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Activity pattern and energy expenditure due to physical activity before and during pregnancy in healthy Swedish women

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Human pregnancy is associated with increased requirements for dietary energy and this increase may be partly offset by reductions in physical activity during gestation. Studies in well-nourished women have shown that the physical activity level (PAL), obtained as the total energy expenditure (TEE) divided by the BMR, decreases in late pregnancy. However, it is not known if this decrease is really caused by reductions in physical activity or if it is the result of decreases in energy expenditure/BMR (the so-called metabolic equivalent, MET) for many activities in late pregnancy. In the present study activity pattern, TEE and BMR were assessed in twenty-three healthy Swedish women before pregnancy as well as in gestational weeks 14 and 32. Activity pattern was assessed using a questionnaire and heart rate recording. TEE was assessed using the doubly labelled water method and BMR was measured by means of indirect calorimetry. When compared to the pre-pregnant value, there was little change in the PAL in gestational week 14 but it was significantly reduced in gestational week 32. Results obtained by means of the questionnaire and by heart rate recording showed that the activity pattern was largely unaffected by pregnancy. The findings support the following conclusion: in a population of well-nourished women where the activity pattern is maintained during pregnancy, the increase in BMR represents approximately the main part of the pregnancy-induced increase in TEE, at least until gestational week 32.

Activity pattern: Doubly labelled water: Physical activity level: Pregnancy

Requirements for dietary energy are increased during human pregnancy due to the energy costs associated with synthesis and maintenance of new tissue. These costs may to some extent be offset by reductions in physical activity, i.e. if the energy expenditure due to physical activity of a woman is lower during pregnancy than it was before conception. A reduction in physical activity can be achieved by selecting less demanding activities or by decreasing the speed at which activities are performed. Recent recommendations (Food and Agriculture Organization, 2004) regarding human energy requirements do not assume that reductions in physical activity generally represent an important way to cover the energy costs of pregnancy. However, it is recognized that such reductions may be potentially important when women are to achieve energy balance during pregnancy, and a previous recommendation proposed that the energy costs of pregnancy could be partly offset by reductions in physical activity (World Health Organization, 1985). The real-life situations in which such reductions may have an impact on the energy needs of pregnant women are, however, not well defined.

The energy expenditure due to physical activity under normal life conditions can be assessed as the total energy expenditure (TEE) measured by means of the doubly labelled water method minus the basal metabolic rate (BMR) measured using indirect calorimetry. These estimates can also be used to calculate activity energy expenditure in MJ/24 h and physical activity level (PAL) as TEE/BMR. Available studies in well-nourished women have shown decreases in PAL during late pregnancy (Goldberg *et al.* 1991, 1993; Forsum *et al.* 1992; Kopp-Hoolihan *et al.* 1999; Butte *et al.* 2004), while in mid-pregnancy decreases (Forsum *et al.* 1992; Kopp-Hoolihan *et al.* 1999; Butte *et al.* 2004) as well as increases (Goldberg *et al.* 1993) in PAL have been reported. The finding of a decreased PAL value in late pregnancy can be reconciled with the finding that the so-called metabolic equivalent (MET) of many activities decreases in late pregnancy (Prentice *et al.* 1996). The reason for such a decrease in the MET value, which is the ratio between the energy expenditure of a subject performing a specific activity and the BMR of the subject, is that when compared to corresponding figures in the non-pregnant state, the BMR of a woman in late pregnancy increases more than her energy expenditure when performing specific activities (Prentice *et al.* 1996). However, it is also possible that a decrease in PAL during late pregnancy is caused by a changed activity pattern where less demanding activities are selected and/or where the speed at which these activities are performed is decreased. Finally, the increased body weight during pregnancy will tend to increase the energy cost of performing different activities, a fact that may influence the effect of pregnancy on activity energy expenditure and PAL. To gain knowledge in this area studies in different populations of women are needed. These studies should preferably be carried out in the same women before and during pregnancy and record the pattern of physical activity, i.e. the duration

Abbreviations: MET, metabolic equivalent; PAL, physical activity level; TEE, total energy expenditure; TEE-BMR, TEE minus BMR.

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and intensity of all activities performed, with simultaneous measurements of TEE and BMR. The aim of the present study was to carry out such an investigation in one population.

