.96 (0.66)	3.11 (0.71)	3.37 (0.64)	0.018
Behaviour Regulation	2.88 (0.82)	2.61 (0.73)	2.70 (0.67)	3.01 (0.69)	0.026

The more active midwives, (via self-report), scored more highly in the 'beliefs about capabilities' domain otherwise there were no differences (table 36).

Table 36*: Comparison of domain mean scores according to self-reported activity.*

Self-reported activity	0-2.5	2.5-5.0	5.0-7.5	7.5-10	p value
Beliefs-capabilities	3.5 (-)	2.89 (1.00)	2.96 (0.90)	3.33 (0.91)	0.036

3.6.6 Correlations

Correlations between domains, demographics and the behaviour question (discuss and advise obese pregnant women re: PA) for Group 1 are presented in table 37. 'Skills', 'beliefs about capabilities', 'motivation and goals', 'memory, attention, decision process', 'environment, context, resources' and 'behaviour regulation' all correlated moderately well with the behaviour question. There was no correlation between Trust employed, years qualified or self-report PA and the behaviour question.

Table 37: Correlations: Group 1 (community/antenatal)

	Know.	skills	Social Prof role	Bel.cap	Bel.con	Motiva. goal	Memory	Env. Cont. Res	Social influence	Emotion	Behav. Reg.	The Behavio-ur	Employ Trust	Yrs qualified	Active scale
Know.		0.442**	0.301*	0.411**	0.463**	0.367*	0.593**	0.301*	0.372**	0.229	0.378**	0.331*	-0.053	0.010	0.191
Skills			0.161	0.686**	0.182	0.462**	0.728**	0.521**	0.262	0.182	0.638**	0.541**	0.322*	-0.186	0.301*
Social Prof. role				0.262	0.332*	0.600**	0.332*	0.091	0.524**	0.492**	0.445**	0.126	0.003	0.142	-0.063
Beliefs Cap.					0.191	0.341*	0.671**	0.482**	0.310*	0.446**	0.605**	0.469**	0.303*	0.003	0.376**
Beliefs Conse.						0.375**	0.273	-0.108	0.334*	0.115	0.377**	0.180	-0.136	0.090	0.019
Motivation Goals							0.396**	0.396**	0.578**	0.505**	0.666**	0.507**	-0.086	-0.033	0.170
Memory, decision								0.518**	0.415**	0.202	0.621**	0.621**	0.214	-0.129	0.300*
Env.Cont. Resource									0.219	0.302*	0.429**	0.406**	0.045	0.043	0.366**
Social Influence										0.339*	0.456**	0.313*	0.042	-0.099	0.048
Emotion											0.541**	0.310*	0.112	0.315*	0.141
Behav. Reg.												0.571**	0.167	-0.100	0.292*
Employer												-0.073		0.060	0.159
Years as midwife												-0.037			0.150
Activity scale												0.237			
Cronbach's alpha	0.549	0.746	0.712	0.824	0.667	0.585	0.833	0.445	0.604	0.695	0.774				
Mean (SD)	4.01 (0.42)	3.00 (0.75)	4.04 (0.54)	3.36 (0.90)	3.96 (0.50)	3.75 (0.56)	3.68 (0.75)	3.09 (0.84)	3.32 (0.64)	3.38 (0.63)	3.14 (0.70)	3.97 (0.98)			

*p<0.05

**p<0.01

low correlation 0.0-0.39

moderate correlation 0.4-0.69 (highlighted yellow)

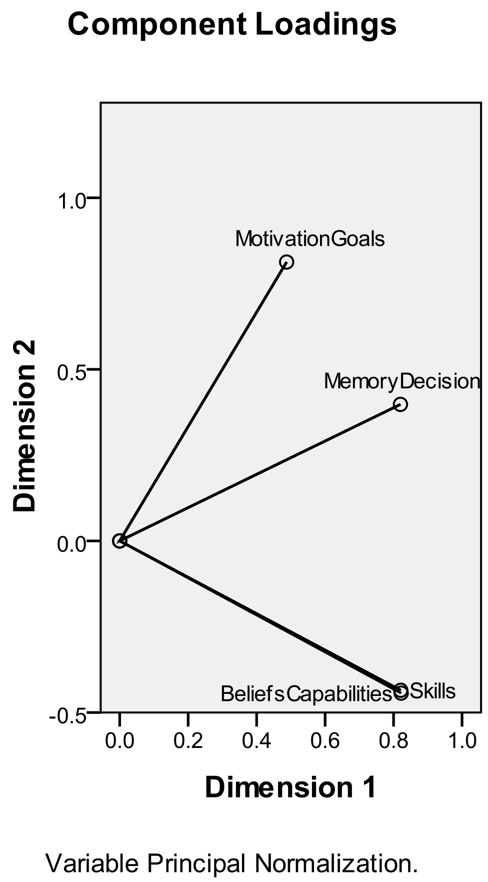
high correlation 0.7-1.0 (highlighted blue)

The 'behaviour' = discuss and advise PA with obese pregnant women

3.6.7 Factor Analysis

The aim of this analysis was to identify, and graphically describe, the domains which had the biggest influence on the behaviour, (discuss and advise PA with obese pregnant women), so reducing the number of domains involved in further regression analysis. The CATPCA results (figure 6) indicated two dimensions appeared to be involved, one containing 'skills' and 'beliefs about capabilities' and the other containing 'motivation/goals' and 'memory/attention/decision'.

Figure 6*: Main findings from Categorical Principle Component Analysis.*



3.6.8 Regression Model

The four domains identified via CATPCA: 'skills', 'beliefs about capabilities', 'motivation and goals' and 'memory, attention, decision process' were initially used as covariates in the ordinal regression analysis. It was subsequently found that only the 'skills' and 'memory/attention/decision' domains had a significant influence on the outcome both for Group 1, (p=0.007 for skills and p=0.024 for memory/decision) and for the whole sample, ($p<0.001$ for both domains). The influence of self-reported activity on the model was also investigated by including this as a covariate; however this was not statistically significant and had no influence on results.

The parameter estimates obtained from the regression analysis were subsequently used to calculate the fitted cumulative probability of being in a specific category of the behaviour question, (1 to 5, never to always). This approach was used to calculate the probability of scoring 1, 2, 3, 4 or 5 for the behaviour question if the ‘skills’ domain score was changed by 1 unit (for example from 3 to 4) or the ‘memory’ domain score was changed by 1 unit (from 3 to 4) or both ‘skills’ and ‘memory’ were changed by 1 unit, (both from 3 to 4).

The regression analysis was repeated using all participants, groups 1 and 2, the ‘community’, and ‘all other not community’. The different parameter estimates for each analysis were used to calculate the changes in probability as explained above and the results are presented in table 38. The results show that for a change in the domain scores (skills and/or memory), from 3 to 4, the probability that a participant will score in one of the lower categories, (never, rarely, sometimes), of the behaviour question is reduced, whilst the probability that they will score 5, (always perform the behaviour), increases. An increase in the ‘skills’ domain score has a bigger effect than an increase in the ‘memory/decision’ score of the same magnitude for all the groups except the community midwives. Increasing the ‘memory’ score by one unit is more likely to increase the probability that they will score 5 for the behaviour question than a corresponding change in the skills measure.

Table 38*:* Change in behaviour resulting in changes in skill and memory.
(Effect of increasing skills, memory and both by 1 unit (from 3-4))

Population	**Change in Domain Scores**	**% Change in probability of being in each category of behaviour**				
		1 never	**2 rarely**	**3 sometimes**	**4 usually**	**5 always**
All	**None**	5	19	25	36	15
	Skills	2	9	14	31	43
	Memory	3	11	17	34	34
	Both	1	5	8	22	62
Group 1	**None**	1	4	22	60	12
	Skills	0.5	1	10	46	42
	Memory	0.6	2	12	50	35
	Both	0.2	0.9	5	29	65
Group 2	**None**	7	30	28	20	16
	Skills	3	14	17	18	47
	Memory	4	20	22	21	33
	Both	2	9	12	14	63
Community	**None**	0.3	2	24	70	2.7
	Skills	0.1	1	15	71	13
	Memory	0	0.5	7	53	39
	Both	0	0.3	4	36	59
All Other (not community)	**None**	6	24	26	26	18
	Skills	2	10	14	21	52
	Memory	4	17	22	27	30
	Both	2	7	10	17	64

3.7 Midwives' comments

110 of the 192 participants (57.3%) made at least one free text comment on the questionnaire. All comments were coded thematically in line with the TDF domains, some of the lengthier, complex comments were coded to more than one domain. Each comment was coded as either being a facilitator, (positive score), or a barrier, (negative score), towards the constructs within each domain. The overall score for each domain was then calculated. Table 39 illustrates examples of the comments coded to specific domains. Figure 7 highlights the domain scores for the coded comments, from lowest to highest, whilst figure 8 highlights the questionnaire domain scores for the corresponding domains.

A recurring theme which was apparent within the comments, and difficult to code, was about place of work. Some midwives felt that it was not appropriate to give advice:

'I do not find it appropriate to give advice to obese women about physical activity during labour'

In which case the social professional role domain was coded negatively, whilst some staff felt that they could not give advice because they did not get the opportunity;

'I don't really have the opportunity to see the women antenatally in my current role'

In these cases the comment was coded as negative for environment/context/resources as it was the midwives' situation or environment that discouraged the behaviour.

A common theme which could not be coded to the TDF was that the advice should be given to all women regardless of their BMI:

'I would give basic physical activity advice to all pregnant women generally as routine, swimming, walking, diet. I would generally not add more to obese women.'

'It would be ideal to have it incorporated within antenatal classes not just for obese women, but for all pregnant women- this would help, taking the stigma away from the 'fat' clinic etc.'

A problem which was frequently cited by midwives was lack of resources, including time, leaflets and referral pathways. They felt it would be easier to give this information if it could be followed up with some action.

'I would like some more info and sessions to send women to'.

'Easier to approach the subject of obesity when a referral can be made'.

There were both similarities and differences between the comment and question domain scores. 'Social professional role' and 'beliefs about consequences' scored highly in both cases, whilst 'environment context resources' had a low score for both. Conversely 'skills' and 'beliefs about capabilities' had a poor score from the questions yet scored positively from the comments.

Table 39: Examples of coded comments for each domain

Domain	Effect on behaviour	No. comments	Example Comment
Knowledge	Facilitator	8	It is basic knowledge that to be healthy you should exercise in the same way that people know smoking is bad for your health but continue to smoke - decision to exercise or not, is not that simple, it is multi-faceted
	Barrier	19	I don't really have enough knowledge to give advice to obese pregnant women at any time
Skills	Facilitator	18	I am confident that I can do this in a non-judgmental and professional manner. This is a sensitive issue that requires good communication skills.
	Barrier	11	Need more advice on how best to structure this and more time to do same Never received any training about giving the above advice to obese pregnant women
Social professional role	Facilitator	44	I view this as part of my role. I am confident that I can do this in a non-judgmental and professional manner
	Barrier	9	we do not accept women with a BMI of over 35, so I am not going to see women who need this advice. I see it as part of the community midwife's role Would be good to have a trained person, ie. Midwife health trainer, like diabetes midwife/substance abuse midwife, as obesity is so common now.
Beliefs capabilities	Facilitator	20	I feel comfortable giving information to all pregnant women and have counseling skills to be able to advice obese women without causing distress.
	Barrier	11	I don't know when I am to give the information and what I need to discuss, no written information to give to women. Unclear of exactly what the risks/implications are therefore feel I cannot approach this with obese women
Beliefs	Facilitator	20	it's a public health concern and

consequences			something which could impact on babies so needs to be discussed
	Barrier	2	If by the time a woman has become pregnant she has not made any effort to improve her health, advice from midwives will probably have little impact
Motivation & goals	Facilitator	0	-
	Barrier	5	I don't see many antenatal patients and when I do it isn't for long so it isn't my main priority
Memory, attention, decision	Facilitator	1	The advice should be given on an individual basis
	Barrier	6	I very rarely see antenatal women unless they are unwell - MAU/Ward 34 or in labour not in "routine" care situations, so other physical factors take precedence
Environment, context, resources	Facilitator	3	Direct referral to South Tyneside Healthy Living has improved level of understanding. Easier to approach the subject of obesity when a referral can be made
	Barrier	45	Leaflets would be very helpful as women may wish to read them in private. I strongly think midwives should have the option for referral to slimming clubs/gyms that GPs presently do Need more advice on how best to structure this and more time to do same
Social Influence	Facilitator	2	Advice is usually given at the initial booking appointment as with all women but not usually at every clinic appointment unless the subject is approached by the woman. We have to listen to what they may already be doing and give info based on that
	Barrier	7	I think obese people are well aware of their status and unless there is a specialist midwife available to supplement the care given by the normal community midwife then the small number of women who would want to access the service wouldn't be likely to be successful. Not my area of practice as care for labouring women mainly

Emotion	Facilitator	2	I am confident that I can do this in a non-judgmental and professional manner.
	Barrier	11	This is a very difficult subject to broach with some women. They may feel they are being targeted because of their size. Difficult as it is quite a personal subject and you don't want to damage relationship with lady
Behaviour Regulation	Facilitator	2	I encourage all women to become/stay active during pregnancy
	Barrier	4	If by the time a woman has become pregnant she has not made any effort to improve her health, advice from midwives will probably have little impact

Figure 7: Sum of positive/negative comments for each domain

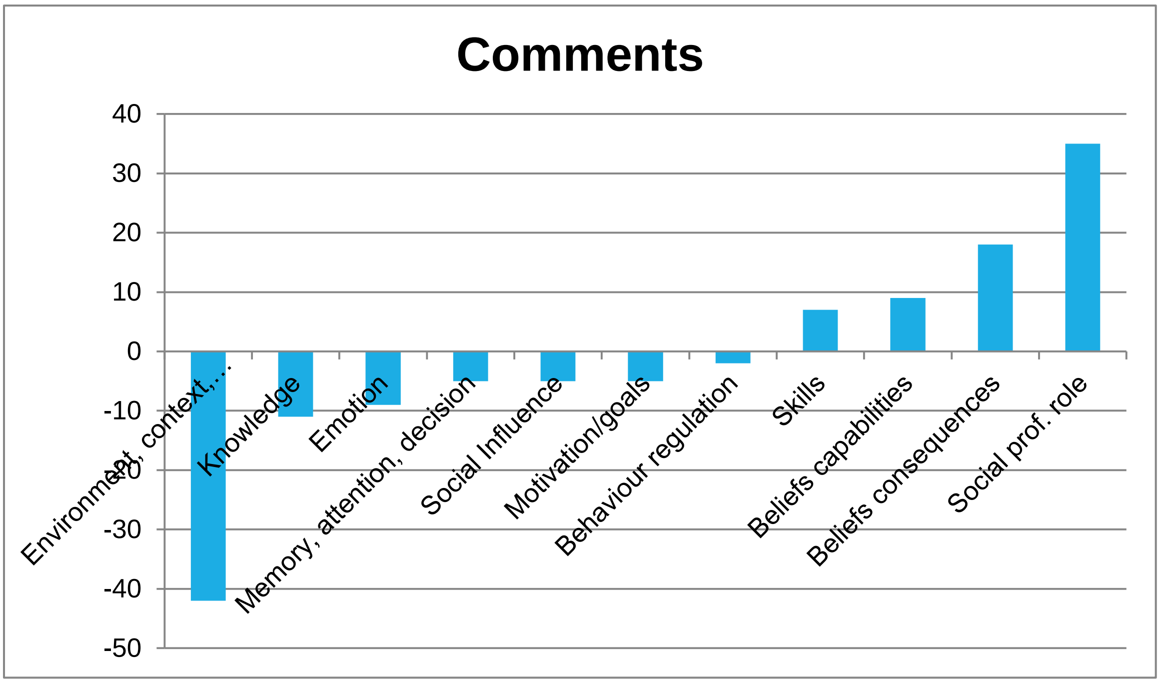
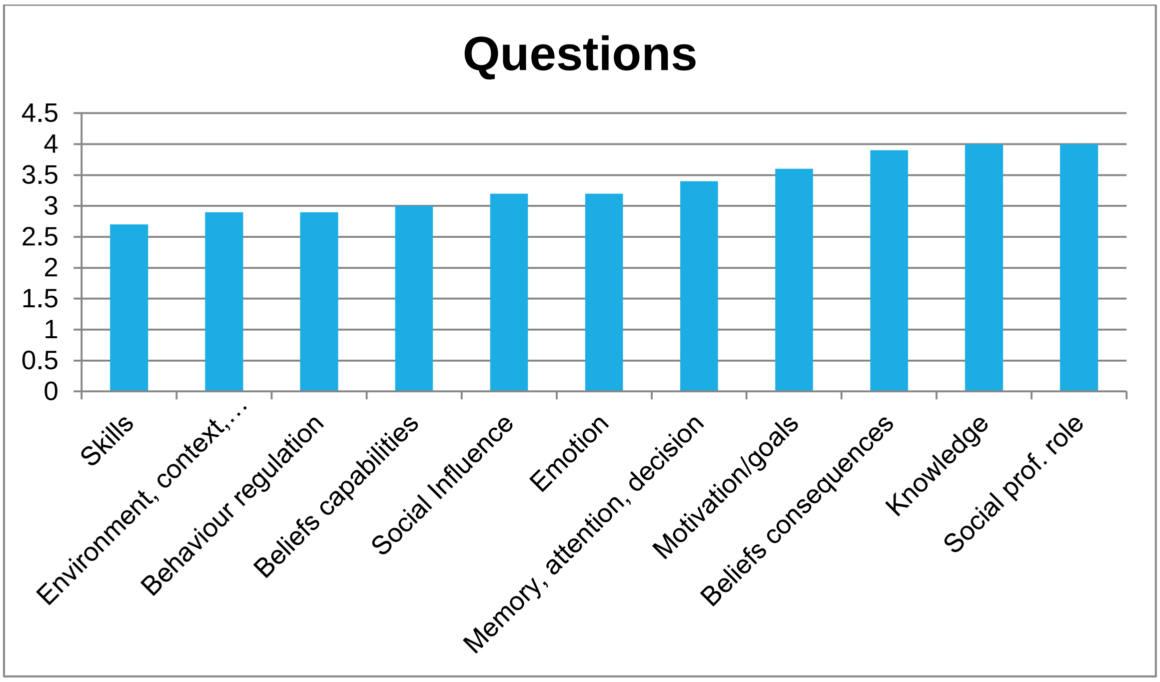


Figure 8: Mean domain scores from questionnaire results



3.8 Discussion

3.8.1 Key findings

The domains with the highest scores were found to be ‘knowledge’, ‘social professional role’ and ‘beliefs about consequences’, conversely the lowest scores were for ‘skills’, ‘behaviour regulation’, ‘beliefs about capabilities’ and ‘environment, context, resources’. These basic descriptive results indicate that as a group the midwives believe that they have the necessary experience, theoretical and/or practical understanding with regards to discussing PA with obese pregnant women. They also see it as part of their identity and professional role, and believe that this behaviour is expected of them and their peers. They are optimistic that delivery of appropriate advice will have the expected physical, social and emotional outcomes. All of these factors are acting as facilitators to midwives performing the desired behaviour: discussing PA with obese pregnant women and advising them appropriately.
However, the midwives reported that they perceive they do not have the ability, proficiency or competence to carry out this behaviour. They are relatively pessimistic and have low self-belief, esteem and confidence about being able to discuss and advise women effectively. They are less likely to plan or make the discussion a priority, and it is not one of their intention or goal to do this. Whilst the results for the environment, context resource domain may not be valid (due to a low Chronbach’s α), a low domain score here indicates that the environment the midwives are working in is not optimising or encouraging the behaviour to be carried out, this may involve lack of material resources or environmental stressors such as lack of time. All of these factors are acting as barriers to midwives performing the desired behaviour.

