Research Articles

Effect of energy expenditure on pregnancy outcome; A cohort study

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ABSTRACT

Objective:

To determine the trimester specific effect of energy expenditure on pregnancy outcome.

Study Design:

A population based prospective cohort study was carried out in two Medical Officer of Health areas in the Gampaha District from May 2001 to April 2002. Eight hundred and seventy five pregnant women were recruited on or before 16 weeks of gestation. Daily energy expenditure was assessed based on the activities resorted at home by housewives and both at home and at work by working mothers indicated in the three day activity record on two occasions during second (n=371) and third (n=271)trimesters. Information on potential confounding factors was gathered on average at 12th 28th and 36th weeks of gestation. There were no statistically significant difference between responders and non-responders in terms of socio-economic characteristics. Multiple logistic regression was applied and the results are expressed as odds ratios (OR) and 95% confidence intervals (95%CI).

Results:

Energy expenditure >2550 kcal/day during second trimester was a risk factor for maternal complications [OR 6.30; 95%CI: 1.8, 21.9]. During third trimester it was a protective factor [OR 0.29; 95%CI: 0.09, 0.96] for small for gestational age defined as <5 centile. Energy expenditure had no association with low birth weight or preterm birth either in second or third trimesters.

Conclusion:

High energy expenditure was a risk factor for maternal complications and a protective factor against the birth of a small for gestational age infant in uncomplicated pregnancies.

Key words:

Birth weight; energy expenditure; preeclampsia; preterm birth; small for gestational age

Introduction

Physical activity refers to any bodily movement produced by skeletal muscles that results in energy expenditure (1) which may be measured either in kilo calories or kilo joules.

As Laporte (2) describes there are more than 30 different methods used to evaluate physical activity. These have been grouped into seven broad categories, namely calorimetry, job classification, survey procedures, physiological markers, behavioral observation, mechanical and electronic monitoring and, dietary measures. The objective way of assessing physical activity is by measuring of energy expenditure. Energy expenditure however, occurs not only from physical activity but also from resting metabolism and the thermic effect of the food. Therefore total energy expenditure is a result of all the three components mentioned above (1). The determinants of energy expenditure with regard to each of the above categories however, are not similar (3).Survey procedures are the most practical way of assessing physical activity for large scale population studies. These may be grouped into four general types namely, Diary Surveys, Recall Surveys, Quantitative History Survey and General Surveys (2).

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The total amount of calories expended is arrived at by summing up the calories spent on each activity, which is based on previously estimated energy expenditure level and the time spent on each activity.

Several studies had investigated the effect of energy expenditure on pregnancy outcome. Magann (4) had reported that women with higher energy expenditure had significantly higher incidence of pregnancy induced hypertension and pre-term rupture of membranes. Schramm (5) had found that on comparison of very low birth weight (LBW) [< 1500g] with normal birth weight infants, exercise during each of the three trimesters had a significantly beneficial effect on the birth weight. Hatch (6) also reported that women with moderate exercise at 36 weeks gave birth to infants with a significantly higher mean birth weight than women with no exercise. Campbell (7) had reported that women who participated in structured exercise in low or high frequency during the third trimester, had a higher risk of delivering small for gestational age infants than those who participated in moderate frequency. However, Rabkin (8) had reported that energy expenditure in paid work and at home had no association with birth weight.

As described above, there are inconsistencies with regard to the influence of energy expenditure on pregnancy outcome. Further it has revealed that the effect of energy expenditure varies from trimester to trimester. Therefore the objective of the study was to determine the trimester specific effect of energy expenditure on pregnancy outcome.

MATERIALS AND METHODS

A population based prospective study was carried out in two Medical Officer of Health areas in the Gampaha District. The duration of the study extended from May 2001 to April 2002. All pregnant women eligible to participate in the study were recruited on or before 16 weeks of gestation and followed up until delivery. Exclusion criteria were age <15 years, rhesus negative blood group, pre-existing diabetes mellitus and hypertension, epilepsy, positive VDRL (Venereal Disease Research Laboratory) test and major psychiatric conditions.

The study instruments consisted of a questionnaire, which included four main components, namely 1) socio demographic and pregnancy related information and details related to occupation and environmental exposures, 2) Activity Record 3) Modified Life Events Inventory and 4) General Health Questionnaire-30. The latter two instruments were used to assess the psychosocial status of the mothers.

Duration of different postures adopted at home in terms of walking, sitting, standing and sleeping were inquired from all women irrespective of whether they were in paid employment or not. For working women the number of hours spent per day in each posture at the work place was considered in addition to what was adopted at home and standardized for the number of working days to determine the number of hours spent per day in each posture.