Material and methods

Subjects

Twenty-three healthy, non-smoking women planning pregnancy were recruited through the health care system, or by advertising in the local press. The women were employed in the areas of office work, childcare and nursing, and fourteen of the twenty-three women reported that they exercised regularly (i.e. running, swimming, aerobics etc.). The women conceived 148 ± 142 d after the first day of the pre-pregnant measurement period and gestational age was estimated on the basis of an ultrasound measurement (Jörgensen, 1997) performed in gestational weeks 12–14. All but three of the women remained occupationally active until gestational week 34. Each woman's body weight was recorded in the delivery room prior to childbirth. All women delivered healthy full-term babies. The study was approved by the ethics committee at the University of Linköping.

Protocol

The women were studied before conception and in gestational weeks 14 and 32. The following procedure was repeated on each occasion. In the morning following an overnight fast the woman came to the hospital by car. She rested for 45 min and then her BMR was measured. Later the same morning she performed six standardised activities (lying, sitting, slow walking, brisk walking, slow jogging and quick jogging), each for 5 min, while wearing a heart rate recorder. A metronome was used to set the speed of the activities as follows: slow walking 58, brisk walking 98, slow jogging 118 and quick jogging 130 (beats/min). The six activities were assigned the following MET values (Ainsworth *et al.* 1993): lying (0·9), sitting (1·5), slow walking (2·5), brisk walking (4·0), slow jogging (4·5) and quick jogging (7·0). Linear relationships between recorded heart rate and these MET values were established on each measurement occasion for each subject. Before leaving the hospital the subject was given a dose of doubly labelled water and asked to collect urine samples during the following 14 d for measurement of TEE. The subject was requested to wear the heart rate recorder as much as possible when awake during the first 7 d of this period. She was also asked to use a notebook in order to record any period of time when the heart rate recorder was taken off, and she was instructed to indicate the kind of activity performed during this time (i.e. sleeping, showering). Satisfactory heart rate registrations were obtained for twelve of the twenty-three subjects before pregnancy as well as in gestational weeks 14 and 32. In the following, these twelve subjects will be referred to as the heart rate recording subgroup, while the twenty-three women will be designated as the entire study group. At the end of the 14 d period the subject returned to deliver the urine samples, the heart rate recorder and the notebook. On this occasion she was interviewed by means of a questionnaire regarding her physical activity during the preceding 14 d period.

BMR

CO_2 production and O_2 consumption were measured during a 20 min period using a ventilated hood system (Deltatrac Metabolic Monitor; Datex Instrumentarium Corp., Helsinki, Finland). BMR was calculated according to de Weir (1949).

Doubly labelled water method

Each subject was given an accurately weighed oral dose of stable isotopes (0·05 g ^2H_2O and 0·15 g $H_2{}^{18}O$ per kg body weight) after collection of two or three background urine samples during a 2–7 d period before dosing. Another five urine samples were collected 1, 4, 8, 11 and 15 d after the day of dosing. Isotopic enrichments of dose and urine samples were analysed using an isotopic ratio mass spectrometer fitted with a $CO_2/H_2/H_2O$ equilibrium device (Deltaplus XL; Thermoquest, Bremen, Germany). Further details of the procedure have been published elsewhere (Thielecke & Noack, 1997; Lof *et al.* 2003). Isotope dilution spaces (N_D and N_O) were calculated from zero-time enrichments obtained from the exponential isotope disappearance curves that provided estimates for the rate constants, k_D and k_O, for ^2H and ^{18}O (Coward, 1988), respectively. N_D/N_O for our twenty-three subjects was 1·037 (SD 0·008), 1·030 (SD 0·008) and 1·027 (SD 0·008) before pregnancy and in gestational weeks 14 and 32, respectively. Total body water was the average of N_D/1·04 and N_O/1·01. CO_2 production was calculated as described by Coward (1988) with N_D and N_O as the distribution spaces matching their respective rate constants for isotopic disappearance and assuming 30 % of water losses to be fractionated. To obtain TEE from CO_2 production, the food quotient was assumed to be 0·85 (Black *et al.* 1986).

Body weight and body fat

Body weight without clothes was recorded before breakfast using the scale KCC150 (Mettler-Toledo, Albstadt, Germany). Total body fat was estimated using the values for total body water obtained by means of the doubly labelled water method. Fat-free mass was calculated as total body water divided by 0·718 (Lof & Forsum, 2004). Total body fat was calculated as body weight minus fat-free mass. In the delivery room, body weight was recorded on an electronic column scale (SECA; Vogel & Halke, Hamburg, Germany).