There were no differences in the domain results between the staff in the two acute hospital Trusts, suggesting that midwifery training, experiences and views do not differ between these two different hospitals. When North of Tyne midwives were compared separately with those working in Newcastle and South Tyneside, differences were found in the mean scores for ‘skills’, ‘memory’, ‘emotion’, ‘behaviour regulation’ and the ‘behaviour’ itself. All of the North of Tyne midwives had community posts and in comparison to staff in the other two Trusts a greater proportion of them had been qualified for more than

10 years. This suggests that the more experienced community midwives were more confident in their abilities, had greater contact and continuity with women during pregnancy, and experienced fewer barriers to discussing PA with women and advising them appropriately.

The mean scores for the ‘behaviour’ and most of the domains were higher for Group 1 (community and antenatal) than Group 2 (inpatient ward), with the exception of ‘knowledge’ and ‘social professional role’. When the community staff were compared to the core antenatal midwives in Group 1 the only significant difference found was in the ‘emotion’ domain. One possible reason for this is that the community midwives have some continuity of care with women and develop a relationship; therefore they may have more of an emotional connection with them and feel more comfortable discussing this sensitive issue.
When the influence of experience was examined in greater detail a surprising trend was noted for the ‘behaviour’ and the ‘beliefs about capabilities’, ‘emotion’ and ‘behaviour regulation’ domains. In all cases the scores were relatively high for newly qualified staff, dropped considerably by 2-5 years qualified, began to rise again by 5-10 years, and reached the highest score when greater than 10 years qualified. Although there is no evidence to explain this, one reason could be that newly qualified midwives are enthusiastic, overconfident and perhaps naïve. By the time they have been working for 2 years the reality of the role has eroded their confidence and enthusiasm, but this does begin to increase again with experience and maturity.

Six of the 11 domains correlated moderately well with the ‘behaviour’, but only four of these were subsequently described by the factor analysis, (skills, beliefs about capabilities, motivation/goals and memory/decision). Of these, the regression model indicated that only ‘skills’ and ‘memory/attention/decision process’ had a statistically significant influence on the ‘behaviour’ (the probability that midwives discuss and advice PA with obese pregnant women), and therefore any interventions aimed at increasing implementation of the guidelines need to focus on the constructs within these domains.

3.8.2 Midwives Comments

Many of the midwives felt that it was part of their role to advise obese pregnant women about PA, others simply stated that giving PA advice in the area of the hospital where they worked was not appropriate, but for many this was because of lack of opportunity rather than feeling it was not part of their role. Some midwives stated that they felt obesity was a serious issue and *'something needed to be done about it'.* Many acknowledged that it was a sensitive topic area and concerns were raised about harming the relationship: *'Advice does have to be given to obese women but the way its communicated to them needs to be sensitive and individualised, otherwise they are going to feel 'victimised' about their weight/physical activity.'*

Several midwives suggested that the advice should be, or was, given to all pregnant women as part of routine practice, in this way staff would not feel so uncomfortable and hopefully the obese pregnant women would not feel so stigmatised. When the coding from the comments was compared with the quantitative results 'social professional role' scored highest and 'environment context resources' scored lowest in both cases. This would indicate a strong perception that their role was not acting as a barrier against performing the behaviour, whilst place of work, opportunity, lack of time and lack of material resources was. Skills and capabilities scored poorly in the quantitative results yet the domains had the second and fourth highest scores from the coded comments. It could be argued that the midwives would be unlikely to say something negative about their skills and abilities in the comments and therefore the lack of negative comments resulted in a positive overall score for the comments domain responses.

3.8.3 Comparison with other literature

The results can be compared to other studies involving the implementation of evidence based practice where it has been reported that health professionals recognised the importance of the advice and understood the health problem but did not necessarily translate this into action with regard to advising patients (Stotland et al., 2010, Wilkinson and McIntyre, 2012). Facilitating factors to giving appropriate advice include having professionals who are informed, motivated as well as adequately trained (Grol and Wensing, 2004). Conversely, lack of action was attributed to inadequate training, low self-efficacy and uncertainty about the effectiveness of the advice or counselling (Grol and Wensing, 2004, Stotland et al., 2010).

Lack of confidence and skills, especially communication skills, are barriers cited by several authors who have reported on health professionals care for obese pregnant and non-pregnant individuals (Wilkinson and McIntyre, 2012, Schmied et al., 2011, Stotland et al., 2010, Macleod et al., 2012). Feeling awkward, ambivalent, avoiding the subject or having a reactive approach to giving lifestyle advice, (that is, only giving advice when specifically asked for it by patients), have all been documented (Brown and Thompson, 2007, Duthie et al., 2013, Stotland et al., 2010). Being able to communicate effectively was a worry for several midwives completing the questionnaire, embarrassment and worries about causing emotional distress were mentioned. Concerns were raised that poor communication would harm the relationship the midwife had with their client. This is a difficult issue as it is not only depended on the skill of the midwife but also on the personality of the midwife and the woman, as well as the influence of past negative experiences encountered by the women with other health care professionals (Heslehurst et al., 2013a). This concurs with previous findings relating to caring for obese women indicating that midwives want the skills to deliver positive messages and empower women, but are concerned about the possible negative impact on the midwife-woman relationship (Schmied et al., 2011, Macleod et al., 2012, Heslehurst et al., 2013b). Midwives also fear that women will disengage from antenatal care (Heslehurst et al., 2011). Similar fears have been expressed by midwives when communicating with pregnant smokers (Aveyard et al., 2005, Abrahamsson et al., 2005). In the latter study this was overcome by taking a ‘person centred approach’, using intuition, experience and being given training in motivational interviewing.

Conversely, insufficient training has been cited frequently as a barrier to discussing healthy lifestyle messages, such as PA levels, with obese pregnant women (Heslehurst et al., 2011, Heslehurst et al., 2013b, Brown et al., 2007a, Macleod et al., 2012). Midwives report being unsure of what to say and also of how to say it, as they are only too aware of the sensitive nature of the topic and the need to provide appropriate and empathetic support.

In contrast to our findings, prior studies examining health professionals PA and lifestyle advice to obese pregnant women found that lack of knowledge was a problem. In these studies women reported receiving limited, inappropriate or inconsistent advice and women perceived that their health care professionals knowledge about appropriate PA advice was limited (Stengel et al., 2012, Oteng-Ntim et al., 2010).

Lack of resources including time, leaflets and classes, were cited frequently as problems for midwives. Previous qualitative research has highlighted the importance of midwives having adequate time to discuss obesity related issues which are often sensitive and emotive (Heslehurst et al., 2013b). Likewise, obese patients have reported more positive and affirming experiences when the midwife, nurse or doctor takes adequate time to listen to weight related issues (Merrill and Grassley, 2008, Nyman et al., 2010). Additional studies have also highlighted the lack of organisational support and supportive resources which impact on behaviour (Brown et al., 2007a). Other pregnancy related issues often take priority or are higher on the 'national agenda' (Heslehurst et al., 2012). Many of the midwives in our study stated that they would like more referral powers or pathways. Previous studies report similar findings; often issues around obesity are explained but then midwives are not sure what to do next (Heslehurst et al., 2011). Similarly a study involving GP's reported that doctors were willing to listen to obesity related problems but did not necessarily have solutions (Epstein and Ogden, 2005).

Most respondents felt it was the role of the midwife to discuss and advise obese pregnant women, or at least the role of 'a midwife', alongside other health care professionals. This concurs with the finding of an Australian study involving qualitative interviews with midwives, who saw themselves as central to providing lifestyle and behaviour change education to pregnant women (Willcox et al., 2012).
Some midwives described it as their 'duty' and part of normal antenatal care, whilst others felt it was the responsibility of the community midwife. Although it is obvious that it is inappropriate to discuss PA in certain situations or stages of pregnancy (for example on delivery suite) it could be argued that all midwives should be aware of the main issues and be able to give advice as and when appropriate. Midwives have an ethical obligation to inform and advise all

pregnant women about risks to themselves and their babies and as such need to take responsibility for this.

Many other elements of a midwife's characteristics such as awareness, experience, health beliefs, self-efficacy, commitment, motivation, personality and both positive and negative attitude, may affect their behaviour. Whilst it is accepted that increasing knowledge alone will not change attitude (Abrahamsson et al., 2005), research suggests appropriate training is needed to address and challenge beliefs, perceptions and judgments (Brown et al., 2007a, Nyman et al., 2010).

3.8.4 Strengths and methodological limitations

Theory Domains Framework

Several behaviour change techniques have been described, however, it has been documented that implementation of interventions without theoretical evidence of effectiveness or identification of the barriers to change, are of little benefit (Hakkennes and Dodd, 2008). By using a theoretical approach, factors which may influence whether or not a behaviour is performed can be identified (Michie et al., 2007). There are many psychological models in the literature which investigate behaviour change, however, the TDF offers an accessible tool which can be used easily by a non-psychologist. The TDF is focused, efficient and structured and covers a very broad range of constructs, so minimising the risk that influencing factors are missed (McSherry et al., 2012). It has been used several times over recent years to investigate the behaviour of health care staff and the implementation of evidence based guidelines using both qualitative and quantitative approaches and therefore is a suitable tool to use to investigate midwives' behaviour. The domain list enhances the understanding of the behaviour change process (Michie et al., 2005) and the framework can be used systematically to select the most appropriate theories to develop interventions to change specific behaviours (Francis et al., 2012).

When using the TDF it should be remembered that it only provides a theoretical understanding rather than definitive answers (Michie et al., 2007). It generates hypotheses about factors which may influence a behaviour, it does not generate the evidence that these are influencing factors (Francis et al., 2012). In this study it would appear that lack of skill, memory/attention and decision processes are acting as barriers to performing the behaviour. The TDF also relies on the presence of evidence based guidelines regarding the behaviour under investigation (Francis et al., 2012). Even when guidelines are in place some clinicians, managers and policy makers do not adhere to guidance, believing they know best and are reluctant to implement new evidence (Eccles et al., 2005). Research may provide the hypothesized determinants of a behaviour and the framework to design effective interventions however time, investment and experience is required to implement them (Eccles et al., 2005, Kolehmainen and Francis, 2012).

Achieving an acceptable internal consistency for each domain was essential but it meant that almost a quarter of potentially available data was lost. This is possibly due to difficulties with the phrasing and construction of questions to make them attributable to distinct concepts, or a superficial interpretation of domain definitions (Francis et al., 2012). It was also impossible to achieve internal consistency for the ‘environment, context, resources’ domain score and therefore, whilst constructs within this domain may be acting as barriers to performing the behaviour no reliable conclusions can be drawn.

Whilst the midwives comments provided some interesting information this method of data capture does have limitations. Not all midwives provided comments, and not all comments were relevant to ‘nature of the behaviour’. The use of semi-structured interviews with a standard topic guide may have provided a richer source of data relating to this domain and, as previously described, this methodology has been used many times to explore implementation of guidelines by health care professionals. Future research may benefit from adopting a mixed methods approach, integrating both qualitative and quantitative methodologies and optimising the strengths of each to answer the research questions (Creswell et al., 2011).

It should be noted that since the design and implementation of this study the original TDF has been refined. The domain ‘Nature of the behaviour’ has been removed as it was not adequately represented in the revalidation and identification of the domains. ‘Beliefs about capabilities’, ‘beliefs about consequences’ and ‘motivation and Goals’ were retained but divided into new domains, ‘Optimism’, ‘Reinforcement’, ‘Intentions’ and ‘Goals’ (Cane et al., 2012). This indicates that the TDF remains a work in progress and there is still some debate about how distinct and definable the individual domain definitions are.

Response rate

The overall questionnaire response rate was 52.6%, this is comparable to other similar NHS staff surveys; Beenstock (Beenstock et al., 2012) had a 43% response rate from midwives in the North East of England when carrying out a similar cross-sectional survey while Brotherton (Brotherton et al., 2010) had a 32% response rate from a postal questionnaire to general practitioners, McNally (McNally et al., 2006) had a 51% return rate from mental health service staff in acute and community settings, Dyson (Dyson et al., 2011) had a 37% return rate from nursing staff in the North of the UK, and Maclaod (Macleod et al., 2012) had a 32% response rate from an e-mailed survey to midwives in Scotland. The aim of a good questionnaire is to gather reliable and valid data from a representative sample of respondents (McColl et al., 2001). Poor survey response rates are known to contribute to error and bias. It is impossible to know if the results are representative of staff opinions or the views and opinions of a motivated sub-set as opposed to the general midwife population. Alongside this a small number of participants did not answer some of the questions, potentially leading to non-response bias. It is possible that non-response to specific questions results because the respondent had difficulties with the specific domain that the question was linked to, the question may have been badly phrased and difficult to understand or it may have simply been missed (Michie et al., 2007). Mode of administration, the length, ordering, wording of questions and even the appearance of the questionnaire can affect response rate (McColl et al., 2001, Edwards et al., 2009).

Some midwives declined to participate and verbally stated that they felt, despite reassurances, their managers were somehow monitoring individual responses. Whilst the aim of the covering letter which was distributed with the questionnaire was to endorse the research and encourage participation, it may have re-enforced the feelings of ‘spying’ as the maternity unit managers signed them. Similarly, whilst the questionnaire was anonymous and it was hoped that this would encourage the midwives to respond honestly and reduce the risk of social desirability or self-report bias (Donaldson and Grant-Vallone, 2002), a small number of midwives commented that they believed the coloured numbering system was some form of code which would result in their responses being known. Others were not concerned at all and did not even bother to remove the number from the front of the questionnaire before returning it. Previous survey research has found that respondents are more likely to disclose the truth and express their views and opinions candidly if the survey is anonymous, especially with sensitive topics (Ong and Weis, 2000). In contrast Campbell, (Campbell and Waters, 1990), found that anonymity does not necessarily increase response rates, therefore it is impossible to say if anonymity improved or reduced our response rate.

A systematic review examining health service staff return rates found that postal and telephone surveys had the highest response rate, however the option of a mixed mode format was also favoured by busy physicians (VanGeest et al., 2007). With the increasing use of technology in today's NHS many staff may have found an internet based survey more accessible. However as many of the community midwives did not have ready access to a computer, a paper based survey was deemed more appropriate. Length of questionnaire, perceived relevance and importance of the topic, endorsements and monetary incentives all affect response rates (VanGeest et al., 2007). A Cochrane Review examining methods to increase response rate also encouraged the use of at least one reminder and to adopt a more personal approach to distribution (Edwards et al., 2009). Attempts were made to incorporate as much of this advice as possible.

Overall the response rate for the Newcastle upon Tyne Hospitals Trust was lower than the other two sites. This is possibly because of the size of the unit and the number and distribution of staff. Despite the second reminder questionnaire, e-mail reminders and posters it was very difficult to personally encourage individual staff to participate, whilst the research midwives at North and South Tyneside had regular face to face contact with individual staff members and groups and were able to verbally encourage participation.

Design issues

Honesty and social desirability bias are problems encountered with all self-report questionnaires. Respondents have a tendency to answer the questions in a way that is viewed favourably; this may have been the case with the current question, ‘discuss/advise PA with obese pregnant women’. This type of bias can result in over reporting of positive, ‘good’ behaviour and under reporting of negative ‘bad’ behaviour. Subsequently this can affect the interpretation of results but in reality can only be avoided by observing the behaviour under investigation or interviewing the women afterwards to confirm the behaviour. This was found to be the case in a qualitative study carried out in the USA: researchers interviewed pregnant women and obstetricians from the same antenatal clinic and, whilst obstetricians stated that they discussed nutrition and PA with all pregnant women, the women said that the obstetricians either discussed the issues in general terms or not at all (Duthie et al., 2013).

Respondents were also asked to rate their own activity levels on a scale of 1 to 10, (1 being very sedentary, 10 being very active). The aim of this question was to identify if respondents own perceived activity level influenced their attitude towards PA advice, or the likelihood of discussing and advising activity with obese pregnant women. Previous research has shown this to be the case with certain health behaviours, such as regular exercise, but not with diet (Howe et al., 2010). However, this was not found to be the case with this study. The activity scale had a low correlation with ‘beliefs about capabilities’, and the ‘behaviour’ under investigation. This may reflect the subjective nature of self-reporting, but more likely reflects the fact this was not a validated scale. Thus it cannot be concluded that there is no relationship with respondent PA. Asking participants to self-report their own BMI was also considered as a potential question, however, as well as possibly causing offence, a recent systematic review reported no difference between the assessment and referral of overweight and obese patients by health care staff who were themselves overweight, compared to their leaner counterparts (Zhu et al., 2011). An Australian qualitative study has, however, subsequently reported that some midwives felt uncomfortable about advising obese pregnant women regarding healthy lifestyle choices as they themselves were overweight or obese (Knight-Agarwal et al., 2013).

3.8.5 Implications for practice, policy and research

By using the TDF the quantitative results from the questionnaire indicate that the ‘skills’ and ‘memory/decision process’ domains have an important effect on

the probability that midwives report discussing and advising PA. In the context of the TDF 'skills' is defined as 'ability/proficiency acquired through practice', and is made up from constructs such as competence, ability, assessment, practice, interpersonal skills and coping strategies. Many of the comments from the midwives concur with this, for example, concerns about communication skills and the need for more training, as do findings from previous studies (Furness et al., 2011, Smith et al., 2012, Macleod et al., 2012).
For the 'memory/attention/decision process' domain the constructs are listed in the domain title, the definition of which is: 'ability to retain information, focus selectively and choose between alternatives'. Implementing this behaviour change may be slightly more problematic as in a busy consultation midwives may have many competing issues and priorities they need to discuss (Macleod et al., 2012).

As well as designing the TDF the research group has developed methods for linking behaviour change techniques to theoretical constructs (Michie et al., 2008). As part of this work they independently rated the appropriateness of 35 behaviour change techniques according to their applicability to change the 11 behaviour determinants, (domains). The techniques agreed upon for 'skills and 'memory/attention/decision process' are listed below in table 40.

Table 40: Suggested behaviour change techniques.

Domain	Behaviour change technique
Skills	Goal/target specified: behaviour or outcome Monitoring Self-monitoring Rewards; incentives (including self-evaluation) Graded tasks, starting with easy tasks Increasing skills: problem-solving, decision-making, goal-setting Rehearsal of relevant skills Modelling, demonstration of behaviour by others Homework Perform behaviour in different settings
Memory/attention decision process	Self-monitoring Planning, implementation Prompts, triggers, cues

Whilst these lists are not exhaustive, they can be used to design theory-based interventions. A review of systematic reviews concluded that multifaceted interventions which target differing barriers to change are likely to give more promising results than single interventions (Grimshaw et al., 2001). More recently it has been reported in other health care settings that education alone does not translate into practice change, a combination of education, training and performance feedback is more likely to result in improved implementation (Boscart et al., 2012). Therefore, whilst training is required it is important that as many as possible of the identified behaviour change techniques are incorporated into a program. In a previous study investigating midwives training needs it was found that midwives endorsed a ‘systematic approach’ and considered reflection and interactive discourse essential to skill development, especially when dealing with emotive topics (Heslehurst et al., 2013b). Similarly nurses have also reported the importance of individual feedback and self-monitoring (Boscart et al., 2012).