The Activity Record was designed to extract information on physical activities for calculation of energy expenditure. Women were asked to complete this on two occasions, during the 20^{th} week (2^{nd} trimester) and during the 32^{nd} (3^{rd} trimester) week of gestation. On each occasion the activity record had to be completed on three different days. For housewives it was two-week days and the Sunday of the same week and for working mothers it was two working days and one routine off day of the same week. The dates on which the women had to complete during the 20^{th} and the 32^{nd} weeks were given in writing and reminded at the clinic visit just prior to the specified date.

In the activity record, a day is divided into 96 periods, each consisting of duration of 15 minutes (9) where a woman is expected to record the physical activities (according to the coded list on different activities made available to her) carried out every 15 minutes. In the event of engaging in two or more different activities within a given 15 minute time period, the woman was instructed to record the activity on which more time was spent. These activities had to be assigned into the nine broad categories for the calculation of energy expenditure, which was based on the median energy cost of each broad activity group (9). In assigning the activities reported by women to one of the broad categories, consensus of opinion was sought and this was helpful in deriving a more accurate estimate of the energy expenditure. The energy cost for of all 96, 15-min periods were summed up to determine daily energy expenditure for each of the three days. Energy expenditure of the three days were then summed up and divided by three to determine the average daily energy expenditure which was used for the final analysis. A reliability study (9) of 61 subjects indicated that it was highly reproducible procedure ($r = 0.96$, $p < 0.01$).

Face and content validity of all the components of the questionnaires were ensured and pre-tests were carried out to determine the clarity of the questions. The first and the last two components of the ques-

tionnaire were administered at the time of recruitment to the study. The last two components and questionnaire related to employment and posture were administered at 28 weeks and 36 weeks in addition. Maternal weight and height, blood pressure and ultrasound scan measurements were carried out according to a standard protocol.

Four well-trained data collectors recruited to gather information under the supervision of the principal investigator. Each data collector was entrusted with eight to nine clinics, for which they were responsible for throughout the study. Each data collector maintained a register of all the relevant details necessary for the follow up of the pregnant women who were under their purview. The data collectors had to determine eligibility of the research participants to the study by scrutinizing the check list developed for that purpose at each antenatal clinic. Those who were eligible were detailed about the study and informed consent was obtained. The next clinic visit due for each woman was noted by the data collectors for follow up. When a recruited women failed to turn up for antenatal care on the due day, data collectors visited their home to gather the required information and to persuade them to continue attending clinics which are held regularly. Intention of migration to another area during the pregnancy or puerparium was also inquired from the women, in order to facilitate collection of outcome data.

Maternal complications was defined as presence of a diagnosis of pregnancy induced hypertension, gestational diabetes mellitus or ante partum hemorrhage during the third trimester. LBW was defined as infants with birth weight of less than 2500 g. Preterm birth (PTB) was defined as births that occurred at a gestational age of less than 37 completed weeks. All mothers were subjected to an ultrasound scan measurement before the 20^{th} week of gestation. Gestational age was determined based on the bi-parietal diameter. Gestational age based on the last menstrual period was considered for the analysis, if the expected date of delivery determined using the last menstrual period and the ultrasound scan measurement were within 7 days. If not, the gestational age based on the ultrasound scan measurement only was used. Customized computer-generated software program was used for the assessment of SGA (10). Gestational age, fetal sex, maternal weight at first antenatal clinic visit, height, ethnic group and parity were entered into the program, which calculated the centile of the birth weight of an individual infant (11,12). SGA was defined as birth weights < 10^{th} and <5^{th} centiles

Logistic Regression was applied and results were expressed as odds ratios (OR) and 95% confidence intervals (95% CI). Women with maternal complications were excluded for analysis on the effect of LBW, PTB, and SGA. Cutoff values with regard to hemoglobin level, height, weight and pre-pregnancy weight were determined by using Receiver Operator Characteristic curves to get a more accurate estimate of the association. Multivariate logistic regression was carried out to control for the confounding factors. Eligibility for including the variables into the regression model was based on both statistical basis (p-value < 0.25) as well as biological plausibility (13). It was ensured that the factors under study would remain in the model despite the probability level achieved during addition and deletion of other independent variables into the model. Variables were coded as 0 and 1 were entered into the model simultaneously and then removed one by one if it was ineligible. A two tailed probability of <0.05 was considered as significant. Interactions were tested and it was not statistically significant. No co-linearity between variables was observed. Cutoff value with regard to energy expenditure was determined by using Receiver Operator Characteristic curves to get a more accurate estimate of the association.