Assessment of activity pattern using heart rate recording

A heart rate recorder (Polar Vantage NV; Polar Sverige AB, Stockholm, Sweden), consisting of a chest belt and a receiver worn around the wrist, was used. Recorded heart rate was transferred to a computer. Satisfactory readings were obtained for 6 and 7 d for two and ten subjects, respectively, before pregnancy, for 5, 6 and 7 d for two, one and nine subjects, respectively, in gestational week 14, and for 6 and 7 d for four and eight subjects, respectively, in gestational week 32. For 222 of these 241 d more than 80 % of all time in the waking state was recorded. In a few cases days were included where only 50–60 % of all time in the waking state was recorded. The recordings obtained during these 241 d were used to assess activity pattern and covered 95·0 (SD 2·3) %, 95·6 (SD 2·7) % and 94·2 (SD 3·6) % (n 12) of all time in the waking state during these days before conception and in gestational weeks 14 and 32, respectively. The MET value corresponding to a particular heart rate was obtained, for each subject and measurement occasion, using the relationship between MET values and heart rate established as described earlier. The MET values thus obtained were classified according to the six activity categories given above using the following intervals of MET values: lying (MET $\leq$ 1·20), sitting (1·20 $<$ MET $\leq$ 2·00), slow walking (2·00 $<$ MET $\leq$ 3·25), brisk walking (3·25 $<$ MET $\leq$ 4·25), slow jogging (4·25 $<$ MET $\leq$ 5·75) and quick jogging (MET $>$ 5·75). These intervals were determined as the average of assigned MET values for two subsequent activities; for example, for sitting the lower value of the interval, 1·2, is the average of the MET values for lying (0·9) and for sitting (1·5), while the higher value of the interval, 2·0, is the average of the MET values for sitting (1·5) and for slow walking (2·5). The number of minutes spent in each of the six different categories during the days when satisfactory recordings of heart rate were obtained was then calculated for each subject. The number of minutes spent sleeping was obtained from the notebook kept by the subject. The total number of minutes spent in each of the seven categories was calculated and divided by the number of days with satisfactory recordings of heart rate to express results per 24 h. The slope (k), intercept (m) and correlation coefficient (r) of the linear relationships between MET value (x) and heart rate (y), as obtained during calibration, were k 13·28 (SD 2·78), m 60·01 (SD 9·32) and r 0·940 (SD 0·026) (n 12) before conception, k 11·08 (SD 2·48), m 70·34 (SD 10·30) and r 0·924 (SD 0·049) (n 12) in gestational week 14 and k 9·80 (SD 2·84), m 80·61 (SD 14·22) and r 0·909 (SD 0·038) (n 12) in gestational week 32.

Assessment of activity pattern by means of a questionnaire

Guided by a researcher the subject's activity pattern during the preceding 14 d period was assessed by means of a questionnaire (Lof *et al.* 2003). The session, which lasted for 20–30 min, started with a discussion of the subject's activity during the 14 d period, and four to eight categories of time were identified that were appropriate for the particular subject. Examples of these categories were: time in bed, time at work, time at home, weekdays, weekend days, etc. The researcher checked that every hour during the 14 d period was covered by such a category and that no hour was represented more than once. The subject was then asked to estimate how her time in each of the categories was divided among the following six different kinds of activities: sleeping, very light activity (e.g. office work), light activity (e.g. washing up), moderate activity (e.g. vacuum cleaning or walking at a normal pace), vigorous activity (e.g. cycling or cleaning windows) and very vigorous activity (e.g. aerobics or running). The researcher recorded the information given by the subject on a questionnaire form. The total number of hours spent in each of the six activity categories during the 14 d period was then calculated and expressed as minutes per 24 h.