Despite many midwives stating that advising obese pregnant women about activity is not part of their everyday role, mandatory training for all staff would ensure that they had skills and awareness if the situation or need arose. Good communication skills, ability to express empathy, address one's own personal attitudes, problem solving and self-reflection are essential and transferrable skills that all midwives should have. Different professional groups are also known to have different levels of training needs (Michie et al., 2007). It is therefore possible that community and core antenatal midwives require more intensive interventions or resources. This may translate into, for example, a simple but well-designed leaflet and another box on the pregnancy booking proforma to act as a prompt for community midwives to raise the subject with women. Previous research has raised concerns about 'information overload' for women at the booking visit, but some form of standard question may help to broach the subject and reduce the stigma associated with discussing the topic (Smith et al., 2012). Clearly written guidelines are also known to make a difference, specifying precise behaviours, (what, who, when, where and how), that assist implementation (Michie and Abraham, 2004).

The main barriers to implementing such training packages are likely to lie at the organisational level, rather than the midwives themselves. The benefits of increasing guideline implementation must be seen to be worth the time commitment of staff and must compete with other priorities. In an era of continuing professional development, mandatory training, complaints, litigation and CNST (Clinical Negligence Scheme for Trusts) the hosting of multi-faceted training workshops may prove to be a cost effective investment in staff skills. However the problem is tackled, the third stage of theoretical behaviour change mapping (implementation of recommendations and monitoring) should follow. As well as assessing if a change has occurred, for example, by using audit and feedback, it is important to know 'why' it has occurred so that future interventions can focus on the strategies that were effective (McEachan et al., 2008).

4 Discussion

4.1 Key findings and contribution to literature

Consistent with the results of other studies using objective measurement, this study reported a decrease in PA levels and compliance with wearing the monitors as pregnancy progressed (Rousham et al., 2006). The results also provide new information about how much MVPA overweight and obese participants were undertaking. Fifty three percent of participants achieved at least 30 minutes of MVPA per day at baseline, and whilst the proportion remained constant at 28 weeks, it decreased to 24% by 36 weeks. This was explained by more active participants reducing PA; less active participants did not change their behaviour. The daily step count was independently associated and strongly correlated with MVPA throughout pregnancy, reflecting both the contribution of walking to MVPA and also the way PA is measured by accelerometry. Higher levels of MVPA carried out at baseline were associated with higher MVPA later in pregnancy.

Subjectively reported PAEE also demonstrated a decrease by 36 weeks, but these results did not correlate well with accelerometer measurements. Thus the RPAQ was shown to be a poor tool for measuring PA in this population but, consistent with other self-report instruments, it did provide information about where participants expend energy and which recreational activities they do throughout pregnancy.

Midwives have a potentially important public health role given their direct contact with women throughout pregnancy. Nevertheless, previous research indicates that in general women receive limited advice or support from them regarding PA (Weir et al., 2010). The questionnaire results indicated that whilst midwives were comfortable that this was part of their scope and role, they felt they lacked skills in how to approach this, were not confident that their advice would be effective, and felt they lacked adequate time and supporting resources. This agrees with previous qualitative research which has reported that midwives feel that they lack communication skills or time to counsel women effectively (Biro et al., 2013, Heslehurst et al., 2013b, Schmied et al., 2011).

Further analysis indicated that the skills and memory/attention/decision domains significantly influenced the behaviour. Tackling barriers, (for example by providing training and information about the importance of PA, communication skills, providing prompts and allowing more time), would increase the probability that the behaviour would be performed. The free text questionnaire comments also suggested that midwives felt that performing the behaviour was part of their role, but that lack of resources were acting as barriers.

Other surveys have examined the practices and attitudes of midwives. However none have used a theoretical framework to investigate the implementation of evidence based guidelines (Macleod et al., 2012, Biro et al., 2013, Wilkinson and McIntyre, 2012). The results in this thesis provide important theoretical information, indicating how training and interventions should be structured and designed in order to increase the probability that midwives discuss PA and advise obese women appropriately.

4.2 Comparing and combining the key findings

The two phases of work presented in this thesis were designed to address the questions:

1. How much PA do overweight and obese pregnant women do and how does this change as pregnancy progresses? (Chapter 2)
2. Do midwives discuss PA and advise obese pregnant women appropriately and what factors help or hinder this discussion? (Chapter 3)

Ultimately the overarching purpose of the thesis was to contribute to the knowledge base about PA levels in overweight and obese pregnant women. It is possible, therefore, that the findings from each study could be brought together, and as a result increase the breadth and depth of our understanding of the problem. This can be done by using the principles of mixed methods data analysis.

4.2.1 Mixed methods as a methodology

Mixed methods is generally defined as a research approach which combines two separate components of data collection and analysis within the same study, (usually qualitative and quantitative approaches), to improve the understanding of the research question (O'Cathain et al., 2010, Creswell, 2014). Combining results can provide more knowledge than separate analyses, but relies on some form of integration between components so that the knowledge derived from this is greater than the sum of the separate parts (O'Cathain et al., 2010). There have been some controversies surrounding mixed methods research in the past, with some researchers feeling it is epistemologically unacceptable to combine results (Bazeley, 2009). These arguments were often termed the 'paradigm wars', researchers who had previously focused on either qualitative or quantitative felt very nervous and unconvinced about the value of integrating different types of data. They felt that the two sets of data were incompatible due to fundamental differences in the paradigms underlying these methods and that these paradigms conflicted with one another, so concluding that the methods should not be combined (Teddie and Tashakkori, 2009). However, supporters of mixed methods approaches advocate the use of 'whatever tools are required to answer the research questions' (Teddie and Tashakkori, 2009).

As a methodology it involves assumptions that the 'mixed methods' approach drives the design, aims, collection and analysis of the data (Creswell, 2014). Creswell 2011 states that the reasons for using a mixed methods approach include:

- To view a problem from multiple perspectives
- To contextualise the information
- To merge quantitative and qualitative findings and so complete an understanding of a problem
- To compare, validate or triangulate results
- To illustrate trends
- As a process evaluation

Therefore, whilst the use of a mixed method approach was not planned at the outset of this PhD, some of the principles and methods involved in this type of data integration, such as comparing, validating and triangulating data were adapted to identify commonalities and achieve a deeper understanding from the results in chapters two and three.

Using this approach can help to maximise the strengths and minimise the weaknesses of each type of data, however, a systematic and transparent integrative approach which involves either emerging, connecting or embedding the different forms of data is required. The process of data integration, interpretation and reporting of the subsequent findings is not simple and has been discussed and debated by many social science researchers (Bryman, 2007). In the past studies may have reported using a mixed methods approach but then only report the findings of either the quantitative or the qualitative components, or report both sets of data without any attempt to integrate them (Bryman, 2007).

O'Cathain 2010 describes different techniques which can assist with the data integration process.

1. **Triangulation**. This process is used to combine two sets of findings that have been collected and analysed separately. A convergence coding matrix is produced which displays emerging findings. Findings from each component are listed and compared to see if they agree on the same issue '*convergence*', offer complimentary information, '*complimentary*', contradict each other '*discrepancy or dissonance'* or if a theme emerges from one set of results but not the other *'silence'*. Agreement, partial agreement, dissonance or silence can then be assessed and themes grouped to from meta-themes.
2. **Following a thread** (one method of carrying out triangulation). Each set of data is analysed to produce key themes and possible questions that may require further explanation. Each theme is then selected from one set of data and it is followed across the other sets of data to look for commonalities, this is called a 'thread'.
3. **Mixed methods matrix**. This form of integration can be carried out when qualitative and quantitative data is available for the same cases/patients/research participants; for example, if semi-structured interviews and a survey had been carried out on the same patients. The focus with this method is on the integration of data from the cases rather than the themes.

4.2.2 Objectives

As the data produced and presented in chapters two and three was obtained from studies conceived and executed independently (objectively and subjectively measured PA and a survey of the knowledge, views and attitudes of midwives), it seemed most appropriate to integrate key findings and themes. Therefore, the ‘following a thread’ technique was utilised.

4.2.3 Methods

Results from each chapter were tabulated with a corresponding interpretation. Each interpretation, or ‘thread’, was then systematically compared to all the other tabulated results to identify any patterns or emerging sub-themes that were related to the overall question. Subsequently, relevant, identified themes were collected together into tables representing meta-themes (presented below). These were consequently used to interpret and integrate findings from the PA data and the midwives questionnaire data.

As previously mentioned in chapter 2, a qualitative sub-study was carried out with 14 of the MAPS participants by a public health registrar (Dr Zoe Weir), (Weir et al., 2010)(Appendix L). This study aimed to gather insights into how overweight and obese pregnant women felt about PA in pregnancy within the context of everyday life. Alongside this the NICE guidelines ‘Dietary interventions and physical activity interventions for weight management before, during and after pregnancy’ (NICE, 2010), suggests ways to incorporate more PA into everyday life, with the aim of promoting health benefits, especially for obese pregnant women.

Therefore, findings from these additional relevant data sources were also used to contextualise the interpretation of the integrated data from chapters two and three within the meta-themes.

4.2.4 Results

Three primary meta-themes arose from this process, entitled ‘simple advice to increase habitual PA’, ‘encouraging change or maintaining behaviour’ and ‘routine behaviour and priorities’.

1. Simple advice to increase habitual PA. The results grouped together in this meta-theme are presented in table 41. The table includes data related to the type of PA participants engaged in and factors that may be related or influencing this. It also contains data related to the midwives perspectives on their role and the perceived barriers to the provision of PA advice. An interpretation and comparison of findings is then presented.

Table 41 Simple advice to increase habitual PA

Study	Sub-theme	Findings	Key messages from the data	Interpretation
MAPS & UPBEAT	Factors influencing recorded PA	MVPA correlates with step count.	The relationship between MVPA and step count suggests that the majority of women in these studies achieved their MVPA levels by walking.	Walking appears to be the predominant and most acceptable type of PA among women in all stages of pregnancy. Additional types of PA women engaged with to a lesser extent included a combination of structured and habitual activity. The structured activity remained stable throughout pregnancy, while habitual activities increased.
MAPS & UPBEAT	Factors influencing recorded PA	Regression analysis indicated that step count significantly predicted MVPA at all time points, (baseline, 28 and 36 weeks).	The association between step count and MVPA suggests that for the majority of women in these studies MVPA was dependent on step count.	
MAPS & UPBEAT	Types of PA carried out	Walking was the most popular activity, 60% of women carried this out at each time point (baseline, 28 and 36 weeks).	Walking was the predominant form of PA (approximately 6/10 women). As walking was carried out at each time point it suggests that walking is an acceptable form of PA for pregnant women in all trimesters of pregnancy	
MAPS & UPBEAT	Types of PA carried out	Swimming and body conditioning classes were the next most popular activity after walking, 16-20% of women carried these out and this proportion remains stable between baseline, 28 and 36 weeks.	Following walking swimming and conditioning activities were most popular although to a lesser extent (approximately 1-2/10 women) in all trimesters of pregnancy.	

MAPS & UPBEAT	Types of PA carried out	Women self-reported more PA in the home and garden as pregnancy progressed.	There was a change in habitual PA over the duration of pregnancy, which increased in the final trimester.	
Midwives questionnaire, domain scores	Midwives role	The mean score for social professional role was high.	The midwives in this study felt it was part of their role to discuss and advise PA with obese pregnant women.	Midwives perceived that it is part of their role to provide PA advice to pregnant women, although they focused on multiple resource barriers to the provision of this advice. These barriers can be divided into resources required in routine consultation (e.g. exercise classes and referral pathways), and lack of time or opportunities to discuss PA. Habitual PA was not discussed by midwives.
Midwives questionnaire, domain scores	Barriers	The mean score for behaviour regulation was low.	The results for behaviour regulation suggest barriers are preventing the midwives provision of advice about PA.	
Midwives questionnaire, free text comments	Resources needed to promote PA	Midwives stated they needed leaflets.	A perceived barrier to providing PA advice is a lack of patient information resources.	
Midwives questionnaire, free text comments	Resources needed to promote PA	Midwives stated they needed referral pathways.	A perceived barrier to providing PA advice is a lack of referral opportunities for additional services to support women.	
Midwives questionnaire, free text comments	Resources needed to promote PA	Midwives stated they needed more time.	Midwives perceive that they lack time to discuss PA with women.	
Midwives questionnaire, free text comments	Resources needed to promote PA	Midwives stated they had lack of opportunities to discuss PA.	Midwives perceived that they lack the opportunity to discuss PA.	

Midwives questionnaire, free text comments	Resources needed to promote PA	Midwives stated there was a lack of structured exercise classes for pregnant women.	Midwives perceived the lack of structured PA services to be a barrier to discussing PA.	

The comparison of results in table 41 highlights divergent findings from the questions and free text comments in the midwives questionnaire and between the data from the midwives and the women.

Midwives appear to have the motivation to discuss PA with obese pregnant women as they see it as part of their role, which is a positive association for future interventions. However, the low score within the behaviour regulation domain along with the perceived resource barriers associated with routine consultations (e.g. opportunity and time), suggest that PA is not a goal or priority among midwives and that there may be a lack of planning or intention to have this discussion.

The additional reported barriers midwives have to discussing PA with obese women in practice relate to structured activities, with a lack of focus on habitual activity. This finding does not reflect the patterns of women's PA behaviours during pregnancy which are predominantly walking throughout the duration of pregnancy, with increasing in-home activities towards the end of pregnancy. NICE guidelines recommend that health care professionals should '*Give specific and practical advice about being physically active during pregnancy'* and that they should '*encourage them to start walking and to build up PA into daily life, e.g. By taking the stairs instead of the lift, rather than sitting for long periods*' (NICE, 2010). The results from these studies and the NICE guidelines suggest that simple messages relating to habitual activity would be acceptable to women. These are evidence-based recommendations to improve the health of the mother and her baby, and should not require the multiple resources perceived as being barriers to practice by the midwives. Examples of habitual PA in addition to walking, gardening and housework could include more active childcare/play. Although these types of habitual PA behaviours are unlikely to be of the intensity of MVPA, for inactive women it would be a good start to reducing sedentary time, as recommended in the guidelines, and increasing a type of PA in early pregnancy which is known to be acceptable and maintainable throughout all trimesters..

However, there is some level of agreement between the studies as some women were engaged with more structured types of PA in pregnancy, which was maintained throughout all trimesters, albeit to a lesser extent than walking. Therefore midwives concerns about the lack of services for structured PA for pregnant women is valid, and the lack of opportunity for pregnancy-specific structured activity is potentially a determinant of the lower engagement among women in MAPS and UPBEAT. The qualitative research with women in the MAPS study suggests that they felt a lack of exercise classes was a barrier to carrying out more PA (Weir et al., 2010), and therefore this warrants further investigation.

2. Encouraging change or maintaining behaviour. The results grouped together in this meta-theme are presented table 42. This table includes data regarding the amount and intensity of PA carried out by the women and how this changes as pregnancy progresses. It also contains the results about the perceived behaviour of the midwives regarding PA advice and which theoretical domains and psychological factors may be influencing this. The potential barriers and facilitators (to encouraging behaviour change or behaviour maintenance), encountered by midwives are then presented.

Table 42 Encouraging change or maintaining behaviour

Study	Sub-theme	Findings	Key messages from the data	Interpretation
MAPS & UPBEAT	Maintaining PA levels	Recorded light PA decreased between baseline, 28 and 36 weeks.	There is a gradual decrease in light activity as pregnancy progresses.	Overall there appears to be a decrease (change) in PA over pregnancy. Women who start pregnancy active can maintain levels in the second trimester but this changes by the third trimester. Women who start pregnancy inactive maintain this inactivity through pregnancy.
MAPS & UPBEAT	Maintaining PA levels	Recorded MVPA remains stable between baseline and 28 weeks but decreases by 36 weeks.	Moderate and vigorous activity decreases in the third trimester.	
MAPS & UPBEAT	Meeting recommendations, maintaining PA	Proportion of women achieving ≥30 minutes MVPA remains similar between baseline and 28 weeks and decreased between baseline and 36 weeks.	Women who are able to meet national PA recommendations at the beginning of pregnancy are able to maintain this in the second trimester but fewer women are able to maintain this in the third trimester.	
MAPS & UPBEAT	Proportion of recorded time	As a proportion of wear time there was no change in sedentary or light PA as pregnancy progressed.	Light activity and sedentary time are likely to remain stable throughout pregnancy.	
MAPS & UPBEAT	Maintaining PA levels	As a proportion of wear time the time spent in MVPA decreased from baseline to 36 weeks.	Moderate and vigorous activity decrease in the third trimester.	
MAPS & UPBEAT	Maintaining PA levels	The MVPA levels of women achieving ≥30 minutes of MVPA at baseline falls by 36wks.	Women who are able to meet national PA recommendations at the beginning of pregnancy are able to maintain this in the second trimester but fewer women are able to maintain this in the third trimester.	

MAPS & UPBEAT	Influencing of MVPA	The MVPA levels of women recording < 30 minutes of MVPA at baseline remain stable throughout pregnancy.	The activity levels of women who are not meeting national PA recommendations at baseline remain fairly stable throughout pregnancy.	
MAPS & UPBEAT	Changing behaviour	Sedentary time correlates with wear time throughout pregnancy.	Recorded sedentary time does not really change as pregnancy progresses.	
MAPS & UPBEAT	Changing behaviour	Self-reported PAEE decreases as pregnancy progresses. Between 28 and 36 weeks self-reported PA in the home increases while PA related to work and commuting decreases.	Women report participating in less PA as pregnancy progresses, this coincides with self-reporting less work related PA.	
Midwives questionnaire	Discussing PA	The mean score for the question 'I discuss PA with obese pregnant women and advise them in accordance with national guidelines' = 3.26/5 (where 3=sometimes, 4=usually).	As a group, the average perception of the participating midwives was that they sometimes discussed PA.	Improving midwives skills and memory, attention and decision process will theoretically improve the probability that they will discuss PA and advise appropriately, (that is, encouraging women to maintain existing PA levels or change their behaviour to increase PA levels). Whilst improving the scores for both domains should impact on all midwives behaviour the memory attentions decision process domain appears to be having the largest influence on community midwives, whilst the skills domain
Midwives questionnaire	Factors influencing midwives behaviour	The domains skills, beliefs about capabilities, motivation & goals, memory/attention/decision, and behaviour regulation correlated with midwives behaviour question.	These domains appear to be associated with whether or not midwives discuss PA and advise obese pregnant women accordingly.	
Midwives questionnaire	Factors influencing midwives	The skills domain (defined as ability and proficiency acquired through practice*), had a	Midwives perceived level of skill appears to be directly influencing whether or not they discuss PA	

	behaviour	significant influence on midwives behaviour.	and advise obese pregnant women accordingly.	appears to be having the largest influence on hospital midwives. Removing barriers associated with these domains within the relevant staff groups should help midwives to either change their behaviour or support midwives to maintain their current practice.
Midwives questionnaire	Factors influencing midwives behaviour	The memory/attention/decision domain (defined as memory, ability to retain information, focus selectively and choose between alternatives*), had a significant influence on midwives behaviour.	Midwives perceived ability to remember and consciously decide to have the discussion appears to be directly influencing whether or not they discuss PA and advise obese pregnant women accordingly.	
Midwives questionnaire	Factors influencing different groups of midwives behaviour	A change in the score for the memory/attention/decision domain (defined as memory, ability to retain information, focus selectively and choose between alternatives*), would have the greatest influence on community midwives behaviour compared with hospital midwives.	Theoretically, influencing the memory, attention, decision domain should increase the likelihood of community midwives discussing PA and advising obese pregnant women accordingly.	
Midwives questionnaire	Factors influencing different groups of midwives behaviour	A change in the score for the skills domain, (defined as ability and proficiency acquired through practice*), would have the greatest influence on hospital midwives behaviour compared with community midwives.	Theoretically, influencing midwives skills should increase the likelihood of hospital midwives discussing PA and advising obese pregnant women accordingly.	

