Relationship between Pre-Pregnancy Body Mass Index, Physical Activity and Sedentary Lifestyles Before and During Pregnancy: A Cross-Sectional Study

Amezcua-Prieto C1-3*, Olmedo-Requena R1-3, Martínez-Ruíz V1-3, Jiménez-Mejías E1-3, Mozas-Moreno J4, Jiménez-Moleón JJ1-3 and Summerbell CD5

1Department of Preventive Medicine and Public Health, University of Granada, Spain
2CIBER de Epidemiología y Salud Pública (CIBERESP), Granada, Spain
3Bio-Health Research Institute (IBs Granada), Granada, Spain
4Gynecology and Obstetrics Service, Virgen de las Nieves University Hospital, Granada, Spain
5School of Medicine, Pharmacy and Health, Durham University, UK

Abstract

Introduction: Pregnant women are recommended to participate in ‘moderate to vigorous’ physical activity (MVPA), each day, to promote and maintain health. The aim of this study was to assess the changes in Total Energy Expenditure (TEE), MVPA, physical activity levels in four different domains (leisure time, transportation, household/caregiver, occupational), time spent watching TV, and numbers of women meeting the recommendations, before compared with during pregnancy, by body mass index category.

Method: A systematic sample of otherwise healthy pregnant women attending their scheduled 20-22nd week assessment at a hospital in Spain during a 4 year period, 2004-2007, were asked for information on socio-demographic and medical information. They completed the Paffenbarger questionnaire and provided an estimate of their height and weight, both during the first half of their pregnancy and during the 12 months prior to their pregnancy.

Results: 1.175 women agreed to take part. TEE decreased from pre-pregnancy in all BMI categories (21.77 to 18.89 in ideal; 24.20 to 21.56 in overweight; and 23.82 to 21.21 in obese women) (p<0.001). Physical activity levels in the transportation and leisure time domains, both before and during pregnancy were negligible across all BMI categories (mean around 1-1.5 MET hours/day), although LTPA did decline during pregnancy. Physical activity levels in the household/caregiver domain did not change as a result of pregnancy in any of the BMI categories (mean approx. 11 MET hours/day in ideal compared with approx 15 in overweight and obese categories). Physical activity levels declined in the occupational domain across all BMI categories.

Discussion: Patterns of physical activity appear to be maintained during pregnancy, with the exception of occupational activity which decreases equally across all BMI categories. Motivating women, regardless their pre-pregnatal BMI index, to be physically active and less sedentary from the beginning and during pregnancy could potentially increase physical activity levels.

Keywords: Physical activity; Leisure time physical activity; Recommendations; Television watching; Pregnant women; Body mass index

Introduction

The non-performance of any exercise before, during or after pregnancy has been associated with a poor general healthy status of the women [1]. Some of the benefits of performing moderate exercise during pregnancy are protective gestational weight gain [2-5] high pressure control [6], helps to quit smoking during pregnancy [7], increase fitness [8-10] or increase self-esteem and well mental health [5,11].

Pre-pregnancy Body Mass Index increased the women risks of gestational diabetes [12], hypertensive disease [13], macrosomia [14] or shoulder dystocia [15]. Thus, antenatal physical lifestyle for overweight and obese pregnant women restricts maternal weight gain during pregnancy and lowers the prevalence of gestational diabetes in women who are overweight or obese [16].

Some international institutions such for example: the American College of Obstetricians and Gynecologists (ACOG) [17] in the USA, the National Institute for Health and Clinical Excellence (NICE) [18] and Royal College of Obstetricians and Gynaecologists (RCOG) [19] in the UK, and ‘Spanish society of Gynecology and Obstetrics’ (SEGO) in Spain20 recommend that all BMI categories of healthy pregnant women pregnant should participate in at least 30 minutes of moderate-intensity physical activity/day. This recommended amount of aerobic activity is required to promote and maintain health, and is in addition to routine activities of daily living of light intensity (e.g., self-care, cooking, casual walking or shopping) [17-20].