The Ethics Committee of the Faculty of Medicine, University of Kelaniya Sri Lanka, granted ethical approval to the study.

RESULTS

Activity record was offered to 875 women at the time of recruitment. Only 833 women were left to complete it at 20 weeks of gestation after the exclusion of 42 women who ended up in spontaneous abortions. Of that only 384 women completed it, which gave a non-response rate of 54%. It was offered to 694 women at the time of the second interview. Of them only 273 women completed it at 32 weeks of gestation, which gave a non response rate of 60.7%. The mean energy expenditure at 20 weeks and 32 weeks of gestation were 2358 (SD 496) kcal / day and 2525 (SD 458) kcal / day respectively.

Demographic and socio-economic characteristics were compared between the groups who completed and did not complete the activity record during the second and the third trimesters. There was no statistically significant difference between the two groups either in the second or third trimesters.

Energy expenditure and maternal complications

Of the 384 women who completed the activity record during the second trimester only 371 were available for analysis after excluding fetal deaths. Of them, 18 (4.8%) women had maternal complications. Of the 273 women who completed the activity record during the third trimester, only 271 were available for analysis after excluding of fetal deaths. Of them, nine women had maternal complications.

In the univariate analysis, energy expenditure in both second and third trimester was found to be significantly associated with maternal complications (Table 1). For the multivariate analysis for maternal complications 358 women were included in the final model. Hosmer and Lemeshow test for goodness of fit was observed to be satisfactory (p value 0.79). The number of events of maternal complications per variable was three. Adjusted OR for energy expenditure >2550 Kcal/day during 20^{th} weeks of gestation was 7.1 [95% CI: 1.9, 26.2] controlling for psychosocial stress, standing hours, body mass index (BMI) and low educational level (Table 2). Therefore, higher energy expenditure during second trimester is considered as a risk factor for maternal complications.

Energy expenditure and LBW

Of the 384 women who completed the activity record during the second trimester only 351 were available for the analysis after excluding those who ended up in fetal loss and maternal complications. Of them, 36 (10.2%) women delivered LBW infants. Of the 273 women who completed the activity record during the third trimester only 261 were available for analysis after excluding those who ended up in fetal loss and maternal complications. Of them, 26 (9.9%) women delivered LBW infants.

In the univariate analysis, energy expenditure during the third trimester was significantly associated with LBW, but not with energy expenditure during the second trimester (Table 3). When applying multivariate analysis, however energy expenditure was found to be unsuitable to be included in the final model.

Energy expenditure and PTB

Of the 384 women who completed the activity record during the second trimester, only 351 were available for analysis after excluding fetal loss and maternal complications. Of them, 36 (10.2%) women delivered PTB infants. Of the 273 women who completed the activity record during the second trimester only 262 were available for analysis after excluding fetal loss and maternal complications. Of them, 19 (7.2%) women delivered PTB babies. By univariate analysis, energy expenditure was not observed to be significantly associated with PTB either in the second or third trimester (Table 4).

Energy expenditure and SGA

Of the 384 women who completed the activity record during the second trimester, only 335 were available for analysis after excluding those who ended up in fetal loss and /or maternal complications. Of them, 50 (14.9%) and 26 (7.7%) women delivered SGA infants defined as $<10^{th}$ and $<5^{th}$ centiles respectively. Of the 273 women who completed the activity record during the third trimester only 253 were available for analysis after excluding those who ended up in fetal loss and maternal complications. Of them, 37 (14.6%) and 22 (8.6%) women delivered SGA infants defined as $<10^{th}$ and $<5^{th}$ centile respectively.

In the univariate analysis, energy expenditure >2550 Kcal/day in the second trimester was not found to be significantly associated with either SGA defined as $<10^{th}$ or $<5^{th}$ centile (Table 5and 6). Energy expenditure >2550 Kcal/day in the third trimester was significantly associated with SGA defined as $<5^{th}$ centile. For SGA defined as $<10^{th}$ centile the probability value for the association was 0.07. For the multivariate analysis, 231 women were included in the final model for SGA defined as $<5^{th}$ centile. Hosmer and Lemeshow test for goodness of fit was observed to be satisfactory (p value 0.74). The number of SGA events per variable was five. Adjusted OR for energy expenditure >2550 Kcal/day during the third trimester was 0.30 [95% CI: 0.09, 0.94] controlling for sleeping and walking hours and alcohol consumption (Table 7). The corresponding adjusted OR was 0.45 [95% CI: 0.20, 1.03] when SGA was defined as $<10^{th}$ centile. Therefore, higher energy expenditure during third trimester is considered as a protective factor for SGA infants.