*(Michie et al., 2005)

The results in table 42 highlight the differences between what women need with regard to appropriate PA advice and what midwives are actually doing in practice. Active women need ongoing support and encouragement to maintain their PA levels, whilst inactive women need encouragement to change and increase PA levels. However, results from the midwives questionnaire indicate that as a group the midwives are only ‘sometimes’ discussing PA with obese pregnant women.

Findings from this meta-theme are reinforced by results from the MAPS qualitative sub-study; women reported that they thought ‘*the midwife was the most appropriate person to provide support and guidance*’. However women stated that they did not receive adequate information, support or advice regarding PA, those who did felt it was negative, conflicting and impersonal (Weir et al., 2010).

Barriers to midwives discussing PA with women and advising them appropriately are likely to come from behavioural constructs within the skills and memory/attention/decision process domains. These include interpersonal skills, coping strategies, deciding how to act or proceed and forgetfulness. Therefore, taking action to remove barriers associated with these domains should be a priority. The results also indicate that community and hospital midwives may have slightly differing training needs. Hospital midwives found factors within the skills domain to be causing more barriers, whilst community midwives found factors within the memory, attention decision domain to be acting as greater barriers to carrying out the discussion regarding PA.

The findings suggest that women need different types of support and advice from midwives depending on their PA levels at the beginning of pregnancy. Midwives therefore need to be able to assess what level of activity women are already doing. This may require suitable training that takes into account the use of appropriate dialogue to facilitate assessment. The subsequent advice can then be tailored to individual need as stated in the NICE guidelines: *‘Give specific and practical advice’ ‘If women exercise regularly before pregnancy they should be able to continue with no adverse effects’ OR ‘If women have not exercised routinely they should begin with no more than 15 minutes of continuous exercise, three times per week increasing gradually’* (NICE, 2010)

3. Routine behaviour and priorities. The results grouped together in this meta-theme are presented in table 43. Data presented in this table highlights the routine patterns of energy expenditure carried out by women in the home, at work, commuting and during leisure time and how this changes as pregnancy progresses. Information regarding how the characteristics of women may be related to these routine patterns is also presented. Results from the midwives questionnaire which highlight midwives' routine behaviour and priorities with regard to advising pregnant women about PA are also highlighted.

Table 43 Routine behaviour and priorities.

Study	Sub-theme	Findings	Key messages from the data	Interpretation
MAPS & UPBEAT	Pattern of energy expenditure	Proportion of PAEE in different areas of life (home, work, commuting, leisure), does not change from baseline to 28 weeks.	The habitual routines of participants did not change markedly between first and second trimesters.	Women with daily routines maintain their self-reported PA between baseline and 28 weeks but this falls by the third trimester. More PAEE is reported at work than at home, subsequently when women stop work total PAEE falls.
MAPS & UPBEAT	Pattern of energy expenditure	From baseline to 28 weeks and 28 to 36 weeks PAEE in home increased and work decreased.	By the third trimester women expend less energy at work and more at home.	
MAPS & UPBEAT	Characteristics influencing energy expenditure	Women's work status had a positive correlation with PAEE.	Women who work self-report more PA than those who do not work.	
MAPS & UPBEAT	Characteristics influencing energy expenditure	At 28 weeks: PAEE from work and commuting had a positive correlation with total PAEE, and negative correlation with home PAEE.	Total energy expenditure is associated with working and commuting at 28 weeks. More PA at work results in less PA at home.	
MAPS & UPBEAT	Pattern of energy expenditure	Self-reported recreational PA remained stable throughout pregnancy.	Energy expended due to recreational PA remains the same throughout pregnancy.	
MAPS & UPBEAT	Characteristics influencing energy expenditure	Nulliparous women were more likely to be in the bottom 2 quartiles of self-reported PAEE.	Women without children report carrying out less PA than women with children.	In general, older women and those with children feel they are more active than younger women, or women with no children.
MAPS & UPBEAT	Characteristics influencing	Women's parity had a positive correlation with PAEE in home.	Higher PA is reported in the home with increasing	

	energy expenditure		numbers of children.	
MAPS & UPBEAT	Characteristics influencing energy expenditure	Women's age had a positive correlation, with PAEE.	Older women self-report more PA than younger women.	
MAPS & UPBEAT	Routine behaviour	Women in paid employment were more likely to record at least 3 days of valid accelerometry at all time points, (baseline, 28 and 36 weeks).	Women who are working are more likely to comply with wearing the monitor.	A daily routine may help women to remember to wear the monitor.
Midwives questionnaire, free text comments	Advice for all women	Midwives stated PA advice should be given to all women regardless of BMI.	Midwives think all pregnant women should receive PA advice.	Whilst midwives think PA should be discussed with all pregnant women they often forget, decide not to, or do not plan to discuss PA.
Midwives questionnaire, domain scores	Reasons for not discussing PA	Domain mean score for behaviour regulation (goal/target setting, implementation intention, action planning, goal priority) was low	Midwives do not plan or prioritise a discussion regarding PA with obese pregnant women.	
Midwives questionnaire	Factors influencing behaviour	The memory/attention/decision domain had a significant influence on midwives behaviour	Midwives forget or decide not to discuss PA with obese pregnant women.	

Rather than being convergent or divergent the results from the two chapters included in this meta-theme tend to complement each other. Routine and priorities appear important for both women and midwives but with a different focus.

PA behaviour of this sample of overweight and obese pregnant women changed very little between the first two trimesters. This is a time when good habits need to be encouraged and routine, sedentary behaviours need to be changed. Higher parity and working were positively correlated with self-reported PAEE. Therefore, it could be perceived that women in paid employment or who have children already, have more of a structured daily routine than women who do not and can subsequently identify, easily remember and self-report their activity. However, a decrease in work related PA by the third trimester resulted in a similar decrease in total PA. A change to the daily routine resulted in reduced self-reported PA, this is a key time when midwives need to encourage women to increase alternative habitual activities to avoid increased sedentary time. Conversely, some women in the MAPS qualitative sub-study reported that their routine and lack of time was preventing them from being more physically active (Weir et al., 2010). It was a priority for them to spend time with children whilst their own weight was not a priority. Perhaps small changes in habitual activity need to be encouraged, breaking the usual routine and gradually increasing PA by incorporating more activity into the working day or combining it with family time such as taking children swimming.

In the midwives questionnaire the mean score for behaviour regulation was low, suggesting barriers to midwives planning or prioritising PA. A habitual routine may help midwives to remember or prioritise the discussion about PA. In the questionnaire, some midwives suggested that PA should be discussed with all pregnant women, not just those who were obese. This would help to ‘normalise’ the discussion and make it part of routine practice.

4.2.5 Discussion

The aim of integrating the results from chapters 2 and 3 was to provide more knowledge, a greater understanding of the data and subsequently the implications of the results. Carrying out this process generated three meta-themes; simple advice to increase habitual PA, encouraging change or maintaining behaviour and routine behaviour and priorities.

Integrating the results from two independently collected and designed research studies posed several challenges. A mixed methods approach was not considered or adopted in the design, conduct, data collection or original analyses, and whilst both studies addressed questions about PA behaviour in overweight and obese pregnant women, they had different objectives and produced two very different sets of data. For this reason many of the results in the two data sets were silent and no common thread could be found, for example, comfort and acceptability of wearing the accelerometer as pregnancy progressed or the influence of personal characteristics on objectively recorded PA. Similarly, data about response rate in the midwives questionnaire, personal characteristics of the midwives, specific place of work and employing Trust could not be linked with other findings. For this reason the production of meta-themes was focused on those results that were relevant to the over-arching aim of promoting PA in pregnancy.

Carrying out the data integration helped to increase the depth of understanding of the data and revealed different perspectives on how midwives could promote PA in pregnancy. Whilst having more resources, such as time and referral pathways, may seem like the ideal solution for some midwives, encouraging women to increase their daily habitual PA may be a more efficient, acceptable and effective approach. Suggesting ways that women can incorporate more walking into their daily routine or break periods of sedentary behaviour may help to promote behaviour change and help women to meet PA recommendations. Women also need to prioritise their health and wellbeing, making small changes to daily routines may impact on overall PA levels. Similarly, midwives need to prioritise the discussion regarding PA. Findings suggest that midwives need to make the discussion about PA part of their usual routine or consultation. They also need to be able to assess how active women are at booking so that they can subsequently tailor their advice and support, either encouraging women to maintain their PA levels or to gradually increase levels. It is likely that midwives would benefit from further training to help overcome the barriers identified in this research and to implement the guideline recommendations into their practice.

Overall, carrying out the integration process has provided an opportunity to examine the data and key messages from a different perspective. This has produced a more critical interpretation of the findings, providing a stronger link to highlight how midwives behaviour and practice can subsequently impact on pregnant women's PA behaviour.

4.3 Implications for practice and research

4.3.1 Ways to increase physical activity

The most reliable predictor of women carrying out PA in pregnancy, especially in the third trimester, has been shown to be PA habits prior to pregnancy (Ning et al., 2003, Haakstad et al., 2009, Leppa¨nen et al., 2014). Whilst no pre-pregnancy data was collected for this thesis, my findings indicated that women who were not meeting the target of 30 minutes of MVPA per day at the beginning of pregnancy were not likely to meet recommendations at any point. Higher levels of PA at baseline were a good predictor of higher PA later in pregnancy. My results suggest that women should be encouraged to increase PA levels before pregnancy. This is reinforced by the findings of a meta-analysis which examined the effects of PA on the development of GDM. The seven included studies used self-reported PA measures. The review concluded that greater total PA before, and in early pregnancy was associated with a lower risk of GDM (pre-pregnancy OR 0.45, 95% CI 0.28-0.75, early pregnancy OR 0.76, 95% CI 0.70-0.83) (Tobias et al., 2011). However, as few women actively seek out advice from health care professionals pre-conception this may prove difficult to achieve. A whole population based life course approach may need to be adopted, increasing public awareness, with more proactive engagement and support by all health and social care professionals. Examples could include information and posters in GP surgeries and family planning clinics and brief interventions by practice nurses and GP's. Advocating policies within the community, schools and the workplace, such as promoting and providing opportunities to be more physically active, as well as educating and informing individuals are other options (Johnson et al., 2006). This emphasises the scale of the challenge. Different strategies are needed to meet the needs of individual women, for example, those who are inactive may have different demographic characteristics, social, psychological and practical needs compared to those who are already active.

4.3.2 Interventions once pregnant

Once pregnant, health care professionals need to make women aware of the risks of being obese and of the potential benefits of PA. They then have the task of keeping them motivated and maintaining PA levels throughout pregnancy, signposting women to services where available, so that levels in more active women do not fall. However, whilst good evidence exists within the non-pregnant population, interventions studies and systematic reviews that have been carried out to date in pregnant women have shown inconclusive results.

In the systematic review by Thangaratinam it was reported that diet and lifestyle interventions can decrease GWG and reduce the risk of pre-eclampsia, but only a trend towards reducing the risk of GDM, pregnancy induced hypertension and pre term birth was seen. A subgroup analysis of overweight and obese pregnancy women reported a reduction in GWG, (mean difference -2.1 kg, 95%CI -3.46 to -0.75), but no other improvements (Thangaratinam et al., 2012b). However, it was found that interventions containing just a dietary component were associated with the greatest reduction in GWG and decreased rates of pre-eclampsia, compared with PA and mixed approach interventions. A different subgroup analysis found that women who successfully achieved a reduced GWG did have a reduced risk of pre-eclampsia and reduced birth weight, compared with women for whom the intervention was ineffective, (termed the 'non-responders'). As previously discussed in section 1.10, caution is required when interpreting the results of this review, suggesting that this synthesis does not take into account the quality of some of the data sources and lack of evidence of effectiveness of the interventions in terms of decreasing GWG (Poston 2012). A systematic review by Oteng-Ntim et al (2012) which just included randomised trials where participants were overweight or obese also found a reduced GWG in the intervention groups, mean difference -2.21 kg (95%CI -2.86 to -1.57), with a trend towards reduced GDM (Oteng-Ntim et al., 2012). They also conclude that the studies analysed were of poor to medium quality only. This leads to uncertainty for clinicians and mixed messages for women. Inconclusive or negative results could be due to poor methodological rigour within the studies. Lack of PA monitoring or use of poor tools, may lead to flawed conclusions.

4.3.3 Appropriate physical activity measurement methods

PA is a complex, multidimensional concept which is influenced be many elements (Butte et al., 2012). Behaviour change interventions which are aimed at increasing PA rely on accurate monitoring tools to determine their effectiveness (Warren et al., 2010). Measurement methods ideally should be reliable, valid, sensitive, feasible and acceptable to the population they are being used in. All measurement methods have limitations. Self-report measures are cheaper, easy to implement and provide information about types of PA, but tend to overestimate MVPA, do not correlate well with objective measures and are heavily prone to bias, so can provide misleading results. Objective measures are more costly and complex but provide more accurate and reliable data. However the most appropriate type of monitor to use in an obese pregnant population remains uncertain. The PA component of interest needs to be considered when choosing. Thus, a monitor appropriate for a 20 year old athlete interested in performance and fitness is unlikely to be useful in our target population who carry out low intensity activities such as movements related to work, domestic tasks, childcare and walking.

Monitors that can be attached to other parts of the body rather than the pregnant abdomen may prove to be more comfortable and acceptable to women. They may also prove to be more reliable, DiNallo *et al.,* (2012) suggested that accuracy of waist mounted monitors could be improved by statistically controlling for changes in abdomen tilt and body girth (as monitors should be kept in the vertical plain). This could be a problem with longitudinal PA measurement in pregnancy, as the abdomen increases in size the tilt will also increase. Changes in recorded MVPA may, at least in part, simply reflect changes in abdominal tilt. In a recent study carried out with pregnant women of all BMI ranges walking on a treadmill at 3 different speeds, the ankle-mounted StepWatch was found to be more accurate than an Actigraph accelerometer, Actical and NL-2000 pedometer at all speeds and BMI ranges (Feito et al., 2010). Also, as previously discussed, the Actiheart is not affected by the pregnant abdomen shape and size and remains discreetly in position throughout the measurement time period so eradicating the reliance on the participant to reattach it. This measurement method may prove to be the most useful in relatively small studies where accurate and reliable estimates of EE are required in order to ascertain relationships with health outcomes, such as progression to GDM. In large scale intervention studies where efficacy of the intervention/successful behaviour change requires monitoring the use of a good quality pedometer should be given serious consideration. Given the high correlation between step count and MVPA, recommendations in National Guidelines (NICE 2010) could be achieved through walking and subsequently monitored using a pedometer. The Guidelines also discourage participation in vigorous activity, thus negating the need to monitor PA of this intensity. This theory is supported by the study findings that the predominant recreational activity carried out by participants was walking. Also, very few participants recorded any vigorous PA, in the small number that did, this amounted to no more than one to two minutes per day. Unfortunately, pedometers may also be affected by abdominal tilt and cause discomfort as they are attached to the waistband in a similar fashion to the accelerometers used in MAPS and UPBEAT.

The present findings suggest that a monitor which could be attached to a different part of the body other than the pregnant abdomen and which could stay in place for 24 hours a day without causing discomfort is required. This would be more acceptable to women and provide more reliable results, overcoming the problems of forgetfulness and missing data. A more acceptable method is also likely to result in fewer withdrawals form participation so leading to a greater number of valid measurements at later gestations. A waterproof monitor would also capture PA related to swimming, a popular activity with some women during pregnancy.

Although the RPAQ asked relevant questions about PAEE within domains of everyday life it did not correlate with objective measurement and was not found to be useful at ranking women as active or inactive. Therefore whilst the RPAQ did provide valuable information about recreational activities and patterns of PAEE, other self-report methods need to be found or developed to subjectively capture absolute PAEE.

Both the accelerometer and RPAQ have advantages and disadvantages but when used together they provide useful complimentary information about PA. Accelerometer results suggest that some overweight and obese pregnant women do achieve recommendations of at least 30 minutes of moderate activity per day while the RPAQ informs us what activities women are doing and how

EE is distributed through daily habits and routines. Future research may benefit from using two complementary methods to provide a more complete picture of PA.

Additional research involving the validation, feasibility and acceptability of objective measurement tools are required under free living conditions. Developing such tools requires the engagement and opinions of the individuals who will ultimately use them; accurate monitors are of little use if not worn appropriately.

Technology is changing rapidly and increasing numbers and types of PA monitors are becoming available. Global positioning systems (GPS) combined with an activity monitor also warrant further investigation. These may provide a rich source of information about where, when and what participants are doing, therefore negating the need for questionnaires and diaries, and they can also be used as a motivational feedback tool (Matthews et al., 2012, Butte et al., 2012). Further studies are also required to ascertain the most appropriate ‘cut points’ to use when interpreting the recorded activity counts in pregnant women. This study adopted the most commonly used definitions used in the adult population but there is still uncertainty as to whether these cut points represent the same amount of PAEE across pregnant and non-pregnant groups.

