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Validation of self-reported recreational exercise in pregnant women in the Norwegian Mother and Child Cohort Study

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Abstract

We compared self-reported frequency of recreational exercise and corresponding metabolic equivalent (MET)-minutes with physical activity measured with a position and motion sensor in pregnant women. One hundred twelve women in the Norwegian Mother and Child Cohort Study (MoBa) completed questions about weekly participation in recreational exercise by week 17 of pregnancy and participated in the validation study around week 20. Data from a validated motion sensor (ActiReg®) that measures physical activity and total energy expenditure (TEE), served as the "gold standard". Self-reported recreational exercise was compared with the following ActiReg-based measures: physical activity energy expenditure (PAEE), minutes of vigorous physical activity (VPA), physical activity level (PAL), and TEE. Pearson correlations between self-reported weekly exercise and the objectively assessed variables were: r_{PAEE}=0.26, r_{VPA}=0.32, r_{PAL}=0.30 (all $p<0.01$), and r_{TEE}=0.17 **(p=0.07).** The partial correlation coefficients between the questionnaire responses and the ActiReg® measurements were similar after adjusting for parity, body mass index, education, age, **height** and smoking, except r_{TEE} increased (r=0.**27**, $p<0.01$). We observed significant positive associations between self-reported exercise activities and motion sensor measurements of physical activity, indicating that the questions used for exercise assessment in MoBa may be useful for ranking pregnant women according to recreational exercise level.

Key words*:* recreational exercise, validation, motion sensor, pregnancy

Introduction

Physical activity is an important contributor to a healthy lifestyle in the general population as well as in pregnant women (Brooks et al., 2004). Historically, vigorous physical activity during pregnancy was discouraged due to concerns about adverse fetal and maternal outcome, and such concerns may still be common (Clarke & Gross, 2004). Recent studies have, however, found no adverse effects of regular exercise of moderate intensity during pregnancy (Gavard & Artal, 2008; Leiferman & Evenson, 2003), and regular exercise performed before and during pregnancy has been associated with reduced risk of gestational diabetes mellitus, preeclampsia, hyperlipidaemia and excessive fetal growth (Butler et al., 2004; Campbell & Mottola, 2001; Dempsey et al., 2004; Sorensen et al., 2003). Nonetheless, the safety and dose of exercise required to achieve specific health-related outcomes in pregnant women remain unclear.

Physical activity is a complex behaviour that is difficult to assess and quantify in epidemiological studies (Pols et al., 1998). Self-reports of physical activity are nonetheless widely used in epidemiological studies, in spite of limited accuracy (Sallis & Saelens, 2000). Self-reports interfere minimally with daily living and assess the four dimensions of physical activity: i.e. type, duration, frequency and intensity. In the Norwegian Mother and Child Cohort Study (MoBa), recreational exercise during pregnancy was ascertained as part of a general questionnaire in order to study its effect on birth and other outcomes. Recently, the associations between regular recreational exercise and preeclampsia, and correlates of regular exercise during pregnancy in MoBa have been reported (Magnus et al., 2008; Owe et al., 2008). Before this questionnaire is used in other studies of health outcomes, however, it would be useful to assess its validity, using an objective measure of physical activity.

The doubly labelled water (DLW) technique is the "gold standard" for precise quantification of physical activity levels and energy expenditure during daily living conditions. Motion sensors are much less expensive and yield results that correlate highly with those from DLW (Westerterp, 1999). Motion sensors have been shown to be an excellent objective technique for assessment of energy expenditure and physical activity both in pregnant and non-pregnant populations (Rousham et al., 2006; Westerterp, 2003). The main objective of this study was therefore to compare self-reported recreational exercise with objectively measured physical activity in pregnant women.

Materials and methods

Subjects and design

The Norwegian Mother and Child Cohort Study is an ongoing, long-term prospective cohort study that aims to include 110,000 pregnancies by the end of 2008. The objective of MoBa is to examine associations between preventable exposures and diseases (Magnus et al., 2006). The cohort database is linked to the Medical Birth Registry of Norway. Pregnant women are asked to participate through a postal invitation after they have signed up for the routine ultrasound examination in their local hospital. The women are asked to provide biological samples and to answer three questionnaires during pregnancy in gestational weeks 15-17 (Q1 and Q2) and 30 (Q3). Q1 and Q3 are general questionnaires covering health, exposures, participation in recreational exercise and other lifestyle and background factors, while Q2 is a food frequency questionnaire (FFQ).

As part of a validation study of the MoBa FFQ, a motion sensor assessment (ActiReg®) was used to provide an objective measure of energy expenditure over four days, and was used to evaluate the probable range of energy intakes (Brantsæter et al., 2008; Meltzer et al., 2008). To be eligible for the validation study, Q1 and Q2 had to be completed by gestational weeks 17-18; in addition, validation subjects had no hyperemesis or anorexia, and received routine ultrasound at the Bærum Hospital in Oslo in gestational weeks 17-18. The inclusion period lasted from 15 January 2003 to 1 February 2004.