DISCUSSION

The objective of the study was to determine trimester specific effect of energy expenditure on pregnancy outcome. The study revealed that energy expenditure >2550 kcal/day in the second trimester was a risk factor for maternal complications [OR 7.74; 95%CI: 1.74, 34.3] having controlled for confounding factors. However, energy expenditure in the third trimester had no significant association with maternal complications [OR 8.32; 95%CI: 0.75, 91.4]. For SGA defined as <5th centile, energy expenditure >2550 kcal/day during third trimester either in the univariate or the multivariate analysis. Energy expenditure >2550 kcal/day either in the second or the third trimester revealed no association with SGA defined as <10th centile, LBW or PTB.

Similar results were reported by Magann (4) according to which, women with higher energy expenditure (2501–2700 kcal /day) had a significantly higher incidence of pregnancy induced hypertension after adjusting for confounding factors, although the results were not statistically significant for antepartum hemorrhage. The median energy expenditure levels in this study tallies with the cutoff used by the present study (2550kcal/ day). However, in the present study all the maternal complications were pooled together as the number of women with maternal complications were small. The 95% CI of the OR derived for association between energy expenditure and maternal complications were wide and this may be due to the small sample size, which was as a result of high non-response rate of the study.

In the present study no association was observed between energy expenditure in the second or the third trimester and PTB even in the univariate analysis. However, Magaan (4) had reported that women in the higher energy expenditure group had a higher incidence of preterm rupture of membranes.

Hatch (6) reported that women with moderate exercise at 36 weeks gave birth to infants with a significantly higher mean birth weight of 117g [95% CI: 17, 217g] than women with no exercise. Those who engaged in heavy exercise throughout pregnancy too had an increase of 276g [95% CI: 54, 497 g] of adjusted mean birth weight. Similarly Schramm (5) also had reported that exercise during each trimester had a protective effect on normal birth weight when compared to very LBW. According to the study carried out by Hall (14) birth weight had been more favorable in the high exercise group than in the low exercise group. In the prospective study conducted by Rabkin (8) the effect of total energy expenditure and energy expenditure at work place and at home separately, on birth weight had been considered. The results revealed that energy expenditure had no association at all with the birth weight.

Growth retardation however, cannot be described by a single weight measure because; birth weight is dependant on two factors, namely duration of gestation and intrauterine growth rate. Further the use of the customised birth weight standards has been considered as a better means of discriminating retarded growth in comparison to other standards (15,16,17). SGA is a parameter which takes into accounts both, birth weight and gestational age. Campbell (7) had reported that those who participated in structured exercise 3 or 4 times a week had a lower risk of delivering SGA infants, defined as <15th centile after 33weeks of gestation, compared to the women who participated in structured exercise of less than 3 and more than 4 times a week. One possible reason is that women who are inactive are those with poor general health status than those who work moderately and as a result the latter group has a favourable pregnancy outcome. This hypothesis is favoured by the finding that women in the lower energy expenditure category had higher ante-partum hospital admissions (4). This may be a reflection of the concept that employed people are considered healthier than those in the general population. However this may be extended beyond working populations and applied in general and deduce that moderately active people are healthier than those who relatively inactive. Another explanation for the above observation may be based on the increase in maternal haem concentration through the release of catecholamines that takes place during exercise. This increase in haem levels is postulated to yield a net gain in fetal weight (18,19).

The results of the present study are consistent with the results of the other studies described, where moderate exercise / energy expenditure were found to have a protective effect on fetal outcome. The American College of Obstetricians and Gynecologists also advocate 30 minutes or more of moderate exercise a day on most days of the week for women who are free of medical and obstetric complications. However this should be implemented based on an evaluation of individual health status (20).

The daily energy expenditure was determined by using the activities indicated in the activity record. Completion of the activity record was carried out by individual woman either at home or at the work place depending on whether it was a mother engaged in paid employment or not. The study was heavily dependant on the corporation of the

individual subjects which in turn was dependant on the awareness of the woman, purpose of the study and the resultant motivation. Hens, it was not surprising that despite every step taken to minimize this, high non response rates were observed for the second (54%) and third (60%) trimesters. However, no significant difference was observed with regard to the demographic and socio economic characteristics between the respondents and non respondents.

The present study concludes that high energy expenditure has a favorable effect on SGA in uncomplicated pregnancies and an unfavorable effect on maternal complications during pregnancy.