Several studies have focused on physical activity patterns during pregnancy in general [21-26], during pregnancy versus post-pregnancy [27-29], and pre-pregnancy versus during pregnancy [30,31]. But less is
known about the physical activity domain patterns according to maternal pre-pregnancy Body Mass Index and regardless sedentary lifestyles.

This study aimed to quantify changes in Mean Energy Expenditure (MEE) of physical activity domain, sedentary lifestyle and compliance with physical activity recommendations between maternal pre-pregnancy and throughout the first half of pregnancy, stratified by maternal BMI.

Method
Design and participants
A prospective series design was employed between June 2004 and October 2007. A sample of healthy (non-complicated pregnancies which restricts activity during pregnancy or metabolic illness) Spanish pregnant women was recruited into the study during a pre-scheduled hospital appointment at the Virgen de las Nieves Hospital (a tertiary hospital located in the city of Granada, Spain). The study was approved by the University Hospital and the University of Granada Ethics Committee, and all women signed a consent form before participation [32]. Most women were between 20 and 22 week gestation, and were part of the Andalusian Programme of Infant-Maternal Health (a free and universal programme for all pregnant women living in the south of Spain). Exclusion criteria were multiple-gestations, pregnancy complications requiring rest or diet modification, and residence outside the geographic catchment area of the hospital.

Study sample
A systematic sample (one in five) of 1,222 women was approached for recruitment into the study: 19 women (1.6%) did not complete the full interview; 15 (1.2%) did not provide all of the required data; and 13 (1.1%) declined to participate. The final sample included 1,175 pregnant women (96% of women invited to participate). The sample size was adequate to detect changes equal to or higher than 20% between the frequency of ideal women reporting any physical activity recommendation during pregnancy compared with obese women, with 80% power, α=5% and a 30% reporting any physical activity recommendation during healthy pregnancy (the frequency of any physical activity recommendation during pregnancy [32,33]).

Data collection
Data were collected through a structured face-to-face questionnaire, managed by two previously trained interviewers on the day of the pre-scheduled hospital appointment. Socio-demographic, obstetric, and lifestyle variables were collected in addition to the physical activity questionnaire. An estimation of maternal pre-pregnancy BMI (one month pre-pregnancy or early pregnancy BMI) was obtained from either the maternal antenatal records, or from maternal self-reports in cases of missing documentation. The BMI categories were concurrent with the World Health Organization (WHO) classifications of underweight (<18.5 kg/m²) ideal (18.5 kg/m²-24.9 kg/m²), overweight (25 kg/m²-29.9 kg/m²) and obese (>30 kg/m²) [34].

Sedentary behaviors and physical activity questionnaire
The Paffenbarger Physical Activity Questionnaire (Pereira, 1997) [35] was used to estimate physical activity levels at two time points: throughout 12 months prior to pregnancy, and during the first half of pregnancy. The questionnaire groups activities into four domains: 1) Leisure Time Physical Activity (LTPA): as walking, gardening, swimming, excursions, cycling, dancing, gymnastic, aerobic, go up and down stairs, jogging, climbing, tennis, football, hockey, skiing, riding horses, walking with dogs, playing with children; 2) Transportation (TPA): walking or cycling transportations in everyday life; 3) Household/caregiver (HCPA): cooking, children caregiver, cleaning, shopping and carrying shopping bags and 4) Occupational activities (OPA): activities at work. The frequency (days/week) and duration (minutes/session) of participation in the physical activity domains were estimated for both time points.

Each of the above described activities was classified from light to vigorous intensity and assigned a pre-specified MET value (energy spent in calories/h.) according to the Compendium of Physical Activities [36,37]. Four categories of LTPA were defined according to their intensity level, following the criteria proposed by the Centre for Disease Control and the American College of Sports Medicine (CDC-ACSM) [38]: 0=No LTPA; 1=Light LTPA (1.5-2.9 MET); 2= Moderate LTPA (3-6 MET); 3=Vigorous LTPA (>6 MET).