Weighted metabolic equivalent values

Weighted MET values were calculated in the following way. Using data obtained by means of the heart rate recorder: (number of minutes spent sleeping $\times$ 0·9 + number of minutes with MET $\leq$ 1·20 $\times$ 0·9 + number of minutes with 1·20 $<$ MET $\leq$ 2·00 $\times$ 1·5 + number of minutes with 2·00 $<$ MET $\leq$ 3·25 $\times$ 2·5 + number of minutes with 3·25 $<$ MET $\leq$ 4·25 $\times$ 4·0 + number of minutes with 4·25 $<$ MET $\leq$ 5·75 $\times$ 4·5 + number of minutes with MET $>$ 5·75 $\times$ 7·0 + number of minutes not recorded times 1·4) divided by 60 $\times$ 24 $\times$ N where N represents the number of days with satisfactory recordings of heart rate. Using data obtained by means of the questionnaire: (number of hours spent sleeping $\times$ 0·9 + number of hours spent in very light activity $\times$ 1·4 + number of hours spent in light activities $\times$ 2·4 + number of hours spent in moderate activities $\times$ 3·0 + number of hours spent in vigorous activities $\times$ 4·5 + number of hours spent in very vigorous activities $\times$ 8·0) divided by 336 (representing 24 h during 14 d).

Statistics

Values are given as means and standard deviations. Significant differences between averages were identified by *t*-test for paired observations or by repeated ANOVA with subsequent *post hoc* analysis using Tukey's multiple comparison test (Hassard, 1991). Linear regression was performed as described by Hassard (1991). Significance was accepted at the $P<0·05$ level. All statistical analyses were carried out using Statistica software, version 6.0 (StatSoft, Scandinavia AB, Uppsala, Sweden).

Results

Subjects

The characteristics of the subjects in the study are presented in Table 1 while their body weight and body composition before and during pregnancy are given in Table 2. The women varied considerably with respect to the following variables before pregnancy: body weight, BMI and percentage of total body fat. During pregnancy, there was a wide range of weight gain from 7·9 to 29·1 kg. The subjects in the heart rate recording subgroup were very similar to those in the entire study group with respect to age, body weight, height, BMI, fat-free mass and percentage of total body fat before pregnancy, and regarding gestational gains in weight, fat-free mass and

Table 1. Characteristics of subjects in the entire study group and in the heart rate recording subgroup

(Mean values and standard deviations)

	Entire study group (n 23)		Heart rate recording subgroup (n 12)	
	Mean	SD	Mean	SD
Age† (years)	30	4	29	3
Height† (m)	1·67	0·07	1·67	0·07
BMI† (kg/m^2)	24·2	4·8	23·5	3·9
Total body fat† (%)	32·7	7·8	31·1	6·6
Weight gain during pregnancy (kg)	18·1	6·6	18·5	6·6
Birth weight of baby (g)	3740	510	3760	530
Length of gestation (d)	280	10	282	9

†At the measurement occasion before pregnancy.

Table 2. Body weight and body composition of subjects in the entire study group and in the heart rate recording subgroup before and during pregnancy

(Mean values and standard deviations)

	Before pregnancy		In gestational week 14		In gestational week 32	
	Mean	SD	Mean	SD	Mean	SD
Entire study group (*n* 23)						
Body weight (kg)	67·2	12·0	69·7*	12·6	79·1*	13·0
Fat-free mass (kg)	44·7	5·5	45·7	6·0	52·2*	5·9
Total body fat (kg)	22·6	8·9	24·0	8·9	27·0*	9·5
Heart rate recording subgroup (*n* 12)						
Body weight (kg)	65·8	11·6	67·9	11·4	77·7*	11·7
Fat-free mass (kg)	44·9	5·9	46·2	6·2	52·3*	6·2
Total body fat (kg)	20·9	7·7	21·7	6·9	25·4*	8·2

Mean values were significantly different from the corresponding values obtained before pregnancy: $^{*}P < 0{\cdot}001$.

total body fat as well as length of gestation and infant birth weight.

Energy metabolism

Table 3 shows BMR, TEE, PAL and TEE minus BMR (TEE-BMR) of the entire study group before pregnancy and in gestational weeks 14 and 32. All these variables were similar in gestational week 14 as compared to corresponding values obtained before pregnancy. The 95 % CI for the slight decrease in TEE-BMR as observed in the complete study group was −354 to +636 kJ/24 h. In gestational week 32 BMR and TEE had increased significantly, by 1420 kJ/24 h and 1250 kJ/24 h, respectively, while PAL had decreased significantly, by 0·23 units, as compared to corresponding pre-pregnant values. Furthermore, at this stage of pregnancy TEE-BMR was lower (170 kJ/24 h, the 95 % CI being −331 to +681 kJ/24 h) than before pregnancy, but this decrease was not significant. However, when expressed per kg of body weight, this decrease was significant (Table 3). Table 3 also shows BMR, TEE, PAL and TEE-BMR before pregnancy and in gestational weeks 14 and 32 for the heart rate recording subgroup. All the estimates obtained in this subgroup were very similar to those obtained in the entire study group before pregnancy as well as in gestational weeks 14 and 32.