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Table – 1 Unadjusted Odds Ratios for Energy Expenditure by Trimester and Maternal Complications

Energy Expenditure (Kcal)		MC Yes n (%)	MC No n (%)	OR	95% C.I.	P value
2nd trimester	>2550	13 (72)	97 (28)	6.86	2.38, 19.75	0.00
	≤2550	5 (28)	256 (72)			
3rd trimester	>2550	8 (89)	110 (42)	11.02	1.36, 89.24	0.02
	≤2550	1 (11)	152 (58)			

MC: Maternal Complications; OR: Odds Ratio; 95%CI: 95% Confidence Interval

Table - 2 Adjusted Odds Ratios for Maternal Complications

Exposure variable	b	SE	OR	95%CI	P value
Energy expenditure >2550 Kcal/day during 20th weeks of gestation	1.96	0.67	7.10	1.91, 26.2	0.003
GHQ Score >5 during 2nd trimester	1.65	0.62	5.21	1.54, 17.6	0.008
Standing >2.5 hours / day during 1st or 2nd or both trimesters	-1.68	0.72	0.19	0.05, 076	0.02
BMI > 26.0 kg/m^2	1.11	0.68	3.02	0.80, 11.5	0.10
Education ≤ 5grade	2.67	0.95	14.5	2.25, 93.1	0.005

b: co-efficient; SE: Standard Error; OR: Odds Ratio; 95% CI: 95% Confidence Interval;

Table – 3 Unadjusted Odds Ratios for Energy Expenditure by Trimester and LBW

Energy Expenditure (Kcal)		LBW Yes n (%)	LBW No n (%)	OR	95% CI	P value
2nd trimester	>2550	7 (20)	90 (29)	0.62	0.26, 1.48	0.28
	≤2550	28 (80)	225 (71)			
3rd trimester	>2550	1 (4)	107 (45)	0.05	0.006, 0.36	0.003
	≤2550	24 (96)	128 (55)			

LBW: Low Birth Weight; OR: Odds Ratio; 95%CI: 95% Confidence Interval

Table – 4 Unadjusted Odds Ratios for Energy Expenditure by Trimester and PTB

Energy Expenditure (Kcal)		PTB Yes n (%)	PTB No n (%)	OR	95% CI	P value
2nd trimester	>2550	11 (31)	85 (27)	1.18	0.55, 2.51	0.65
	≤2550	25 (69)	229 (73)			
3rd trimester	>2550	7 (37)	102 (42)	0.80	0.30, 2.10	0.65
	≤2550	12 (63)	140 (58)			

PTB: Preterm Birth; OR: Odds Ratio; 95%CI: 95% Confidence Interval

Table – 5 Unadjusted Odds Ratios for Energy Expenditure by Trimester and SGA < 10th Centile

Energy Expenditure (Kcal)		SGA < 10th centile Yes n (%)	SGA < 10th centile No n (%)	OR	95% CI	P value
2nd trimester	>2550	12 (24.5)	79 (30)	0.84	0.42, 1.70	0.63
	≤2550	37 (75.5)	206 (70)			
3rd trimester	>2550	10 (30)	95 (44)	0.49	0.22, 1.06	0.07
	≤2550	26 (70)	121 (56)			

SGA: Small for Gestational Age; OR: Odds Ratio, 95%CI: 95% Confidence Interval

Table – 6 Unadjusted Odds Ratios for Energy Expenditure by Trimester and SGA < 5th Centile

Energy Expenditure (Kcal)		SGA < 5th Centile Yes n (%)	SGA < 5th Centile No n (%)	OR	95% CI	P value
2nd trimester	>2550	5 (19)	86 (28)	0.62	0.23, 1.69	0.35
	≤2550	21 (81)	223 (72)			
3rd trimester	>2550	4 (18)	101 (44)	0.29	0.10, 0.87	0.03
	≤2550	18 (82)	130 (56)			

SGA: Small for Gestational Age; OR: Odds Ratio, 95%CI: 95% Confidence Interval

Table – 7 Adjusted Odds Ratios for SGA < 5th centile

Exposure variable	b	SE	OR	95%CI	P value
Energy expenditure >2550 Kcal/day during 32nd weeks of gestation	-1.21	0.58	0.30	0.09, 0.94	0.04
Sleeping ≤ 8 hrs / day during 2nd or 3rd or both trimesters	1.27	0.52	3.55	1.28, 9.85	0.02
Walking >2.5 hours / day during 3rd trimester	-0.97	0.66	0.14	0.10, 1.37	0.14
Alcohol consumption during 3rd trimester Yes	2.59	1.48	13.4	0.73, 246.0	0.08

β: co-efficient; SE: Standard Error; OR: Odds Ratio; 95% CI: 95% Confidence Interval; Prob: Probability