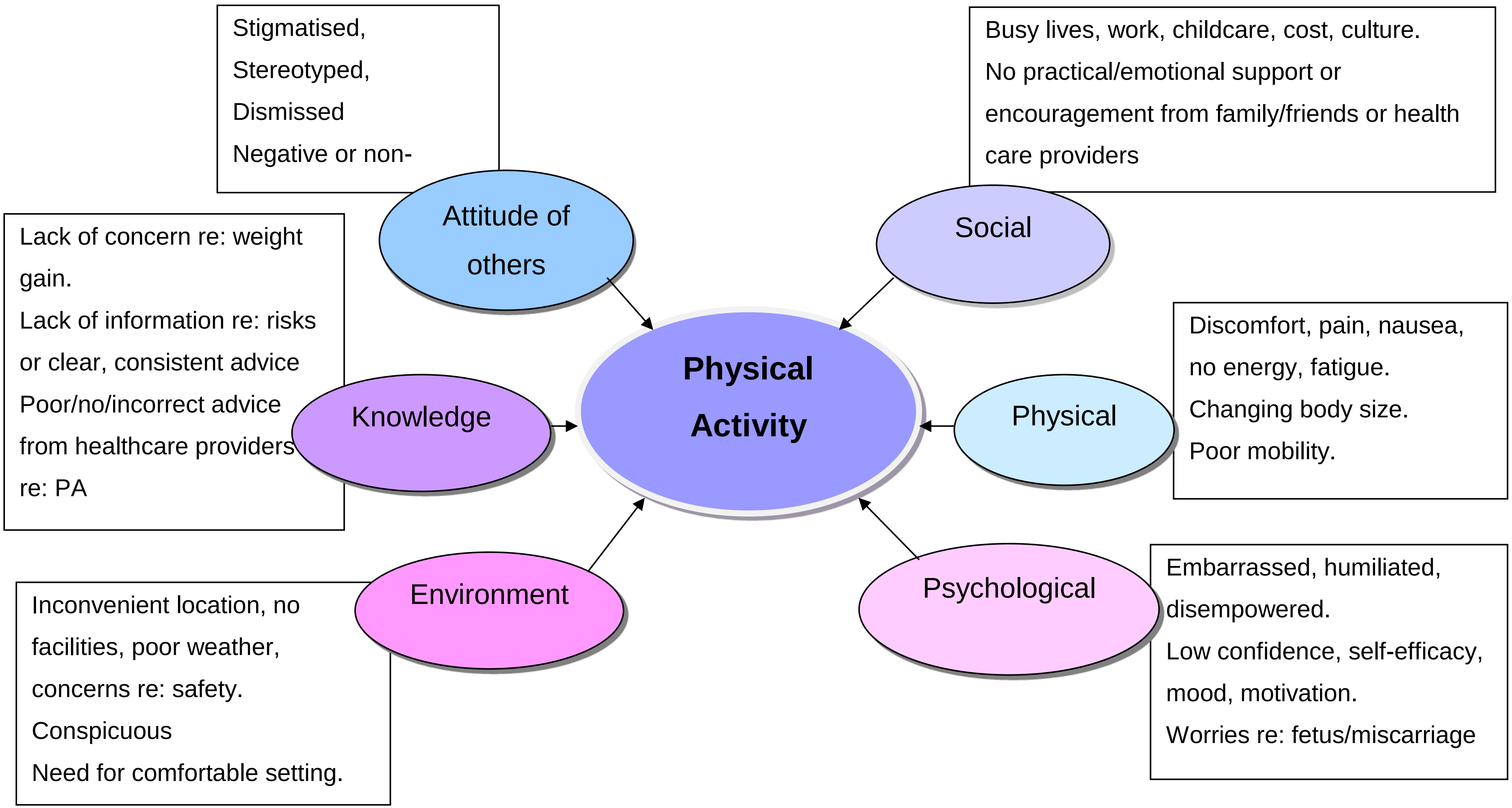
4.3.4 Pregnant women and behaviour change

Pregnancy has been described as the ideal opportunity to impart healthy lifestyle messages (Lawlor and Chaturvedi, 2006, Phelan, 2009) however recent work has suggested that some women are not receptive at this time. Most studies have focused on women’s views about weight and pregnancy related weight gain rather than on PA. It has been reported that many overweight and obese pregnant women lack concern about GWG, (Olander et al., 2011, Olander and Atkinson, 2013, Leslie et al., 2013), or the development of GDM (Harrison et al., 2012), or feel weight gain is inevitable (Smith and Lavender, 2011). Some obese women also report that they do not want to focus on their weight during pregnancy (Olander and Atkinson, 2013), do not want their pregnancy care dominated by their weight (Furness et al., 2011), or do not feel that this is the correct time to make lifestyle changes (Sui et al., 2012, Sui et al., 2013b, Leslie et al., 2013). Previous studies have found that whilst pregnant women value health care professionals as a source of information (Stengel et al., 2012), and are receptive to healthy lifestyle messages, they do not plan to execute these until the post-natal period (Smith and Lavender, 2011, Smith et al., 2012). This may be in part due to a presumption that they will lose the gained weight post-natally (Weir et al., 2010, Olander et al., 2011), or a lack of knowledge and information about risks of excessive GWG and benefits of lifestyle changes (Olander et al., 2011, Harrison et al., 2012, Leslie et al., 2013). An Australian study highlighted that women were willing to change their behaviour with regard to alcohol, smoking or eating foods that may gave them Listeriosis but were much less likely to adopt healthy lifestyle changes because of their BMI, despite the fact that the obesity related risks were much higher (Knight-Agarwal et al., 2013). Although not discussed within the study, this could be because the women were less well informed about obesity related risks. As previously discussed, many health care professionals have problems discussing obesity related issues due to the perceived sensitive nature of the topic. PA presented to women as a healthy lifestyle choice rather than being linked to weight and BMI may prove less stigmatising and successful.

Qualitative research has highlighted that obese pregnant women experience negative or dismissive attitudes, discrimination and stigma from health care providers (Nyman et al., 2010, Mulherin et al., 2013, Merrill and Grassley, 2008). They feel stereotyped, embarrassed, conspicuous and struggle to fit in to the health care environment (Merrill and Grassley, 2008, Furber and McGowan, 2010). Inappropriate communication and poor interactions with health care providers, as well as lack of adequate information and support are not conducive to the adoption of healthy lifestyle habits or encouraging behaviour change such as increasing PA. Figure 9 summarises the physical and psychological barriers obese pregnant women face when considering increasing PA during pregnancy. Many of these barriers to PA may also be relevant to pregnant women with a BMI within the normal range, for example too busy, too expensive, nausea, pain, inconvenient, lack of information. However, for obese women, who are likely to benefit most from increasing PA levels, these barriers are compounded by psychological and emotional issues and the attitudes of others (Merrill and Grassley, 2008, Evenson et al., 2009, Hegaard et al., 2010a, Nyman et al., 2010, Furber and McGowan, 2010, Olander and Atkinson, 2013, Olander et al., 2011, Harrison et al., 2012, Leslie et al., 2013, Mulherin et al., 2013, Sui et al., 2013b).

Ethnicity, culture and socio economic status impact on obese pregnant women's lifestyles (Smith and Lavender, 2011). Women from disadvantaged backgrounds have been reported to participate in lower levels of PA (Foxcroft et al., 2011), which is compounded by the evidence that many of these women may already have poor access to health care (Michie et al., 2009). For some women with complex social needs PA levels are a very low priority as they face day to day difficulties such as housing issues and financial problems (Ahmed et al., 2013). These are the very women who need extra support from midwives in all aspects of their maternity care.

Figure 9: Summary of barriers faced by obese pregnant women when considering physical activity



4.3.5 Impact in terms of midwifery training and support

Midwives have the potential to support and help women overcome many of the barriers to increasing PA, for example, giving appropriate information, encouragement and support. A cross sectional survey carried out in Australia on 350 post-natal women found that midwives were the most important source of information during pregnancy (Grimes et al., 2014), whilst Claesson et al (2008) found that women who participated in their PA intervention study reported that the motivational talks and mental coaching from midwives was beneficial (Claesson et al., 2008a). Other positive midwifery attributes appreciated by women include listening, affirmation, reassurance, perception, support, encouragement, time, respect and understanding, as well as a professional approach (Nyman et al., 2010, Merrill and Grassley, 2008, Hegaard et al., 2010a, Smith et al., 2012). This evidence adds weight to the importance of the interaction between midwives and obese pregnant women. The findings of my study, and those of studies published before and after the implementation of the questionnaire, highlight that midwives lack the skills, especially communication skills, and resources to counsel obese pregnant women effectively, or to provide unambiguous advice in a sensitive and professional manner (Schmied et al., 2011, Smith et al., 2012, Wilkinson and Stapleton, 2012, Furness et al., 2011, Knight-Agarwal et al., 2013, Biro et al., 2013, Macleod et al., 2012, Heslehurst et al., 2013b). These studies go on to recommend that midwives/health care providers need ongoing training, education and organisational support, (Heslehurst et al., 2013b, Biro et al., 2013, Furness et al., 2011, Rollans et al., 2013). The results presented in this thesis will provide a theoretical framework on which to base such training and inform future practice.

4.4 Future research questions

Despite many intervention studies and systematic reviews several research questions remain unanswered:

1. Can PA levels in overweight and obese pregnant women be increased in a sustainable way?
2. What is the most reliable and acceptable measurement method that can monitor this behaviour change in this group of women?

3. Does increasing PA in this population of pregnant women result in improved health outcomes for the mother and the offspring in the short and longer term?
4. What interventions are required to change midwives behaviour so that they are more likely to discuss PA with obese pregnant women and advise them appropriately?
5. How can midwives quickly and easily assess women's current PA levels?
6. If midwives do discuss PA with obese pregnant women does it actually have an impact on women's subsequent behaviour?

4.4.1 Increasing PA

Evidence from good quality RCT's is still lacking but two ongoing studies, (both presented in the introduction), do show promise: UPBEAT in the UK and DALI, a European multicentre RCT. Table 44 highlights the main aims of the studies and content of the interventions. If these complex interventions are effective in improving maternal and infant outcomes clinicians and policy makers will have the challenge of cost-effectively implementing the recommendations nationally on a large scale. This will present its own logistic and financial problems, but at least a robust evidence base will exist which can be used to inform guidelines. Alternatively, new approaches will be required. One possible strategy would be to have a lower intensity intervention and/or data collection process that was less burdensome on participants. An RCT carried out in the USA which included normal, overweight and obese pregnant women and a low intensity intervention, (one face to face session, weekly mailed material containing information about GWG, diet and PA, individual graphs of weight gain and telephone feedback), had an 82% retention rate at 6 months post natally and was therefore very acceptable to participants (Phelan et al., 2011). The study found that only the normal weight women were more likely to remain within IOM GWG guidelines compared to the control group during pregnancy, but a higher proportion of overweight and obese women returned to their pre pregnancy weight by 6 months post-partum. This suggests that simple clear, individualised messages may be effective at achieving longer term healthy lifestyle changes, focusing on achievable and acceptable everyday habitual activity.

Table 44 Comparison of UPBEAT and DALI interventions

Study	**UPBEAT (Briley et al., 2014)**	**DALI (Jelsma et al., 2013)**
Design	Multicentre RCT in the UK Diet + PA intervention	Multicentre RCT, 9 European countries Various combinations of Vitamin D, diet and PA in 8 arms
Population	BMI≥30kg/m^2. Gestation≥15 weeks, n=1546	BMI≥29kg/m^2. Gestation<19+6weeks, n=880
Intervention	1x face to face meeting with study health trainer to discuss program, receive handbook, log book, exercise DVD and pedometer. 8x weekly group meetings before 27 completed weeks when OGTT performed • Focus on different diet and PA goals to help achieve outcomes • Self-monitoring of goals + feedback from health trainer • Identify barriers and problem solve • Review previous goals and set new SMART goals (specific, measureable, achievable, relevant and timely) **Specific PA aims:** Increase daily step count and habitual daily activity, aim for moderate PA when walking, use pedometer to monitor and motivate.	5x face to face individual sessions with the study lifestyle coach trained in motivational interviewing. 4x booster sessions via telephone. Receive manual, pedometer, training video, dynaband, personalised plan with adapted F.I.T.T. model- frequency, intensity, time, type. **Specific PA aims:** 30 minutes of moderate PA, increasing to 60 minutes on at least 5 days/week, 5 key messages: 1. Be active every day 2. Sit less, reduce sedentary time 3. Build your strength 4. Take more steps 5. Be more active at weekends
Primary outcomes	IGT at 28 weeks. Infant birth weight >90th centile/gestational age	GWG, fasting glucose, insulin sensitivity in late pregnancy
Secondary	Obstetric and neonatal outcomes, long term follow up of infant	Obstetric and neonatal outcomes

4.4.2 Engaging obese pregnant women

More information about the psychological and social reasons why some pregnant women carry out less PA than others, or decline to participate in research or in health care programs would prove useful when designing interventions and providing appropriate support. Knight (Knight and Wyatt, 2010) reported a 14.5% recruitment rate to their dietary intervention project, whilst the UPBEAT pilot study had a 39% recruitment rate overall (Poston et al., 2013). The women who decline may be inherently different from those who do participate or attend, and may face other barriers and obstacles to changing their behaviour. Atkinson (Atkinson et al., 2013) carried out a small qualitative sub study alongside a weight management program, interviewing 7 women who declined to participate and 7 women who disengaged from the service. Many of the reported barriers were similar to those in figure 9, but they also included lack of information or insensitivity at the referral stage, wanting to self-manage their weight, or feelings that the service did not meet their needs. As part of the 'Fit for Delivery' study, (which aimed to increase PA and decrease GWG during pregnancy), researchers asked a cohort of 60 Norwegian women who declined to participate for their reasons (Sagedal et al., 2014). Fifty percent of these women said it was because they were happy with their own nutrition and fitness plan and 43% stated they were too busy. Non-participants were more likely to be younger, smoke and have a lower level of education but there was no difference in BMI or reported PA levels. More studies involving in depth qualitative interviews or focus groups are required, comparing women who do participate and remain in studies/programs with those who decline or withdraw. This information needs to be used to devise different strategies for engaging with women. Further research is also needed to investigate alternative types of motivational techniques, format of programmes and individual support requirements. Ideally, some form of professional assessment, for example, from psychologists, or midwives trained in motivational interviewing or cognitive behavioural techniques may identify underpinning psychological issues for women so that the most appropriate type of support can be offered to help overcome individual barriers.

4.5 Future directions

Alternative approaches and strategies are needed to engage with this at risk population. Greater engagement between public health, primary and secondary care needs to be implemented and all health care professionals need to consider discussing lifestyle issues at every opportunity, so increasing public awareness of the risks associated with obesity and the benefits of behaviour change, specifically PA.

‘Normalisation’ of the discussion regarding PA and healthy lifestyle choices between midwives and all pregnant women may prove beneficial. A standard question at booking and a tick-box in the hand held maternity notes next to smoking and alcohol may help to reduce stigma and initiate discussion. Routine enquiry has proved successful in other areas of antenatal care, for example, domestic violence. This has been shown to increase disclosure by women to midwives, but alongside this support, referral pathways and follow up was needed by the women, whilst adequate training was needed by midwives (Price et al., 2007). Parallels can be made with smoking cessation advice a decade ago and discussing obesity related issues today. Midwives feared that giving smoking cessation advice would damage the relationship they had with women or cause additional stress and anxiety (Aveyard et al., 2005, Abrahamsson et al., 2005). Women reported feeling ‘unworthy’ in the eyes of some health care professionals but appreciated supportive caregivers (Petersson et al., 2009), whilst a person centred approach to advice and counselling based on co-operation, trust and dialogue was seen to be more effective than a didactic approach (Abrahamsson et al., 2005, Petersson et al., 2009). It has been suggested that in such cases midwives need to change from the expert who gives advice to the expert who enables women to take control and change her own behaviour. Staff training using appropriate techniques is required alongside clear guidelines and care pathways. Training and education packages for midwives need to be designed and tested for effectiveness and acceptability by midwives and women. Currently a theory based intervention package to support the implementation of obesity management guidelines by midwives is being developed in the North East of England (led by Dr. Nicola Heslehurst). It is planned to test this intervention in a cluster RCT involving four hospitals in the North East of England (GLOWING trial: Gestational Obesity Weight-management: Implementation of National Guidelines). Hopefully, results from this pilot study will inform a larger multicentre RCT.

Recent research has suggested that there may be value in the re-introduction of weighing of every pregnant woman at certain ante natal visits (Leslie et al., 2013). For several years this practice has been considered unnecessary by the medical profession (Knight-Agarwal et al., 2013). However, if it was part of routine care for all women this may provide an opportunity to open discussions between the midwife/obstetrician and the woman regarding BMI and health behaviours such as PA, and help reduce the stigma attached to only weighing obese women.

The use of text messaging, social networking and peer support have shown promising results in other areas of health promotion and could be adopted by researchers and health care professionals implementing interventions with this population. A Cochrane Review (VodopivecJamsek et al., 2012) concluded that despite limited evidence, in some circumstances text messaging as part of an intervention may help improve health behaviour outcomes. A recent systematic review (Head et al., 2013) also reported text messaging within interventions could be effective in some circumstances, but only as one of many tools within the intervention. Text messaging is common practice for women of childbearing age, is affordable, can be personalised, sent at any time to any location and has been shown to be effective in young adults with regard to smoking cessation (Free et al., 2011, Rodgers et al., 2005, Bramley et al., 2005, Haug et al., 2012) and the use of sunscreen (Armstrong et al., 2009).

The benefits of using social media in health communication include the ability to interact with others, facilitate, share and obtain health messages (Moorhead et al., 2013). It is accessible, convenient, can be tailored to meet needs and can offer a valuable support network; however concerns have been raised regarding quality of information, reliability, confidentiality and privacy. A recent systematic review concluded that social media has the potential to be a very powerful tool but needs careful monitoring and control; and further robust trials, evaluations and reviews are required to determine how it may affect health communication in the short and long term (Moorhead et al., 2013).

Peer support is not a new phenomenon within the health care setting and has been used widely to support, for example, breastfeeding (Jolly et al., 2012) and diabetes care (Boothroyd and Fisher, 2010). The aim of peer support is to link individuals who are sharing the same experiences so that they can offer each other practical, emotional and ongoing support, for example, healthy lifestyle behaviour changes. A PA intervention study involving obese pregnant women reported that participants appreciated the support they received from their peers as part of an educational group and exercise class (Claesson et al., 2008a). Although not all women enjoy attending groups, this form of support could be one of several alternatives offered to women.

The use of social marketing also has the potential to inform interventions designed to stimulate behaviour change. Social marketing combines marketing principles and social science and is defined as *'the use of marketing concepts in programmes designed to influence the voluntary behaviour of target audiences in order to improve health and society,'* (Stead et al., 2007). It can influence behaviour change or maintenance in a sustainable and cost effective manner, but does not necessarily change what an individual thinks or how aware they are about a specific issue. Social marketing techniques attempt to consider what drives an individual's behaviour and what attributes they would value, thus 'selling' an idea. To put this into the context of obese pregnant women increasing their PA levels, women may be encouraged to adopt more healthy lifestyles because, for example, being able to play actively with their children or to take their dog for a walk is important and desirable for them. In contrast, health care professionals might be thinking about GWG and blood sugar levels.

4.6 Summary

Women who are obese at the beginning of pregnancy are at increased risk of many serious pregnancy complications which can impact on their short and long term health and that of their baby. Increasing PA levels may be one method of improving health outcomes but achieving this behaviour change in this population is difficult.

Findings from this study highlighted that it is possible to measure longitudinal changes in PA in this population of pregnant women, although there were strengths and limitations to each method used.

Over half of the participants achieved the recommended 30 minutes of MVPA per day at baseline but in these women the PA decreased by 36 weeks of pregnancy. Conversely, PA in women who did not achieve recommendations at baseline remained at a low level throughout pregnancy. MVPA at baseline predicted MVPA later in pregnancy, suggesting that increasing PA prior to pregnancy may have a beneficial effect on PA levels throughout pregnancy. Step count was strongly related to MVPA levels, reflecting the contribution of walking to MVPA. However, none of the other participant characteristics appeared to influence PA levels. The PA questionnaire highlighted a shift in self-reported PAEE from being predominantly work related to home based as pregnancy progressed. The most commonly reported recreational activity was walking, followed by swimming and conditioning exercises, but recreational PAEE only accounted for a very small proportion (3-4%) of total self-reported PAEE throughout pregnancy.