Activity pattern before pregnancy and in gestational weeks 14 and 32

The number of minutes per 24 h spent in each of the six activity categories as assessed using the questionnaire before pregnancy and in gestational weeks 14 and 32 is shown in Table 4 for the entire study group. The corresponding weighted MET values are shown in Table 5. As indicated in Table 4, the activity pattern for these subjects as assessed by means of the questionnaire was affected very little by pregnancy, although the data indicate that, when pregnant, subjects spent slightly less time in physically demanding activities and slightly more time in less demanding activities. The average weighted MET value decreased from 1·80 before pregnancy to 1·72 in gestational week 14 and to 1·65 in gestational week 32 (Table 5). However, these decreases were not

Table 3. BMR, total energy expenditure (TEE), physical activity level (PAL) and TEE minus BMR (TEE-BMR) before pregnancy and in gestational weeks 14 and 32 for the entire study group (*n* 23) and for the heart rate recording subgroup (*n* 12)

(Mean values and standard deviations)

	Before conception				In gestational week 14				In gestational week 32			
	(*n* 23)		(*n* 12)		(*n* 23)		(*n* 12)		(*n* 23)		(*n* 12)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BMR (kJ/24 h)	5430	640	5500	620	5580	630	5560	620	6850**	970	6830**	680
TEE (kJ/24 h)	10 510	1500	10 850	1850	10 520	1380	10 980	1340	11 760**	1670	12 110*	1590
PAL (TEE/BMR)	1·95	0·24	1·97	0·26	1·89	0·20	1·98	0·17	1·72**	0·17	1·78*	0·20
TEE-BMR (kJ/24 h)	5080	1270	5350	1560	4940	1070	5420	970	4910	1170	5280	1350
TEE-BMR (kJ/24 h per body wt)	77·1	20·3	82·3	23·3	72·2	16·8	80·9	14·9	63·1**	15·9	68·6*	17·0

Mean values were significantly different from the corresponding values obtained before pregnancy: $^{*}P < 0{\cdot}05$, $^{**}P < 0{\cdot}001$.

Table 4. Amount of time (number of minutes per 24 h) spent in different activity categories as assessed by means of the questionnaire in the entire study group (*n* 23) and in the heart rate recording subgroup (*n* 12)

(Mean values and standard deviations)

	Before pregnancy		In gestational week 14		In gestational week 32	
Activity category	Mean	SD	Mean	SD	Mean	SD
Entire study group (*n* 23)						
Sleep	458	61	503*	77	472	69
Very light	446	250	447	198	491	191
Light	300	219	296	173	320	168
Moderate	187	178	149	131	142	118
Vigorous	41	47	43	63	14	23
Very vigorous	8	14	2	5	0*	2
Heart rate recording subgroup (*n* 12)						
Sleep	452	52	501	62	480	54
Very light	459	208	444	203	501	191
Light	295	173	319	173	311	184
Moderate	166	164	117	79	126	115
Vigorous	59	54	55	77	21	27
Very vigorous	9	19	5	7	1	2

Mean values were significantly different from the corresponding values obtained before pregnancy: $^*P < 0.05$.

Table 5. Weighted metabolic equivalent values before pregnancy and in gestational weeks 14 and 32 as assessed by means of the questionnaire for the entire study group (*n* 23) and the questionnaire as well as heart rate recording in the heart rate recording subgroup (*n* 12)

(Mean values and standard deviations)

	Before pregnancy		In gestational week 14		In gestational week 32	
	Mean	SD	Mean	SD	Mean	SD
Questionnaire (*n* 23)	1·80	0·28	1·72	0·25	1·65	0·19
Questionnaire (*n* 12)	1·74	0·21	1·75	0·28	1·64	0·18
Heart rate recording (*n* 12)	1·67	0·21	1·68	0·26	1·63	0·20

Table 6. Amount of time (number of minutes per 24 h) spent in different activity categories as assessed by means of heart rate recording in the heart rate recording subgroup (*n* 12)