Further dichotomous variables were also defined. The first set of variables included yes and no responses for: 1) Any LTPA, 2) Any Moderate LTPA and 3) Any Vigorous LTPA. Each of these variables was stratified according to the women occupational status (0=always working, 1=stop working at pregnancy; 2=never working). The second set of dichotomous variables was related to the compliance with physical activity recommendations during pregnancy: 30 minutes of moderate-intensity activity (LTPA and walking or cycling for transportation) at least 5 times/week [17-20].

Women were asked about time for television watching (hours/day) one year pre-pregnancy and till the mid-pregnancy. This variable was categorized into categories; firstly into four categories (<1 hour/day; 1-2 hours/day; 2-3 hours/day; >3 hours/day) [39,40], and secondly in two categories (<2 hours/day vs. ≥ 2 hours/day), as previously in pregnant women [41].

Statistical Analysis
Mean Energy Expenditure of domains and their 25 and 75 percentiles were calculated during pregnancy and were compared with 12 months before pregnancy (in ideal, overweight and obese related samples) assessed by t- test. The Chi squared test was used to estimate differences in any LTPA, any moderate-vigorous LTPA and any recommendation LTPA between pre-pregnancy BMI categories according to their occupational status. A p value equal to or less than 0.05 was considered statistically significant. Data were analyzed using Stata 12.0.

Results
The mean age of the sample women was 29.8 (SD=5.14) years with a range of 18-45 years. The incidence of previous miscarriage was higher in overweight women compared with normal or obese women. The frequency of nulliparous women with ideal BMI range was higher (57%) than the frequency of nulliparous women with overweight or obese BMI range (44% and 47%, respectively). Those with a parity of two or more were primarily obese women. There were less university educated women, high social class, and employed women in the obese category, whereas women with an ideal BMI were more likely to be in employment, high social class, and university educated (Table 1).

The percentage of underweight women in this sample of 1,175 was of 3.23% (n=38). Due that this percentage was rather low; we included these women in the ideal category for all the analysis. Withdrawing this 3.23% of women from the analysis, the results were similar.
Women in all BMI groups showed a reduction in Total Mean Energy Expenditure (TMEE), 'LTPA' and 'Occupational' domain in MET h/day (P25-P75) during pregnancy compared with before pregnancy, significant for all pre-gestational BMI women. For example, in overweight women the MEE from LTPA domain decreased from 1.58 (0.00-2.00).

MET h/day during 12 months prior to pregnancy to 0.92 (0.09-1.24) MET h/day during the first half of pregnancy (p=0.001); from Occupational domain from 6.48 (0.00-10.28) to 4.00 (0.00-7.50) MET h/day (p<0.001), and from the TMEE from 23.82 (12.18-31.07) to 21.21 (9.08-29.34) (p<0.001). The 'Household/caregiver' and 'Occupational' domains represented the majority of daily physical activity before and during pregnancy for ideal, overweight and obese women (Table 2). Even all BMI groups reported a significant reduction in LTPA MET h/day during pregnancy, obese women reported the lowest level of it and women with an ideal BMI reported the highest level. Similar results were found for the Occupational MET h/day during pregnancy (p<0.001) (Table 2).

Regarding the activities intensity and the pre-gestational BMI group of women, 'Any moderate-vigorous' and 'Any recommendation' physical activity decreased as the women BMI index increase. Only in the ideal BMI group the recommendation compliance was higher in the domains represented the majority of daily physical activity before and during pregnancy for ideal, overweight and obese women. Previously, it has been described that pre-pregnancy activity is the strongest predictor of pregnancy activity, and pre-pregnancy behavioral patterns persist into pregnancy [31].

‘Household/caregiver’ and ‘Occupational’ domains represented the highest percentage of TMEE in all the BMI categories. These patterns have also been observed in other studies during pregnancy [23,24,27] or before and during pregnancy [31]. In addition, some sociodemographic variables have also been identified by others as related to distribution of energy expenditure between physical activity domains during pregnancy, such as parity, age, annual income, and educational level [24,31].