Both measurement methods were feasible, although compliance with wearing the accelerometer decreased as pregnancy progressed, the most likely cause being discomfort. Whilst some participants commented that many of the recreational activities listed in the questionnaire were inappropriate for pregnant women, they had no problems completing it. However, there was no correlation between PA assessed by questionnaire and accelerometer. The RPAQ is therefore likely to be of limited value in calculating total PA, but does provide important information on domains of PAEE and recreational activity.

The midwives questionnaire was investigating barriers and facilitators the behaviour: *'Discussing PA with obese pregnant women and advising them accordingly'*. Midwives scored highest on domains relating to knowledge, social-professional role and beliefs about consequences and lowest on domains relating to skills, beliefs about capabilities and behaviour regulation. Regression analysis indicated that skills and memory/attention/decision domains had an influence on discussing PA.

By relating the midwives' domain scores to the original constructs within each domain, (table 23), the results suggest that as a group, the midwives believe

that they have the experience and theoretical understanding in relation to discussing PA with obese pregnant women. They also see it as part of their identity and professional role, and believe that this behaviour is expected of them and their peers. They are optimistic that the actual delivery of appropriate advice would have the expected physical, social and emotional outcomes. All of these factors are acting as facilitators to midwives performing the desired behaviour: discussing PA with obese pregnant women and advising them appropriately.
Conversely, the results also suggest that the midwives felt they do not have the ability, proficiency or competence to carry out this behaviour. They are pessimistic and have low self-belief, esteem and confidence about being able to discuss and advise women effectively. They are less likely to plan or make the discussion a priority, and it is not one of their intentions or goals to change this. All of these factors are acting as barriers to midwives performing the desired behaviour. Interventions aimed at increasing implementation of the NICE guidelines need to focus on the constructs within these domains, for example: by providing training and information about the importance of PA, communication skills, providing prompts and allowing more time for discussion, would increase the probability that the behaviour would be performed.

Previous research indicates that there is no clear evidence about the effectiveness of interventions designed to increase PA and more methodologically robust studies are required. PA advice embedded into clinical practice and given to all pregnant women as part of healthy lifestyle and dietary advice may be effective and help to avoid some of the stigma and stereotyped attitudes experienced by overweight and obese women. Further good quality research is required to ascertain the most effective way to do this.

In order to achieve long term benefits for maternal and child health more resources, (time, financial and true commitment from managers and policy makers), training and ongoing research needs to be dedicated to tackling the problems associated with obesity and sedentary lifestyles. Ultimately, national legislation, advertising and more credible methods of increasing and promoting professional and public awareness are required.

Reflections

Undertaking a PhD has been the greatest and most difficult challenge of my career. The time, effort, commitment and responsibility has been immense, nothing could have prepared me for the physical, emotional and psychological challenges. Having a continued interest in maternal medicine, obesity and physical activity was essential along with the support and patience of family, friends and supervisors.

Over the last five years I have gained many useful and transferable skills which will be utilised in the future, these include project management and IT skills, administration, time management, communication and presentation skills. Handling and analysing large datasets was challenging and required an organised and logical approach. My statistical knowledge and understanding has increased enormously, having to learn and use different statistical techniques to analyse the PA and the midwives questionnaire data.

I found learning about behaviour change theories and frameworks and the opportunity to work with a health psychologist especially interesting. Designing the questionnaire and interpreting the results in line with the TDF was fascinating but very testing. My understanding of the TDF has improved substantially over the last 3-4 years. Whilst still pleased with the overall structure of the questionnaire, I would perhaps word some individual questions differently and potentially carry out back validation of the questions to improve validity. Giving staff the option of completing the questionnaire in different formats, for example, electronically as well as on paper, would also be a consideration.

Carrying out qualitative interviews with obese pregnant women and midwives to ascertain their views, attitudes and beliefs about PA may have provided a rich source of data to compliment the questionnaire data. Using this methodology would certainly be a consideration for any future projects.

Approaching and trying to recruit overweight and obese pregnant women to research projects was initially difficult. I started recruiting to MAPS in 2008 and at this time I was often the first health care professional to discuss a woman's BMI with her. The booking appointment and proforma have changed dramatically over recent years with all women having their BMI calculated by community midwives and discussed before they attend hospital. The NICE guidelines (Weight management before, during and after pregnancy), and Joint

RCOG/CEMACE guidelines were also published in 2010. Following on from this care pathways and specific antenatal clinics were introduced for women with a BMI over 30. This certainly helped with recruitment to UPBEAT. However, weight remains a very sensitive topic, women often do not want to focus on it, they feel stigmatised and do not want to be categorised according to their BMI. Therefore, discussing participation in a research study to which they are eligible because of their weight required care and thoughtfulness and occasionally provoked hostility and offence. Drawing upon experience and communication skills developed over many years was essential together with providing information in an individual and non-judgemental manner.

In retrospect, having public/patient involvement may have been helpful to improve recruitment, retention and response rate in both the PA measurement studies and the midwives questionnaire. Other studies that I have subsequently been involved with have had lay representatives on the steering groups and encouraged active involvement and engagement with all stages of the research process. This is something I will ensure in future studies.

Carrying out integration of the data from chapters two and three was not part of the original thesis plan. However, by attempting to integrate the results I have learnt a great deal about mixed methods as both a methodology and a valuable process to combine data and provide a deeper interpretation and understanding of the results. I will definitely consider using this methodology, where appropriate, in the design, conduct and analysis of future studies.

Overall I have learnt many valuable skills which I will take forward in my future career. Of these, improved organisational skills has to be one of the most important, this encompasses searching for and reviewing literature, data collection and time management. As a researcher I found the whole concept of behaviour change fascinating but very challenging. I would like to explore this further, especially in relation to PA during pregnancy, and learn more about brief interventions and motivational interviewing.

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Appendices

Appendix A: MAPS PIS

Appendix B: MAPS consent form

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Appendix A: MAPS participant information leaflet


Thank you very much for taking the time to read this information

The Newcastle Upon Tyne Hospitals NHS

CONTACT FOR FURTHER INFORMATION
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Research Midwife
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MEASURING ACTIVITY IN PREGNANCY STUDY

The Newcastle Upon Tyne Hospitals NHS

Participant Information Sheet

We would like to invite you to take part in a research study. Before you decide whether or not to participate it is important for you to understand why the research is being done and what it will involve.

Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

There is some evidence to indicate that physical activity during and before pregnancy may have a beneficial effect on likelihood of pregnant women developing problems such as diabetes and high blood pressure. Activity does not just include exercise such as going to the gym, a class, running or swimming, it also includes every day tasks such as childcare, housework, gardening and shopping.

Unfortunately there is no standard way of monitoring activity in pregnant women. Therefore, in this study we are trying to find a useful way of measuring how active pregnant women are so that in the future we can investigate how activity affects the progress of pregnancies.

Why have I been chosen?

Most women who are attending the RVI to have their early ultrasound scan are being sent information about the study. Women who are of above average weight may be invited to take part because they may benefit most from future programmes to increase activity.

Taking part in the study will not result in a change to the care you receive.

Do I have to take part?

It is up to you to decide if you would like to take part or not. If you do take part you will be free to withdraw at any time and without giving a reason. If you do withdraw or decide not to take part, this will not affect the standard of care you receive. You will be given a copy of this information sheet to keep.

What will happen to me if I take part?

After you have had your early ultrasound scan, (at approximately 12 weeks), a research midwife will discuss the study with you and give you time to ask any questions. If you agree to take part you will be randomly put into 1 of 3 groups. The research midwife will give you 2 short questionnaires about activity to complete. She will then arrange a convenient time to visit you, either at home or wherever you chose, where she will give you a small monitor to wear over your right hip. This will measure the amount and type of movements you make. It is attached by an elastic strap and must be worn for 7 days. After 7 days the research midwife will arrange to collect the monitor and ask you to complete the same questionnaires and ask you how you felt about wearing the monitor.

If you are put into Group 1 or 2 this will be repeated either 3 or 6 months later, if you are in Group 3 it will be repeated 3 AND 6 months later, so that we can see how activity changes during pregnancy.

A small number of women will be asked if they would like to take part in a short interview to find out more information about their views surrounding physical activity. This interview will be recorded but the information given will be keep completely anonymous.

What are the possible disadvantages and risks of taking part?

Wearing the monitor may be slightly inconvenient but should not be uncomfortable; it measures approximately 3cm x 3cm and is 1cm wide. You should not change your activity or behaviour while you wear the monitor.

What are the possible benefits of taking part?

Although the study will not benefit you directly in this pregnancy, the information that we get from the study should help to develop future studies which will give doctors and midwives important information which will improve the care and advice we give to women and hopefully reduce some of the complications that occasionally occur during pregnancy.

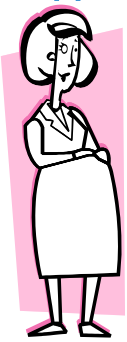
Will my taking part in this study be kept confidential?

All the information that is collected about you will be kept strictly confidential and your name will never appear in print.

What will happen to the results of the research study?

When the study is finished the findings will be published in medical journals and, if requested, summaries will be sent to those who have helped in the study. There will be no way of identifying results from any individuals that take part in the study.

Appendix B: MAPS consent form



Consent Form

Measuring Activity in Pregnancy Study

Study Number

Addressograph or
Name:
____
Hospital number:
____
Date of Birth:

1. I confirm that I have read and understood the information sheet for the above study and have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without my medical care or legal rights being affected. ☐

3. I understand that sections of any of my medical notes may be looked at by responsible individuals from the research team within Newcastle upon Tyne NHS Trust. I give permission for these individuals to have access to my records. ☐

4. I agree to the researcher informing my GP of my involvement in the above study. ☐

5. I understand that I may be asked to take part in an interview and if I agree to do so this will be audio recorded. I understand that small sections of my interview (‘quotes’) may be used in published writing about the study, and that I will not be identified at any time. ☐

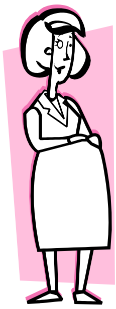
6. I agree to take part in the above study. ☐

Name of participant	Date	Signature
________________________	____________	__________________
Name of researcher taking consent	Date	Signature
________________________	____________	__________________

Appendix C: MAPS demographic questionnaire

Date □□/□□/□□

Study ID. □□



Measuring physical activity during pregnancy

Personal details questionnaire

In this section we would like to know more about you.

Q1 What is your age? □□ **Years**

Q2 What is your postcode? □□□□ □□□

Q3 When is your baby due? □□/□□/□□

Q4 What is your height? □□**ft** □□ **inches or** □.□□ **meters**

Q5 What was your weight before you became pregnant?

□□**st**□□**lb or** □□.□**kg**

Q6 What was your weight when you were first weighed by the midwife?

□□**st**□□**lb or** □□.□**kg.** Date weighed □□/□□/□□

Q7 Did you smoke any cigarettes in the last year? Yes □ **No** □

Q8 At the start of pregnancy were you in paid employment? Yes □

No □ **If yes, how many hours per week?** □□

Q9 Who normally lives at home with you?

Partner/husband Y/N

Other adults Y/N

Other children age 0-4 □

5-16 □

16+ □

Q10 What is the highest educational qualification you have achieved?

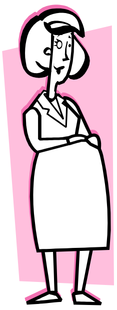
- □ None
- □ GCSE, 'O'level, or equivalent
- □ 'A' level or equivalent
- □ BTEC, GNVQ, or equivalent
- □ First Degree

☐ Postgraduate qualification

Q11 What is your ethnic group?

☐ White British
☐ White Irish
☐ White any other background
☐ Mixed white & Black Caribbean
☐ Mixed white & Black African
☐ Mixed white & Black Asian
☐ Mixed any other mixed background
☐ Asian or British Asian Indian
☐ Asian or British Asian Pakistani
☐ Asian or British Asian Bangladeshi
☐ Asian or British Asian any other Asian background
☐ Black or Black British Caribbean
☐ Black or Black British African
☐ Black or Black British any other Black background
☐ Other ethnic group Chinese
☐ Other ethnic group any other ethnic group

Appendix D: Feedback questionnaire



Study ID ☐☐

Date ☐☐/☐☐/☐☐

Measuring physical activity during pregnancy

Feedback questionnaire

Q1 How comfortable was it to wear the monitor?

1 2 3 4 5

☐ ☐ ☐ ☐ ☐

very uncomfortable very comfortable

Q2 How convenient was it to wear the monitor?

1 2 3 4 5

☐ ☐ ☐ ☐ ☐

very inconvenient very convenient

Q3 How easy was it to wear the monitor?

1 2 3 4 5

☐ ☐ ☐ ☐ ☐

not very easy very easy

Q4 How easy did you find it to answer the questions in the questionnaire?

1 2 3 4 5

☐ ☐ ☐ ☐ ☐

not very easy very easy

Q6 Do you have any other comments you would like to make?

Appendix E: MAPS diary

Name: Monitor no:

<u>Please put your activity monitor on EVERY day for the next seven days</u>

The activity monitor should be worn all day apart from swimming, getting washed etc. It should be worn snugly, on the right hip, under or over clothes. *<u>The black button should be on top, so that the word Actigraph is the right way up.</u>*

Put the activity monitor on in the morning and record when you started to wear it under “Time On”.

Please ensure the monitor is always taken off at bed-time and record when you stopped wearing it under “Time Off”.

The monitor will stop flashing when it starts recording.

Day and date	Time on	Time off	Please give times you removed the monitor and why you removed it.

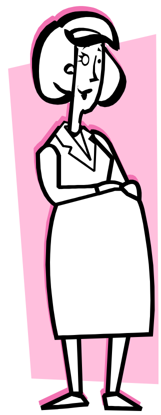
;

Measuring Physical Activity

In Pregnancy

Activity Monitor Diary

Study no. ______



Appendix F: RPAQ

Study ID ☐☐
Date☐☐/☐☐/☐☐

Measuring Activity in Pregnancy study

RPAQ

Recent Physical Activity Questionnaire

This questionnaire is designed to find out about your physical activity in your everyday life in the last week

This questionnaire is divided into 3 sections
Please try to answer every question.

- **Section A** asks about your physical activity patterns in and around the house.
- **Section B** is about travel to work and your activity at work.
- **Section C** asks about recreations that you may have engaged in during the last week.

Your answers will be treated as strictly confidential and will be used only for medical research

Section A Home Activities

Getting about

Which form of transport have you used **most often** in the last week apart from your journey to and from work? (Please tick (✓) one box only)

Usual mode of travel			
Car / motor vehicle	Walk	Public transport	Cycle

TV, Video Viewing or Computer using *but not at work*

(Please put a tick (✓) on every line)

Hours of TV, video or computer using per day	Average over the last week					
	None	Less than 1 hour a day	1 to 2 hours a day	2 to 3 hours a day	3 to 4 hours a day	More than 4 hours a day
On a weekday before 6 pm						
On a weekday after 6 pm						
On a weekend day before 6 pm						
On a weekend day after 6 pm						

Stair climbing at home (please put a tick (✓) on every line)

Number of times you climbed up a flight of stairs (approx 10 steps) each day at home	Average over the last week					
	None	1 to 5 times a day	6 to 10 times a day	11 to 15 times a day	16 to 20 times a day	More than 20 times a day
On a weekday						
On a weekend day						

Activities in and around the home (please put a tick (✓) on every line)

	Average over the last week						
	None	Less than 1 hour a week	1 to 3 hours a week	3 to 6 hours a week	6 to 10 hours a week	10 to 15 hours a week	More than 15 hours a week
Preparing food, cooking and washing up							
Shopping for food, groceries or other items (e.g. clothes, toys)							
Cleaning the house							
Doing the laundry and ironing							
Caring for someone at home (pre-school children, babies, handicapped or elderly people)							

Section B Activity at work

Please answer this section to describe if you have been in paid employment at any time **during the last week** or you have done regular, organised voluntary work.

Have you been in employment during the last week? *Yes* ☐ *No* ☐

During the last week how many hours work did you do per week? ☐

Type of work

We would like to know the type and amount of physical activity involved in your work. **Please tick** (✓) the option that **best** corresponds with your occupation(s) in the last week from the following four possibilities:

Please tick only one of the following

1. Sedentary occupation
You spend most of your time sitting (such as in an office) ☐

2. Standing occupation
You spend most of your time standing or walking. However, your work does not require intense physical effort (e.g. shop assistant, hairdresser, guard) ☐

3. Manual work
This involves some physical effort including handling of heavy objects and use of tools (e.g. plumber, electrician, carpenter) ☐

4. Heavy manual work
This implies very vigorous physical activity including handling of very heavy objects (e.g. dock worker, miner, bricklayer, construction worker) ☐

Section B Activity at work

Travel to and from work in the last week

What is the approximate distance from your home to your work?

☐☐☐ Miles *or* ☐☐☐ Kilometers

How many times a week did you travel from home to your main work? ☐☐
Count outward journeys only

Please tick (✓) one box **only** per line

How did you normally travel to work?	Always	Usually	Occasionally	Never or rarely
By car/motor vehicle				
By works or public transport				
By bicycle				
Walking				

What is the postcode for your main place of work during the last week?

Postcode ☐☐☐☐ ☐☐☐

If not known please give your work address
Work address - ______________________

What is the postcode for your home address?

Postcode ☐☐☐☐ ☐☐☐

Section C Recreation

The following questions ask about how you spent your leisure time.

Please indicate how often you did each activity on average over the last week

Please indicate the average length of time that you spent doing the activity on each occasion.

Example

If you went walking for pleasure for 40 minutes once a week.
If you had done weeding or pruning every fortnight and took 1 hour and 10 minutes on each occasion.
You would complete the table below as follows:

Please give an answer for the NUMBER OF TIMES you did the following activities in the past week and the AVERAGE TIME you spent on each activity.

Please complete EACH line

	Number of times you did the activity in the last week					Average time per episode	
	None	Once a week	2 to 3 times a week	4 to 5 times a week	Every day	Hours	Minutes
Weeding and pruning			✓			1	10
Walking for pleasure				✓			40

Example

Now complete the table on pages 6, 7 and 8.

Please give an answer for the average time you spent on each activity and the number of times you did that activity in the past week

Please complete each line

	Number of times you did the activity in the last week					Average time per episode	
	None	Once a week	2 to 3 times a week	4 to 5 times a week	Every day	Hours	Minutes
Swimming - competitive							
Swimming leisurely							
Backpacking or mountain climbing							
Walking for pleasure *(not as a means of transport)*							
Racing or rough terrain cycling							
Cycling for pleasure *(not as a means of transport)*							
Mowing the lawn							
Watering the lawn or garden							
Digging, shovelling or chopping wood							
Weeding or pruning							
DIY e.g. carpentry, home or car maintenance							
High impact aerobics or step aerobics							
Other types of aerobics							
Exercise with weights							

Please complete each line

	Number of times you did the activity in the last week					Average time per episode	
	None	Once a week	2 to 3 times a week	4 to 5 times a week	Every day	Hours	Minutes
Conditioning exercises e.g. using a bike or rowing machine							
Floor exercises e.g. stretching, bending, keep fit or yoga							
Dancing e.g. ballroom or disco							
Competitive running							
Jogging							
Bowling- indoor, lawn or 10 pin							
Tennis or badminton							
Squash							
Table tennis							
Golf							
Football, rugby or hockey							
Cricket							
Rowing							
Netball, volleyball or basketball							
Fishing							
Horse-riding							
Snooker, billiards or darts							

Musical instrument playing or singing							
Ice skating							
Sailing, wind-surfing or boating							
Martial arts, boxing or wrestling							

Thank You for completing the survey.