(Mean values and standard deviations)

	Before pregnancy		In gestational week 14		In gestational week 32	
Activity category	Mean	SD	Mean	SD	Mean	SD
Sleeping	535	46	559	76	570	65
Lying	236	130	231	125	131*	90
Sitting	204	52	224	88	225	77
Slow walking	234	81	224	88	311*	93
Brisk walking	89	51	96	45	92	40
Slow jogging	44	21	50	40	31	16
Quick jogging	23	15	24	20	5*	4

Mean values were significantly different from the corresponding values obtained before pregnancy and in gestational week 14: $^*P < 0.05$.

significant. The corresponding results for the heart rate recording subgroup obtained by means of the questionnaire are also shown in Tables 4 and 5. The present results are very similar to those observed for the entire study group. Furthermore, Table 6 shows the number of minutes per 24 h in each of the seven activity categories, as assessed using the heart rate recorder, before pregnancy and in gestational weeks 14 and 32 for the subjects in the heart rate recording subgroup. The corresponding weighted MET values are shown in Table 5. Also these data show that the activity pattern of these subjects remained relatively unaffected by pregnancy, while the average weighted MET values were slightly but non-significantly decreased in gestational week 32.

Discussion

The women in the present study were not randomly selected. They volunteered to participate 'in a study of diet and physical activity during pregnancy'. They may therefore not be typical of all Swedish pre-pregnant women. It is likely that the physical activity of our women was relatively high before pregnancy, since more than half reported that they exercised regularly and their average PAL was 8 % higher than the corresponding value of 136 non-pregnant women with the same age range as those in our present study (Food and Nutrition Board and Institute of Medicine, 2002). On the other hand, 26 % and 9 % of the women in the present study had a BMI above 25 and 30, respectively, before conception. These figures are in good agreement with recent estimates in Swedish women of similar age (National Board of Health and Welfare, 2002) as well as in comparable women from several other Western countries (International Obesity Task Force, 2004). The average weight gain during pregnancy for our subjects was somewhat higher than recommended by the Institute of Medicine (1990). However, earlier studies suggest that Swedish women tend to gain slightly more weight during pregnancy as compared to other Western women (Sohlstrom & Forsum, 1995; Prentice *et al.* 1996). The average PAL value obtained before conception in our women was similar to values obtained in earlier studies in Swedish (Forsum *et al.* 1992) and American (Butte *et al.* 2003) women of reproductive age. Thus, in several respects our women appear to be representative of Swedish women of child-bearing age and they certainly do not differ greatly from many women of child-bearing age in other Western countries.

In the present study TEE-BMR has been considered as 'energy expenditure in response to physical activity'. It should be noted, however, that so-called dietary-induced thermogenesis is also included in this estimate. This component of energy metabolism is generally considered to be small (about 5–10 % of TEE). On the basis of a review of relevant studies in the area, Prentice *et al.* (1996) concluded that dietary-induced thermogenesis is likely to remain essentially unaltered during pregnancy.

In the present study, activity pattern was defined as the number of minutes per 24 h spent in each of six or seven activity categories measured in two different ways. According to this definition, two women who have spent an equal number of minutes per 24 h in each of the defined categories will be considered to have the same activity pattern. It is therefore crucial that all the time in the study period is covered, and that the duration of the activities is correctly reported and their intensity correctly classified. The questionnaire may provide incorrect results since it is based on the subject's own report regarding her physical activity. This reporting may be influenced by factors such as a poor memory, attitudes towards physical activity or difficulties when assigning an appropriate MET value to a specific activity. On the other hand, an advantage in using the questionnaire is that all the time comprising the study period is covered. With respect to the heart rate recording method, a source of error is that it is very difficult to obtain recordings for all the time in the waking state because the device is rather easily interrupted (e.g. by electronic equipment) and also because the heart rate recorder is fairly technically advanced and may therefore be difficult to handle. However, the subject is unable to influence the recordings obtained by this method and it therefore represents a more objective assessment of her activity pattern. This is true regarding both the amount of time spent in the different activity categories and the intensity of the different activities performed. Thus, although neither of the two methods can be considered as a perfect way of assessing activity pattern, they do complement one another. In this context it may also be important to point out that except for sleeping, the defined activity categories were not identical in the two methods. Therefore, the number of minutes spent in each activity category cannot be directly compared between the two methods.