Studies carried out in the USA [24] and the UK [27] identified a TME in pregnancy which were higher than the participants in this study (35.0 MET hours/day and 40.5 MET hours/day, respectively) vs. (Table 4). We also observed a higher frequency of more than two daily hours watching TV in obese women than in overweight or ideal weight women. The higher BMI index, the higher the time spent watching TV. For example, ideal pregnant women increased from 50.4% of more than 2-3 hours on television watching before pregnancy to 56.7% during the first half of pregnancy. The same was true for the frequency of overweight (from 52.2% to 60.0%) and obese women (from 61.9% to 67.8%) p<0.001.

**Discussion**

The results of this study have identified a decreased of the TMEE during pregnancy compared with 12 months before pregnancy among women, independently of their pre-gestational BMI index: ideal, overweight or obese women. Previously, it has been described that pre-pregnancy activity is the strongest predictor of pregnancy activity, and pre-pregnancy behavioral patterns persist into pregnancy [31].

Demographic characteristics of a group of Spanish women by pre-pregnancy BMI.

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Total N=1,175 (100%)</th>
<th>Ideal n=789 (67%)</th>
<th>Overweight n=268 (23%)</th>
<th>Obese n=118 (10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Mean (SD) Range</td>
<td>29.8 (6.1); 18-45</td>
<td>29.7 (5.1); 18-44</td>
<td>30.0 (5.2); 19-45</td>
<td>29.7 (4.8); 18-41</td>
</tr>
<tr>
<td>BMI Mean (SD) Range</td>
<td>24.2 (4.4)</td>
<td>21.7 (1.9)</td>
<td>29.0 (1.3)</td>
<td>34.1 (3.6)</td>
</tr>
<tr>
<td>0</td>
<td>(933) 79%</td>
<td>(639) 81%</td>
<td>(198) 74%</td>
<td>(96) 81%</td>
</tr>
<tr>
<td>1</td>
<td>(242) 21%</td>
<td>(150) 19%</td>
<td>(70) 26%</td>
<td>(22) 19%</td>
</tr>
<tr>
<td>2</td>
<td>(128) 11%</td>
<td>(75) 9%</td>
<td>(35) 13%</td>
<td>(18) 15%</td>
</tr>
<tr>
<td>Parity n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educational Level n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>(358) 30%</td>
<td>(271) 34%</td>
<td>(64) 24%</td>
<td>(23) 19%</td>
</tr>
<tr>
<td>Secondary</td>
<td>(339) 28%</td>
<td>(241) 30%</td>
<td>(71) 26%</td>
<td>(27) 23%</td>
</tr>
<tr>
<td>Primary</td>
<td>(478) 41%</td>
<td>(277) 35%</td>
<td>(133) 50%</td>
<td>(68) 58%</td>
</tr>
<tr>
<td>Social Class n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>(172) 14%</td>
<td>(142) 18%</td>
<td>(24) 9%</td>
<td>(6) 5%</td>
</tr>
<tr>
<td>II</td>
<td>(144) 12%</td>
<td>(104) 13%</td>
<td>(130) 11%</td>
<td>(10) 8%</td>
</tr>
<tr>
<td>III</td>
<td>(346) 29%</td>
<td>(233) 29%</td>
<td>(85) 32%</td>
<td>(28) 24%</td>
</tr>
<tr>
<td>IV-V</td>
<td>(513) 43%</td>
<td>(310) 39%</td>
<td>(129) 48%</td>
<td>(74) 66%</td>
</tr>
<tr>
<td>Smoking Status at pregnancy n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never or ex-smoker</td>
<td>(955) 81%</td>
<td>(639) 81%</td>
<td>(215) 80%</td>
<td>(101) 86%</td>
</tr>
<tr>
<td>Current Smoker</td>
<td>(220) 19%</td>
<td>(150) 19%</td>
<td>(53) 20%</td>
<td>(17) 14%</td>
</tr>
<tr>
<td>Employment out of home at pregnancy n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always work</td>
<td>(558) 47%</td>
<td>(424) 54%</td>
<td>(105) 39%</td>
<td>(29) 25%</td>
</tr>
<tr>
<td>Never work</td>
<td>(427) 36%</td>
<td>(249) 32%</td>
<td>(111) 42%</td>
<td>(67) 57%</td>
</tr>
<tr>
<td>Stop at pregnancy</td>
<td>(189) 16%</td>
<td>(116) 15%</td>
<td>(51) 19%</td>
<td>(22) 19%</td>
</tr>
</tbody>
</table>