For further information contact
Cath McParlin
Research Midwife
Women's Services
RVI
Tel:- 0191 2820362
e-mail: Catherine.mcparlin@newcastle.ac.uk

Appendix G: UPBEAT participant information leaflet

What are the benefits of taking part?
You may not benefit personally from taking part, but you may help plan an effective antenatal programme that improves the outcome of pregnancy for many women in the future, and influence the health of their children for the whole of their life.

What are the side-effects of taking part?
The main side-effect is that we will need your time. We will want to stay in touch with you throughout your pregnancy & we appreciate how busy pregnant women are.

What happens if anything goes wrong?
In the unlikely event that you are harmed by taking part in this study no special insurance applies. However if you are harmed due to negligence normal NHS indemnity may apply, but you may have to pay for this action. Regardless of this, should you wish to complain about any aspect of the way you have been approached or treated during the course of this study the normal NHS complaints mechanism is available to you.

What drug is being tested?
There is no drug being tested.

What will happen to the results of the study?
The results will be published in medical journals. No individual information will be available. We will use the results to plan a large study where we will test diet and activity programmes on a lot of pregnant women to make sure they work.

What if new information becomes available?
Should new information become available the researchers will discuss this with you and you can decide if you want to continue in the study. It may be that the doctors and midwives decide it would be better for you to stop being part of the study. If this happens they will discuss this with you.

Who is paying for this research?
The National Institute for Health Research (NIHR) have funded this study. The midwife and health trainer working on this project have their salaries paid by this organisation. The hospital and other midwives and doctors do not receive any payment if you help with this research.

Who has reviewed this study?
St Thomas' research ethics committee reviewed and agreed this study.

What do I do if I have further questions or want to take part?

For further information please contact:

Cath McParlin/Nicola Miller
Research Midwives
Tel: 0191 2820362 (answerphone)

Or, Annette Briley,
Clinical Trials Manager
Tel: 020 7188 3643

The Newcastle upon Tyne Hospitals
NHS Foundation Trust

UPBEAT

UK Pregnancies: Better Eating and Activity Trial

Phase 2

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with friends and relatives if you wish. Please ask if anything is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Patient Information Sheet Phase 2 Version 3 Jan 2010

Background:
You can't open a paper or watch TV today without hearing that people are heavier than previous generations, and that this increase in weight leads to health problems.
Many women who are heavy when they become pregnant have no problems in pregnancy and deliver a healthy baby. At the moment no one can predict those women at greatest risk.
But we do know that heavier women are more at risk of pregnancy complications than women who are thinner. These complications include miscarriage, gestational diabetes & high blood pressure in pregnancy for the mother. At the same time the baby can grow excessively & be larger than expected, sometimes the baby can grow more slowly and therefore be smaller than expected, both can cause problems during delivery for the mother & the baby. We also know that being born too large or too small can have health consequences that last well into childhood and beyond.
We want to see if we can develop an antenatal programme that improves the outcomes for women and their babies. This will need to include advice about what you eat and the physical activities you feel able to do, and enjoy, in pregnancy. The dietary advice will be about food we believe will be better for you to eat rather than a "diet" in the usual meaning, as weight loss in pregnancy has not been linked to better outcomes. The exercise advice will be tailored to your fitness level. There are many "experts" involved in this project, including nutritionists, psychologists, activity experts, service evaluators, midwives and health trainers.
In order to work out what works best, in terms of what pregnant women should eat and how much & what type of activity works for them, we have talked to women but now need to ask a group of women to try this out for us. This will involve talking to the study midwife or health trainer every week, and putting the dietary and activity advice we think will work into practice. We want to know if our ideas work for real women with busy lives. You will be asked how following the plan fits in with your life, so we will therefore be very interested in how it works for you. You will therefore be asked to complete questionnaires about this. Once we have worked out what works best for women & could become part of routine antenatal care we test this in a large clinical trial.
What we want you to think about is whether you would be prepared to help us in this first testing of the advice.

Why have I been chosen?
You have been asked to take part because you are pregnant and had a body mass index (BMI) of 30 or more when you first saw your midwife or doctor.

What do I have to do if I take part?
You will be seen by a research midwife who will answer any questions you may have. Once you have agreed to take part you will be asked to sign a consent form and be given a copy of this to keep. The midwife will ask you about your past medical & obstetric history. You will also be asked about your current eating & physical activity. You will be asked to wear a monitor that measures your activity for 7 days. This will be repeated on two more occasions during your pregnancy. You will be asked to take part in the study & will be asked what you think about it.
The midwife will also take a blood sample from you when you first take part , at 28 weeks (6 months) and again at around 34 weeks (about 6 weeks before your baby is due). You will also have a glucose tolerance test at 28 weeks. This is often done on pregnant women to see how their bodies are handling the blood sugar levels
When you return the monitor, about a week after the first appointment, you will be put into one of two groups. Group 1 will have routine antenatal care and see the midwife two more times, group 2 will see a health trainer and meet other women in the study weekly for 8 weeks, at these sessions advice and information about healthy lifestyle choices will be discussed. At all these appointments information will be collected about what you are eating and the activities you are doing. You may be asked to wear a monitor for some of the time to measure your activity level.
All of this will be in addition to your normal antenatal care, although wherever possible we will arrange visits to suit you, and they may take place in the hospital, at your GP surgery, in another venue close to your home or may even be in your home.
We would also like to speak to your partner and take a blood sample from him, although you can still take part even if he does not want to.
When you have had your baby we would like to record details about your pregnancy and delivery, including measurements from your baby and a blood sample from the umbilical cord, or the baby's saliva sample.
We would also like to see you and your baby when he/she is 6 months old. At this appointment we will measure & weigh your baby & ask about feeding since birth. At this time we would also like to weigh and measure you and ask you questions about food and activity.

Will my taking part be kept confidential?
All information stored about you will have your name, address and other identifying details removed. No one will be able to identify you from anything we record. All computers used will be password protected.
Only people directly involved in the study will have access to the information.

Do I have to take part?
Whether you decide to take part or not is entirely up to you. Your decision will not affect the care you receive in any way. If you agree to take part, you are free to withdraw at a later stage, without giving a reason, although you may be asked if you mind us collecting details about your delivery from your medical notes. Again it is entirely up to you if you agree to this.

Appendix H: UPBEAT consent form

The Newcastle upon Tyne Hospitals NHS
NHS Foundation Trust

UPBEAT

UK Pregnancies: Better Eating and Activity Trial

CONSENT FORM

1. I have read the information sheet for the UPBEAT study (version 4, dated March 2011) and have had the opportunity to ask questions.

2. I understand that participation in this study is voluntary and that I am free to withdraw at any time, without giving a reason.

3. I understand that parts of my medical/obstetric notes will be looked at by members of the Maternal and Fetal Research Unit at St Thomas' Hospital, and by regulatory bodies auditing research practice.

4. I consent to taking part in UPBEAT, which will mean extra antenatal visits and tests for research purposes throughout my pregnancy.
5. I consent to my baby being measured following his/her birth, including skinfold thicknesses, and in some areas, PeaPod scans

6. I consent to cord blood or saliva samples being taken from my baby shortly after birth

7. I consent to a follow up visit when my baby is 6 months old, during which time I agree to my baby being weighed and measured, this may include a PeaPod scan

8. I agree to my baby and I being followed up until my baby is 5 years old, and understand this may involve tracing through NHS databases and GP records

9. I understand that my samples may be analysed in other institutions in the UK and abroad
10. I consent to my samples being used in commercial collaborations

Name..

Address..

Signed (Volunteer)_________________________________ Date_________

Signed (Research Midwife)__________________________ Date__________

Print name (midwife)________________________________

Signed (witness, where appropriate) __________________ Date________

Appendix I: Simple linear regression. (Dependent variable MVPA at each respective time period.)

	Baseline			28 weeks			36 weeks		
Variable	β	Std. Error	p	β	Std. Error	p	β	Std. error	p
Age									
MAPS	0.248	0.431	0.568	0.220	0.514	0.673	1.022	0.408	0.022
UPBEAT	0.002	0.523	0.997	-0.111	0.667	0.869	-0.190	0.491	0.702
All	0.061	0.334	0.855	0.047	0.404	0.909	0.125	0.338	0.714
Parity									
MAPS	-1.919	4.568	0.676	-1.467	5.802	0.831	5.098	3.494	0.161
UPBEAT	-0.047	5.304	0.993	-3.633	7.268	0.620	2.223	6.647	0.741
All	-0.486	3.442	0.888	-2.214	4.770	0.644	3.671	4.005	0.364
BMI									
MAPS	0.242	0.460	0.601	0.618	0.612	0.322	0.851	0.393	0.043
UPBEAT	0.342	0.433	0.433	-0.502	0.586	0.398	0.321	0.459	0.490
All	0.435	0.277	0.119	0.077	0.390	0.844	0.408	.0271	0.139
Work									
MAPS	10.361	5.917	0.086	11.823	10.347	0.264	12.457	5.384	0.032
UPBEAT	3.489	5.037	0.491	-2.056	6.365	0.749	2.890	6.459	0.659
All	4.048	3.688	0.276	0.276	4.990	0.956	3.717	4.448	0.407
Ethnicity									
MAPS	5.868	12.872	0.632	-10.729	17.515	0.546	-9.664	8.105	0.248
UPBEAT	4.110	5.411	0.451	-6.767	6.879	0.332	-4.222	6.432	0.517
All	5.031	4.331	0.224	-6.015	5.573	0.285	-3.246	4.596	0.483
Degree status									
MAPS	5.049	4.680	0.286	6.638	6.558	0.343	1.073	3.1058	0.734
UPBEAT	-0.198	5.100	0.969	-4.098	6.402	0.526	-1.226	5.173	0.815

All	2.890	3.485	0.409	0.282	4.551	0.951	-0.356	3.238	0.913
Smoking status									
MAPS	-2.223	5.190	0.670	-1.100	7.131	0.879	-2.959	4.146	0.484
UPBEAT	18.576	8.386	0.031	8.438	11.543	0.470	17.690	7.620	0.028
All	2.526	4.419	0.569	1.258	5.798	0.829	5.227	4.361	0.237
Living with partner									
MAPS	8.470	8.728	0.337	-1.133	10.622	0.916	*	*	*
UPBEAT	-1.373	5.096	0.789	2.294	6.428	0.723	1.095	5.188	0.834
All	2.977	3.874	0.444	2.056	4.886	0.675	1.175	3.546	0.742
IMD quintile									
MAPS	-0.294	1.650	0.860	-0.639	2.590	0.807	0.297	1.904	0.878
UPBEAT	0.694	2.237	0.758	1.176	2.643	0.659	2.990	2.337	0.214
All	0.726	1.285	0.573	0.379	1.738	0.828	1.814	1.278	0.164
Step count									
MAPS	0.007	0.001	<0.001	0.007	0.001	<0.001	0.005	0.002	0.005
UPBEAT	0.007	0.001	<0.001	0.008	0.001	<0.001	0.008	0.001	<0.001
All	0.007	0.001	<0.001	0.007	0.001	<0.001	0.007	0.001	<0.001
MVPA baseline									
MAPS				0.719	0.107	<0.001	0.209	0.089	0.029
UPBEAT				0.385	0.150	0.015	0.219	0.142	0.133
All				0.514	0.098	<0.001	0.220	0.091	0.019

MVPA 28 weeks									
MAPS							0.342	0.074	0.002
UPBEAT							0.187	0.161	0.255
All							0.233	0.118	0.057
Study									
All	-4.162	3.359	0.218	-1.651	4.619	0.722	-2.490	3.860	0.522

* too few participants to perform analysis. Variables with highlighted cells examined further in multiple regression

Appendix J: MAPS Ethical approval

NHS

National Research Ethics Service

County Durham & Tees Valley 2 Research Ethics Committee

Professorial Unit of Surgery
The Tatchell Centre
University Hospital of North Tees
Piperknowle Road
Stockton-on-Tees
TS19 8PE

Telephone: 01642 624164
Facsimile: 01642 624164

20 August 2007

Dr. Ruth Bell
Clinical Senior Lecturer in Public Health
Newcastle University
Institute of Health and Society
4th Floor William Leach Building, Newcastle University,
Framlington Place, Newcastle upon Tyne
NE2 4HH

Dear Dr. Bell

Full title of study: **Measuring Physical Activity During Pregnancy**
REC reference number: **07/H0908/53**

Thank you for your letter of 06 August 2007, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chairman

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

Ethical review of research sites

The Committee has designated this study as exempt from site-specific assessment (SSA. There is no requirement for [other] Local Research Ethics Committees to be informed or for site-specific assessment to be carried out at each site.

Conditions of approval

The favourable opinion is given provided that you comply with the conditions set out in the attached document. You are advised to study the conditions carefully.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Application	5.3	07 June 2007
Investigator CV		
Protocol	2	30 May 2007

This Research Ethics Committee is an advisory committee to North East Strategic Health Authority

The National Research Ethics Service (NRES) represents the NRES Directorate within the National Patient Safety Agency and Research Ethics Committees in England

Covering Letter		07 June 2007
Summary/Synopsis	1	01 June 2007
Interview Schedules/Topic Guides	2	01 June 2007
Questionnaire: Women's activity survey		
Questionnaire: Feedback questionnaire	1	01 June 2007
Questionnaire: Personal details	1	01 June 2007
Questionnaire: Recent physical activity		
Sample Diary/Patient Card	1	01 June 2007
Sample Diary/Patient Card	2	26 July 2007
GP/Consultant Information Sheets	2	31 May 2007
Participant Information Sheet: 2		01 June 2007
Participant Information Sheet	2	26 July 2007
Participant Consent Form: 2		31 May 2007
Response to Request for Further Information		06 August 2007
Regulatory requirements from monitor manual		
Scientif critique report		20 May 2007

R&D approval

All researchers and research collaborators who will be participating in the research at NHS sites should apply for R&D approval from the relevant care organisation, if they have not yet done so. R&D approval is required, whether or not the study is exempt from SSA. You should advise researchers and local collaborators accordingly.

Guidance on applying for R&D approval is available from http://www.rdforum.nhs.uk/rdform.htm.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

Feedback on the application process

Now that you have completed the application process you are invited to give your view of the service you received from the National Research Ethics Service. If you wish to make your views known please use the feedback form available on the NRES website at:

https://www.nresform.org.uk/AppForm/Modules/Feedback/EthicalReview.aspx

We value your views and comments and will use them to inform the operational process and further improve our service.

07/H0908/53	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project

Yours sincerely

Leigh Pollard

pp **Mrs P Forster**
Chair

Email: leigh.morgan@nth.nhs.uk

Enclosures: ✓ *Standard approval conditions*

Copy to: Ms A Tortice, Research & Development Department, 4th Floor, Leazes Wing, Royal Victoria Infirmary, Queen Victoria Road, Newcastle upon Tyne, NE1 4LP

Appendix K; UPBEAT Ethical approval

St Thomas' Hospital Research Ethics Committee
South London REC Office 3
Ethics Committee Office
Governors' Hall Suite,
Ground Floor South Wing
St Thomas' Hospital
London
SE1 7EH

Telephone: 020 7188 2257
Facsimile: 020 7188 2258

02 June 2009

Professor Lucilla Poston
Professor of Maternal and Fetal Research
Maternal and Fetal Research Unit
GKT Department of Women's Health
10th Floor, North Wing
St Thomas' Hospital, Lambeth Palace Road
London
SE1 7EH

Dear Professor Poston

Study Title:	**UK Pregnancy Better Eating and Activity Trial (UPBEAT)**
REC reference number:	**09/H0802/5**
Protocol number:	**1**

Thank you for your letter of 17 April 2009 and further correspondence responding to the Committee's request for further information on the above research and submitting revised documentation. This has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

<u>Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.</u>

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk. *Where the only involvement of the NHS organisation is as a Participant Identification Centre, management permission for research is not required but the R&D office should be notified of the study. Guidance should be sought from the R&D office where necessary.*

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Response to Request for Further Information		17 April 2009
Participant Information Sheet: Phase 2	2	01 March 2009
Participant Information Sheet: Phase 1	2	01 March 2009
Sample Diary/Patient Card	1	01 April 2009
Questionnaire: FFQ	1	01 April 2009
Questionnaire: Psychology	1	01 March 2009
Interview Schedules/Topic Guides	2	01 March 2009
Questionnaire: RPAQ	1	05 February 2009
Actiheart Monotor Diary	1	11 March 2009
Participant Consent Form: Activity measurement study	2	13 March 2009
Participant Information Sheet: Activity Measurement Study	1	13 March 2009
Questionnaire: Activity Measurement Study Personal Details	2	13 March 2009
Questionnaire: Activity Measurement Study feedback	1	13 March 2009
Protocol	6(2)	01 March 2009
Covering Letter		06 January 2009
Investigator CV		
Application		06 January 2009
Cv for Annette Briley		
Participant Consent Form: Partner	1 - December 2008	
Participant Consent Form: Patient	1 - December 2008	
Participant Information Sheet: Partner	1 - December 2008	

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

09/H0802/5	Please quote this number on all correspondence

Yours sincerely

Dr Robert Carr
Chair

Email: stella.hirsch@gstt.sthames.nhs.uk

Enclosures: "After ethical review – guidance for researchers"

Copy to: *Ms Karen Ignatian, R&D office for GSTT*

Appendix L: Abstracts form full text papers relating to MAPS

Objectively measured physical activity during pregnancy: a study in obese and overweight women

Catherine McParlin, Stephen C Robson, Peter WG Tennant, Hervé Besson, Judith Rankin, Ashley J Adamson, Mark S Pearce and Ruth Bell*

Background: Obese and overweight women may benefit from increased physical activity (PA) during pregnancy. There is limited published data describing objectively measured PA in such women.

Methods: A longitudinal observational study of PA intensity, type and duration using objective and subjective measurement methods. Fifty five pregnant women with booking body mass index (BMI) ≥ 25 kg/m^2 were recruited from a hospital ultrasound clinic in North East England. 26 (47%) were nulliparous and 22 (40%) were obese (BMI ≥ 30 kg/m^2). PA was measured by accelerometry and self-report questionnaire at 13 weeks, 26 weeks and/or 36 weeks gestation. Outcome measures were daily duration of light, moderate or vigorous activity assessed by accelerometry; calculated overall PA energy expenditure, (PAEE), and PAEE within four domains of activity based on self-report.

Results: At median 13 weeks gestation, women recorded a median 125 mins/day light activity and 35 mins/day moderate or vigorous activity (MVPA). 65% achieved the minimum recommended 30 mins/day MVPA. This proportion was maintained at 26 weeks (62%) and 36 weeks (71%). Women achieving more than 30 mins/day MVPA in the first trimester showed a significant reduction in duration of MVPA by the third trimester (11 mins/day, p = 0.003). Walking, swimming and floor exercises were the most commonly reported recreational activities but their contribution to estimated energy expenditure was small.