In the present study we also calculated weighted MET values using information obtained by means of a questionnaire and heart rate recording. The purpose was to convert activity pattern, expressed in number of minutes spent in different activity categories during defined time periods, into an integrated estimate of physical activity. It is important to point out that during pregnancy the weighted MET values do not represent the true PAL values of our women, since the MET used were assessed in non-pregnant subjects (Ainsworth *et al.* 1993) and the MET values for different activities are influenced by pregnancy (Prentice *et al.* 1996). Nevertheless, a weighted MET value may be regarded as an estimate reflecting the duration as well as the intensity of the physical activity during a defined time period. It may also be argued that the weighted MET values obtained using heart rate recording may be inaccurate, since a MET value of 1·4 was used for time that was not recorded. However, as discussed earlier (Lof *et al.* 2003), we consider it unlikely that such time was spent in vigorous activities. Furthermore, the amount of unrecorded time was similar before pregnancy and in gestational weeks 14 and 32, and recalculation of the weighted MET values using only recorded time did not change the results in any important way for any of the measurements.

The linear relationships between MET values and heart rate demonstrate some interesting aspects regarding how pregnancy influences the effect of physical activity on heart rate as illustrated by the following example calculated from these relationships. When performing an activity with such a low MET factor as 1, the heart rate of a woman will be higher in gestational week 32 than before pregnancy by about 17 beats/min while, when performing an activity with a higher MET factor such as 6, the heart rate will be the same on the two occasions. In this context it is relevant to note that, as shown in Table 3, TEE-BMR per kg body weight was significantly lower in gestational week 32 than before pregnancy. Other relevant observations are those by Pivarnik *et al.* (2002) who reported that the O_2 consumption at a given heart rate is lower for pregnant than for non-pregnant women. Together these observations provide support for the suggestion that the efficiency of energy metabolism is increased during pregnancy.

In the present study we were unable to detect any major changes in activity pattern during pregnancy as compared with the measurement before conception. This finding appears very reasonable considering the everyday lives of our subjects. Almost 90 % of our women were still working at the time of the measurement in gestational week 32, and almost 50 % of them had small children at home. It is thus likely that their activity pattern in late pregnancy was the same as it was before conception. In this context it is of relevance to point out that the three subjects who were not occupationally active at the time of the measurement in gestational week 32 also maintained their activity pattern during pregnancy.

Our finding that the activity pattern of the subjects in the present study was affected very little, if at all, by pregnancy was obtained by means of two different methods that were largely independent of one another. Average weighted MET values based on data obtained with the two methods were also in agreement with this finding. It may, however, be argued that the results obtained using heart rate recording are not reliable since they were based on only twelve of the twenty-three subjects. Results for body fatness, body weight and PAL before pregnancy as well as weight gain during pregnancy were very similar in the heart rate recording subgroup and in the entire study group. Furthermore, activity pattern changes during pregnancy were very similar for these two groups. This supports our conclusion that the activity pattern of the subjects in the entire study group was affected very little by pregnancy.

When compared to the value before pregnancy, only small and non-significant decreases in TEE-BMR (kJ/24 h) were observed in the present study. Nevertheless, PAL in gestational week 32 was significantly lower than before pregnancy and the elevation in BMR represented roughly the increase in TEE at this stage of pregnancy. We thus propose that in a population of Western women such as those in the present study, a decrease in PAL may, at least until gestational week 32, be the result of physiological changes taking place during pregnancy rather than a result of a decrease in the intensity and/or duration of the different activities associated with normal life. In this context it is of interest to note that using available information regarding energy metabolism during pregnancy (Goldberg *et al.* 1991, 1993; Forsum *et al.* 1992; Kopp-Hoolihan *et al.* 1999), a recent expert consultation group (Food and Agriculture Organization, 2004) calculated the energy costs of pregnancy on the basis of the increase in TEE and found this figure to be very similar to the corresponding figure obtained when these costs were calculated on the basis of the increase in BMR, findings that apparently are in agreement with our present results. However, our study is the first to show that similar increases in BMR and TEE during pregnancy can occur in women with only small changes in their pattern of physical activity. This observation is relevant when estimating energy needs of pregnant women. It is important to point out, however, that human populations vary considerably with respect to their activity pattern. Therefore, additional studies are needed to elucidate completely the relationship between changes in physical activity and energy requirements during pregnancy.

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