Table 1: Demographic characteristics of a group of Spanish women by pre-pregnancy BMI.†

† Cut-off points just at the beginning of pregnancy or one month prior to pregnancy according to WHO classification categorized into normal weight (18.5 kg/m²-24.9 kg/m²), overweight (25 kg/m²-29.9 kg/m²) and obesity (>30 kg/m²) (WHO, 2000). † The measurement of the social class in health sciences (Alvarez-Dardet, 1995).

<table>
<thead>
<tr>
<th>Activity domain</th>
<th>Ideal</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET hours/day</td>
<td>(20 GW)</td>
<td>1.28 (0.00; 1.13)</td>
<td>9.29 (0.00; 1.24)</td>
</tr>
<tr>
<td>Leisure (LTPA)</td>
<td>(P25, P75)</td>
<td>(0.00; 2.43)</td>
<td>(0.00; 2.31)</td>
</tr>
<tr>
<td>MVPA total</td>
<td>(20 GW)</td>
<td>0.14 (0.00; 0.57)</td>
<td>0.47 (0.00; 0.47)</td>
</tr>
<tr>
<td>Transportation</td>
<td>(20 GW)</td>
<td>0.00; 0.57</td>
<td>0.44; 0.00</td>
</tr>
<tr>
<td>Physical activity</td>
<td>(20 GW)</td>
<td>0.00; 0.00</td>
<td>0.00; 0.00</td>
</tr>
</tbody>
</table>

Table 2: Mean Energy expenditure (MEE) in MET hours/day during 12 months prior to pregnancy and during the first half of pregnancy (around 20 Gestational Week) in different domains of everyday life by pre-pregnancy BMI.

Our results suggest a decrease in ‘LTPA’ and ‘Occupational’ activities in women among all BMI categories. However, previous published data relating to changes in both domains observe a higher decrease of MEE for obese women compared with before pregnancy [18]. But we observed that obese women had the lower MEE for leisure and occupational activities, before and during pregnancy, compared to ideal or overweight women. Similarly, our study observed a less frequency of ‘Any moderate-vigorous Leisure Physical Activity’ among obese women compared with ideal BMI or overweight women.

20.55 MET hours/day (P25-P75=9.59-29.12) MET hours/day in our study. The difference in results could be due to a number of factors. Firstly, the studies also consider sedentary activities of the daily life which were excluded in our study (constituting mainly by activities such watching television, computer, driving, sitting sleeping, reading, etc.), and it may possible that these differences in MEE between studies may be attributed to the application of different metabolic equivalent scores or also because the methods used to collect the data were different.

Our results suggest a decrease in ‘LTPA’ and ‘Occupational’ activities in women among all BMI categories. However, previous published data relating to changes in both domains observe a higher decrease of MEE for obese women compared with before pregnancy [18]. But we observed that obese women had the lower MEE for leisure and occupational activities, before and during pregnancy, compared to ideal or overweight women. Similarly, our study observed a less frequency of ‘Any moderate-vigorous Leisure Physical Activity’ among obese women compared with ideal BMI or overweight women. Although pre-pregnancy obesity has been associated with a reduction in sports and exercise during pregnancy compared to before pregnancy, [31,41] it has not previously been identified as a factor involved...
in the distribution of energy expenditure between domains. Before and during pregnancy LTPA and Occupational MEE categories, in obese women, were lower and the Household/caregiver domain was higher than in ideal or overweight women.

In general, changes in TMEE during pregnancy appear to be influenced by the activity domain with decreasing occupational and recreational activities, and constant domestic activities [23]. These findings demonstrate similar patterns to our results, although Clarke et al [23] explored longitudinal changes throughout pregnancy, whereas our study compared during 12 months prior to pregnancy and during the first half of pregnancy.