Conclusion: Overweight and obese pregnant women can achieve and maintain recommended levels of PA throughout pregnancy. Interventions to promote PA should target changes in habitual activities at work and at home, and in particular walking. (*BMC Pregnancy and Childbirth* 2010,

10:76 doi:10.1186/1471-2393-10-76 http://www.biomedcentral.com/1471-2393/10/76)

Physical activity in pregnancy: a qualitative study of the beliefs of overweight and obese pregnant women

Zoe Weir, Judith Bush, Stephen C Robson, Catherine McParlin, Judith Rankin and Ruth Bell.

Background: Whilst there has been increasing research interest in interventions which promote physical activity during pregnancy few studies have yielded detailed insights into the views and experiences of overweight and obese pregnant women themselves. The qualitative study described in this paper aimed to: (i) explore the views and experiences of overweight and obese pregnant women; and (ii) inform interventions which could promote the adoption of physical activity during pregnancy.

Methods: The study was framed by a combined Subtle Realism and Theory of Planned Behaviour (TPB) approach. This enabled us to examine the hypothetical pathway between beliefs and physical activity intentions within the context of day to day life. The study sample for the qualitative study was chosen by stratified, purposive sampling from a previous study of physical activity measurements in pregnancy. Research participants for the current study were recruited on the basis of Body Mass Index (BMI) at booking and parity. Semi-structured, in-depth interviews were conducted with 14 overweight and obese pregnant women. Data analysis was undertaken using a Framework Approach and was informed by TPB.

Results: Healthy eating was often viewed as being of greater importance for the health of mother and baby than participation in physical activity. A commonly cited motivator for maintaining physical activity during pregnancy is an aid to reducing pregnancy-related weight gain. However, participants often described how they would wait until the postnatal period to try and lose weight. A wide range of barriers to physical activity during pregnancy were highlighted including both internal (physical and psychological) and external (work, family, time and environmental). The study participants also lacked access to

consistent information, advice and support on the benefits of physical activity during pregnancy.

Conclusions: Interventions to encourage recommended levels of physical activity in pregnancy should be accompanied by accessible and consistent information about the positive effects for mother and baby. More research is required to examine how to overcome barriers to physical activity and to understand which interventions could be most effective for overweight/obese pregnant women. Midwives should be encouraged to do more to promote activity in pregnancy. (BMC Pregnancy and Childbirth, 10 (18) http://www.biomedcentral.com/1471-2393/10/18)

Measuring physical activity in pregnancy: a comparison of accelerometry and self-completion questionnaires in overweight and obese women (2013)

Bell R, Tennant PWG, McParlin C, Pearce MS, Adamson AJ, Rankin J, Robson SC

OBJECTIVES: Increased physical activity in pregnancy may reduce the risk of gestational diabetes and pre-eclampsia, which occur more commonly in overweight and obese women. There is limited assessment of physical activity questionnaires in pregnancy. This study compares self reported physical activity using two questionnaire methods with objectively recorded physical activity using accelerometry in overweight and obese pregnant women.

STUDY DESIGN: 59 women with booking BMI ≥25 kg/m2 completed the Recent Physical Activity Questionnaire (RPAQ) and Australian Women's Activity Survey (AWAS) or recorded at least 3 days of accelerometry at median 12 weeks' gestation. Accelerometer thresholds of 100 counts/min and 1952 counts/min were used to define light and moderate or vigorous physical activity (MVPA) respectively.

RESULTS: 48% of women were in their first pregnancy and 41% were obese. Median daily self-reported MVPA was significantly higher for both AWAS (127 mins, $p<0.001$) and RPAQ (81 mins, $p<0.001$) than that recorded by accelerometer (35 mins). There was low or moderate correlation between questionnaire and accelerometer estimates of total active time (AWAS $\rho=0.36$, $p=0.008$; RPAQ $\rho=0.53$, $p<0.001$) but no significant correlation between estimates of time spent in MVPA.

CONCLUSIONS: These self-report questionnaires over-estimated MVPA and showed poor ability to discriminate women on the basis of MVPA. Accelerometry measurement was feasible and acceptable. Objective methods should be used where possible in studies measuring physical activity in pregnancy. Questionnaires remain valuable to define types of activity.

(Journal: European Journal of Obstetrics & Gynecology and Reproductive Biology, 170(1) Pages: 90-95, http://dx.doi.org/10.1016/j.ejogrb.2013.05.018)

Appendix M: Midwives questionnaire

Newcastle University

The Newcastle upon Tyne Hospitals NHS Foundation Trust

Midwives Knowledge, Views and Beliefs about physical activity during pregnancy

Private and confidential

This survey is for midwives employed by either the Royal Victoria Infirmary or South Tyneside District Hospital. You are not required to complete it but your help and support would be greatly appreciated and will help us to identify any training or resources that are needed to help midwives give lifestyle advice to obese pregnant women.

If you do complete it we will assume that you consent to the responses you give being analysed and used, (anonymously), as part of reports, publications and as part of Catherine McParlin's PhD thesis.

There are no right or wrong answers, it is your views, beliefs and opinions that we are interested in. Some of the questions may seem repetitive but they are all subtly different and your patience in answering them all will improve the results. Similarly you may feel that the questions are not relevant to your area of work, however your opinions and views are still important and we'd like to know them.

The questionnaires will be anonymous and confidential and individuals cannot be identified from particular responses. This study has been reviewed by the Sunderland Research Ethics Proportionate Review Sub-Committee.

If you have any queries before, during or after completing the questionnaire please contact Catherine McParlin, Tel: 0191 2228239, (RVI ext 20362) or e-mail Catherine.mcparlin@ncl.ac.uk

Instructions

Questions should be answered by placing a ☑ in the relevant box.

Once complete please detach the slip on the front of the questionnaire and return it and the questionnaire to their separate boxes in the maternity department. These will be located at Maternity Reception in the RVI and on Delivery Suite at South Tyneside.

The returned slip will let us know that you have responded but we will have no idea which questionnaire is yours. In this way, midwives who do not return questionnaires can be sent reminders.

Just in case you are in any doubt, by obese we mean a body mass index greater than, or equal to, 30 kg/m^2 at the beginning of pregnancy.

By physical activity we mean **ANY** bodily movement that expends energy. Moderate physical activity results in a small increase in heart rate and slight sweating, however it should still be possible to hold a conversation.

Thank you for taking time to read and complete the questionnaire!

	Always	Usually	Sometimes	Rarely	Never
I advise obese women to be physically active during pregnancy in line with national guidance.	☐	☐	☐	☐	☐

How do you view giving physical activity advice ot obese pregnant women?

Do you have any other comments about this questionnaire?

Once you've completed the questionnaire please return it to the post boxes

Please tell us some information about yourself.

Which Trust do you work for?

- Newcastle Hospitals NHS foundation Trust ☐
- South Tyneside NHS Foundation Trust ☐

Where is your main place of work?

- Community ☐
- Day assessment ☐
- Antenatal clinic or fetal medicine ☐
- Delivery Suite ☐
- Inpatient ward– ante or post natal ☐
- Rotational ☐
- Integrated Team ☐
- Other (please specify ________________________

How many years have you practised as a midwife?

- Less than 2 years ☐
- 3-5 years ☐
- 5-10 years ☐
- More than 10 years ☐

On a scale of 0—10 how physically active do you think you are?

Please put a cross on the table below.

Very inactive/ Sedentary											Very Active
	0	1	2	3	4	5	6	7	8	9	10

To what extent do you agree or disagree with these statements, please tick one option per question

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1. It is acceptable for obese pregnant women who find physical activity difficult to rest and remain more sedentary during pregnancy.	☐	☐	☐	☐	☐
2. If I encounter a problem when discussing physical activity with obese pregnant women I know how to solve it.	☐	☐	☐	☐	☐
3. GPs expect me to discuss physical activity with obese pregnant women	☐	☐	☐	☐	☐
4. I feel competent discussing activity levels with obese pregnant women.	☐	☐	☐	☐	☐
5. I find it easy to discuss activity levels with obese pregnant women.	☐	☐	☐	☐	☐
6. I worry about making obese pregnant women anxious by advising and encouraging them to be more active.	☐	☐	☐	☐	☐
7. It is beneficial for obese women to increase their physical activity levels during pregnancy as it will reduce their risk of getting gestational diabetes..	☐	☐	☐	☐	☐
8. It is safe for obese pregnant women to follow the recommendations of at least 30 minutes of moderate intensity activity per day.	☐	☐	☐	☐	☐
9. I am keen to implement the guidelines regarding physical activity for obese pregnant women.	☐	☐	☐	☐	☐
10. Obese pregnant women expect me to discuss physical activity with them during pregnancy.	☐	☐	☐	☐	☐
11. I am usually too busy to discuss physical activity with obese pregnant women.	☐	☐	☐	☐	☐
12. I feel confident giving obese pregnant women advice about physical activity during pregnancy.	☐	☐	☐	☐	☐
13. I know when to discuss physical activity with obese pregnant women.	☐	☐	☐	☐	☐

		Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
14	I do not discuss physical activity with obese pregnant women because: ▪ I usually forget	☐	☐	☐	☐	☐
	▪ I don't really know what to advise	☐	☐	☐	☐	☐
15	I feel optimistic that if I give physical activity advice to obese pregnant women they will follow it.	☐	☐	☐	☐	☐
16	I have a clear plan of what to recommend to obese pregnant women regarding physical activity.	☐	☐	☐	☐	☐
17	I only discuss physical activity with obese women who ask me for advice about it.	☐	☐	☐	☐	☐
18	If obese women have not exercised prior to pregnancy they should not attempt to start during pregnancy.	☐	☐	☐	☐	☐
19	I feel uncomfortable talking to women who are obese about their physical activity levels.	☐	☐	☐	☐	☐
20	If women are obese I am more likely to discuss physical activity with them.	☐	☐	☐	☐	☐
21	Experts don't really know if physical activity is beneficial or harmful for obese pregnant women.	☐	☐	☐	☐	☐
22	I am trained to give obese pregnant women appropriate advice regarding physical activity in pregnancy.	☐	☐	☐	☐	☐
23	Obese pregnant women will feel guilty if I discuss physical activity with them and they find it difficult to be more active.	☐	☐	☐	☐	☐
24	I know what the recommendations are in the NICE guidelines, (*Weight Management Before, During and After Pregnancy*), regarding physical activity during pregnancy.	☐	☐	☐	☐	☐
25	I am able to implement the recommendations regarding physical activity and obese pregnant women.	☐	☐	☐	☐	☐
26	It is beneficial for obese women to increase their physical activity levels during pregnancy as it will reduce their chance of excessive weight gain.	☐	☐	☐	☐	☐

		Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
27	It is part of my role as a midwife to advise obese pregnant women about the appropriate type and amount of physical activity they should do during pregnancy.	☐	☐	☐	☐	☐
28	If I had a leaflet to give to obese pregnant women I would feel more comfortable about discussing physical activity.	☐	☐	☐	☐	☐
29	Obstetricians expect me to discuss physical activity with obese pregnant women.	☐	☐	☐	☐	☐
30	It is part of my role as a midwife to discuss physical activity during routine ante-natal care with obese pregnant women.	☐	☐	☐	☐	☐
31	I have a clear plan of how to address physical activity issues with obese pregnant women.	☐	☐	☐	☐	☐
32	I am more concerned about other pregnancy related issues than giving advice about physical activity to obese pregnant women.	☐	☐	☐	☐	☐
33	Attending exercise classes is the best way obese pregnant women can meet activity recommendations.	☐	☐	☐	☐	☐
34	I aim to discuss physical activity with obese pregnant women as part of my routine ante-natal care .	☐	☐	☐	☐	☐
35	I have more important things to discuss with obese women during ante-natal appointments than their physical activity levels.	☐	☐	☐	☐	☐
36	Other midwives in my NHS Trust do not discuss physical activity routinely with obese pregnant women.	☐	☐	☐	☐	☐
37	I worry that discussing physical activity with obese pregnant women may harm my relationship with the woman.	☐	☐	☐	☐	☐
38	Advising obese women to be more physically active during pregnancy may put their baby at risk of harm.	☐	☐	☐	☐	☐
39	If I have any questions regarding physical activity in obese pregnant women there is no one readily available to give me the support and answers I need.	☐	☐	☐	☐	☐
40	It is the responsibility of the GP or Obstetrician to discuss physical activity with obese pregnant women	☐	☐	☐	☐	☐

Appendix N: Covering letter

DD/MM/YYYY

Dear Colleague,

Midwives knowledge, views and beliefs about physical activity in obese pregnant women

Almost 18% of women are obese at pregnancy booking in the North East of England. Being obese at the start of pregnancy can increase a woman's risk of several serious complications and national guidelines have now been published that inform health professionals as to the best lifestyle advice to give obese pregnant women to try and improve outcomes.

Previous research has found that one barrier to successful behaviour change could be related to the conflicting advice some women receive from health care professionals.

Therefore, as midwives are the key health care professionals working with pregnant women, this survey aims to investigate your knowledge, views, attitudes and opinions about giving physical activity advice to obese pregnant women. It is not compulsory for you to complete the questionnaire however your participation would be greatly valued and appreciated by the research team and will contribute to the growing body of evidence surrounding this important topic. We hope that the results from this will help us to identify any areas of practice that need attention, such as resources or training needs.

The survey is being sent to all midwives in the RVI and South Tyneside Hospital so that a cross section of views can be obtained from 2 different hospitals in this area.

The questionnaire will take less than 10 minutes to complete, all instructions are included on the first page and no personal identifiable information will be collected. The study has been specifically designed so that it is entirely anonymous and confidential and by completing and returning the questionnaire it will be assumed that you agree to participate.

The results of the study will be summarised and reported back to both maternity units, however it will not be possible to identify individual responses.

If you have any questions about this study please contact Cath McParlin, Senior Research Midwife, (0191 222 8239, Catherine.mcparlin@ncl.ac.uk)

Many thanks for your help with this important work.

Yours sincerely

Principle Investigator Head of Women's' Services

Appendix O: Ethical approval

NHS

National Research Ethics Service

NRES Committee North East - Sunderland
Room 002
TEDCO Business Centre
Viking Business Park
Jarrow
Tyne & Wear
NE32 3DT

Telephone: 0191 4283563
Facsimile: 0191 4283432

06 June 2011

Dr Ruth Bell
Senior Lecturer in Public Health
Newcastle University
Baddily Clarke Building
Newcastle University
Newcastle upon Tyne
NE2 4AX

Dear Dr Bell

Study title:	**Midwives knowledge, attitudes and beliefs about physical activity during pregnancy, a quantitative survey examining midwives views about giving physcial activity advice to obese pregnant women in 2 Tyneside hospitals**
REC reference:	**11/NE/0152**

The Proportionate Review Sub-committee of the NRES Committee North East - Sunderland Research Ethics Committee reviewed the above application on 03 June 2011.

Ethical opinion

No ethical issues raised.

On behalf of the Committee, the sub-committee gave a **favourable ethical opinion** of the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

<u>Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned</u>.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

You should notify the REC in writing once all conditions have been met (except for site approvals from host organisations) and provide copies of any revised documentation with updated version numbers. Confirmation should also be provided to host organisations together with relevant documentation.

Approved documents

The documents reviewed and approved were:

Document	*Version*	*Date*
Covering Letter		20 May 2011
Investigator CV	Dr Ruth Bell	15 March 2011
Investigator CV	Catherine McParlin	20 May 2011
Investigator CV	Umo Esen	13 April 2010
Letter of invitation to participant	RVI Version 2	20 May 2011
Letter of invitation to participant	STDH Version 2	20 May 2011
Protocol	Version 3	20 May 2011
Questionnaire: non-validated QU RVI	Version 4	15 March 2011
REC application	Version 3.1	05 May 2011

Membership of the Proportionate Review Sub-Committee

The members of the Sub-Committee who took part in the review are listed on the attached sheet.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

11/NE/0152	Please quote this number on all correspondence

With the Committee's best wishes for the success of this project.

Yours sincerely

HMWilson

Mr Paddy Stevenson
Chair

Email: Helen.Wilson@suntpct.nhs.uk

Enclosures: *List of names and professions of members who took part in the review*

"After ethical review – guidance for researchers"

Copy to: Mr Andrew Johnston, Newcastle upon Tyne Hospitals NHS Foundation Trust

NHS
Health Research Authority

NRES Committee North East - Sunderland

Room 002
TEDCO Business Centre
Viking Business Park
Jarrow
Tyne & Wear
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Tel: 0191 4283563
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24 February 2012

Dr Ruth Bell
Chief Investigator
Newcastle upon Tyne Hospitals NHS Trust
Royal Victoria Infirmary
Queen Victoria Road
Newcastle upon Tyne
NE1 4LP

Dear Dr Bell

Study title:	**Midwives knowledge, attitudes and beliefs about physical activity during pregnancy, a quantitative survey examining midwives views about giving physcial activity advice to obese pregnant women in 2 Tyneside hospitals.**
REC reference:	**11/NE/0152**
Amendment number:	**New study end date of 30/09/2012**
Amendment date:	

Thank you for your letter of 23 February 2012, notifying the Committee of the above amendment.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Notification of a Minor Amendment	New study end date of 30/09/2012 and two new sites	
Covering Letter		23 February 2012

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for

Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

11/NE/0152:	**Please quote this number on all correspondence**

Yours sincerely

Mrs Helen M Wilson
Committee Co-ordinator

E-mail: Helen.Wilson@suntpct.nhs.uk

Copy to: *Andrew Jonston, Newcastle upon Tyne Hospitals NHS Foundation Trust*

Appendix P: Published abstract, Perinatal Medicine conference 2014

Implementation barriers experienced by midwives when advising obese pregnant woman about physical activity: A cross-sectional survey.

Catherine McParlin, Stephen C. Robson, Vera Araujo-Soares, Debbie Carrick-Sen, and Ruth Bell

Introduction Increasing levels of physical activity (PA) may help to reduce the risk of some obesity related pregnancy complications and NICE guidelines advise at least 30 minutes of moderate PA per day. However, women receive limited advice concerning PA from midwives. This study investigated perceived implementation difficulties for midwives advising obese pregnant women regarding PA.

Methods A self-completion, anonymous questionnaire was distributed to all midwives employed by three Trusts in Tyne and Wear (n=365; response rate 52.6%). It was designed to identify barriers to midwives 'discussing PA with obese pregnant women and advising them in accordance with national guidelines'. The design used the Theoretical Domain Framework approach (Michie, 2005), which describes 11 domains of behavioural determinants used to investigate perceived implementation difficulties.

Results Midwives scored highest on knowledge, social-professional role and beliefs about consequences and lowest on skills, beliefs about capabilities and environment/context/resources domains. There were no differences in mean domain scores between hospital Trusts but midwives providing antenatal care scored higher than ward midwives, indicating they perceived fewer barriers to the behaviour. Regression analysis indicated that skills and memory/attention/decision domains had a significant influence on discussing /advising on PA.

Conclusions Midwives feel knowledgeable about PA advice for obese women and believe it is part of their role, but perceive they lack necessary skills, capabilities and resources. Designing interventions that improve skills, promote routine enquiry regarding PA and provide resources (eg. Information, referral pathways) may help improve midwives' PA advice.

(Archives of Disease in Childhood-Fetal and Neonatal Edition 99 (Suppl 1))