The recommended level of physical activity for an adult woman and for a healthy pregnant woman is ‘moderate’ [10,42,43]. However, no more than 21.9% of ideal, 15.7% of overweight and 11.0% of obese women performed ‘any recommendations’ during pregnancy. Ideal women who were working before and during pregnancy were more compliant, compared with ideal women who have never worked or quit working during pregnancy. No data are available before this study to compare these results with others. However, some other studies pointed out a 15.8% in American women and 21.5% in Irish women who complied with ACOG recommendation during pregnancy [27,28].

In contraposition, sedentary activities measured as time spent per day watching television, increased for all BMI categories women during pregnancy when compared with before pregnancy. The obese women were the ones watching more than two hours of television daily. Others author estimated watching television as a considerable risk factor of excessive weight gain during pregnancy [40].

Several methodological considerations need to be taken into account in order to make an accurate interpretation of the results in this study. Regarding internal validity, our selection procedure and the low rate of non-response support the representativeness of our sample compared with our reference population (all healthy pregnant women from a defined geographical area). Secondly, weight data were self-reported retrospectively when information was not available in the maternal pregnancy document. Thirdly although recall bias derived for self-reported physical activity information cannot be ruled out, it should be present in a lower degree than that affecting other studies in which information was collected at the end of pregnancy or after delivery [10,44-46]. Furthermore, the questionnaire used to obtain information about LTPA has been validated in a Spanish adult population [47], as well as in Spanish pregnant women [48].

In conclusion, the decreased of Total Mean Energy Expenditure during pregnancy compared with before pregnancy is considerable for all BMI categories women. Some resilience is noted within ‘Transportation’ and ‘Household/caregiver’ domains, with the exception of ‘LTPA’ and ‘Occupational activity’, decreasing in all women respecting prior to pregnancy. This suggests that physical activity interventions could be effective among women planning pregnancies, and those in the early stages of pregnancy to avoid the decreasing domains and capitalize on the resilience.

Pregnancy is a recognized naturally occurring transition event when women are receptive to behavior change [49]. Therefore, motivating women from all BMI categories to be physically active when planning a pregnancy, in the early stages of pregnancy and throughout pregnancy, could potentially impact on longer term physical activity among women. The identification of activity domains in this study which are most like to be resilient to pregnancy, and those which are most likely to change provides useful information on activity type which would be prudent to include in interventions. In relation to occupational activity there may be limited effectiveness of interventions, as occupational status is potentially highly changeable among pregnant women, and particularly postnatal continuation of occupational activity intervention would be limited due to maternity leave. However, interventions incorporating LTPA (potentially in conjunction with occupational activity intervention) and transportation on foot, and television reduction counselling could help to increase the proportion of moderate intensity activity, decrease sedentary activity domains, and assist women in meeting activity recommendations. Further exploration of acceptable forms of LTPA and occupational activity domains with women planning a pregnancy, during pregnancy, and after pregnancy would also be prudent to ensure the components of any intervention are acceptable to women (of all BMI groups).

**References**


### Table 4: Sedentary lifestyle measure by time spent in television watching (hours/day) by pre-pregnancy BMI.

<table>
<thead>
<tr>
<th>Time/day</th>
<th>Frequency</th>
<th>1p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 hour</td>
<td>144 (18.25%)</td>
<td>p=0.001</td>
</tr>
<tr>
<td>1-2 hours</td>
<td>248 (31.43%)</td>
<td>p=0.001</td>
</tr>
<tr>
<td>≤ 2 hours</td>
<td>392 (49.68%)</td>
<td>p=0.001</td>
</tr>
<tr>
<td>2-3 hours</td>
<td>253 (32.07%)</td>
<td>p=0.001</td>
</tr>
<tr>
<td>&gt;2-3 hours</td>
<td>396 (50.38%)</td>
<td>p=0.001</td>
</tr>
<tr>
<td>&gt;3 hours</td>
<td>144 (18.25%)</td>
<td>p=0.001</td>
</tr>
</tbody>
</table>

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**Table 4** Sedentary lifestyle measure by time spent in television watching (hours/day) by pre-pregnancy BMI.


49. NICE public health guidance 6 ‘Behaviour change at population, community and individual levels’ National Institute for Health and Clinical Excellence.