Of ~800 MoBa participants who came to Bærum Hospital during the inclusion period, the exact number of invited women was not recorded, but 119 were included and 112 completed the motion sensor assessment. The study protocol was approved by the regional ethics committee of Southern Norway, and informed written consent was obtained from all participants.

Questions about recreational exercise in MoBa

The section of the questionnaire (Q1) addressing recreational exercise listed 14 different recreational exercises. The participants were asked to report how often they had engaged in the following activities since becoming pregnant: strolling, walking (brisk), running (jogging or orienteering), bicycling, fitness training in a training center, swimming, aerobic classes (low or high impact), prenatal aerobic classes, dancing, skiing, ball games, horse back riding, and other. The 5 response categories were: "never", "1-3 times per month", "once a week", "twice a week", and "≥ 3 times a week". To express uniformly as weekly frequency, these categories were recoded to 0, 0.25, 1, 2 and 3 times a week, respectively. The final version of

MoBa Q1did not collect information about time spent on each activity, but in a preliminary version 2,555 women reported the duration of each exercise performed. We used the median duration for these 2,555 women to impute the time spent on each exercise in the present study, with medians ranging from 20 minutes for bicycling to 90 minutes for skiing. The level of intensity for each exercise activity was expressed as metabolic equivalents (METs represent a multiple of resting metabolic rate) according to Ainsworth (Ainsworth et al., 2000). The following MET-scores were used: strolling, 2.5; brisk walking, 3.5; running/jogging/orienteering, 7; bicycling, 6; fitness training, 3.0; swimming, 5; low impact aerobic classes and prenatal aerobic classes, 5; high impact aerobic classes, 6.5; dancing, 4.5; skiing, 7; ball games, 4. None of the participants in this study reported horse back riding. The "other" activities reported were Pilates and strength training; these were assigned the same intensity as fitness training. For every individual, the number of minutes spent in each reported exercise was multiplied by its MET intensity and summed to estimate the total energy expenditure from exercise (total MET-minutes **per week**). **MET-minutes were computed because this measure also takes into account energy expenditure as an expression of the exercise intensity.**

The questionnaire also inquired about occupation and occupation-related activity like working position and heavy lifting, but this information was not sufficient to quantify physical activity during work hours. In Norway sick leave during pregnancy is frequent for women with physically demanding work, and only 5% of the participants reported heavy lifting at work. Consequently, the focus of the present study was recreational physical activity, including walking and cycling as transportation.

The first MoBa questionnaire provided information about smoking habits, marital status, age, parity, education, health status, weight and height. Body mass index (BMI, in kg/m^2) was computed using self-reported weight at time of the motion sensor assessment.

The ActiReg® Motion Sensor

The ActiReg® system (PreMed AS, Oslo, Norway) consists of two components, an activity monitor (ActiReg®) and a computer program (ActiCalc®) for processing the data (Hustvedt et al., 2004). The ActiReg® measures physical activity level based on recordings from two sensors attached by medical tape to the chest and front of the right thigh. The sensors are connected to a storage unit fixed to a waist belt and it is worn under clothing. Based on 60 recordings per minute of body movement and position, each minute is given an activity factor. **Given input on the subjects age, height, weight and resting energy expenditure (kJ/minute),** ActiCalc® estimates total energy expenditure by combining the activity factor of each minute with the energy cost of the body position (Hustvedt et al., 2004).

The ActiReg® has been validated against doubly labelled water (Arvidsson et al., 2006; Hustvedt et al., 2008). Furthermore, it has been used to validate physical activity questions and questionnaires in various population groups (Andersen et al., 2005; Kurtze et al., 2007; Kurtze et al., 2008; Matthiessen et al., 2008), but not in pregnant women.

Resting energy expenditure (REE) was estimated for each individual using the WHO equation based on self-reported weight, height and age [age <30: REE=(55.6 * weight in kg) + (1397.4 * height in m) and age 30+: REE=(36.4 * weight in kg) + (104.6 * height in m)] (World Health Organisation, 1985). An additional energy requirement due to pregnancy was not taken into account, but weight at the time of the motion sensor registration rather than pre-pregnant weight was used in the equation.

Physical activity energy expenditure ($PAEE_{AR}$) was computed as the difference between total energy expenditure (TEE_{AR}) and REE; physical activity level (PAL_{AR}) was calculated as the ratio of TEE_{AR}/REE; and vigorous physical activity (VPA_{AR}) was the time (in minutes) categorized as moderate to high by the ActiReg®. To be counted as a minute of VPA_{AR}, the intensity of activity had to correspond to 6 metabolic equivalents or more.

The 119 participants received detailed training from an instructor on use of the motion sensor. Three of the four days of activity monitoring had to be weekdays and one day had to be a Saturday or a Sunday. The ActiReg® was worn at all times except during water-based activities or at night while sleeping. During the night when sleeping, the instrument was on, but put aside with the sensors placed horizontally as this mimics the recording of lying still. If the instrument was not carried for a period of 15 min or more during daytime, the participants were instructed to record the type of activity during that time. The recorded activity and duration of non-wear time was used to impute MET-minutes times REE and added to the TEE. Seven women reported swimming, and the non-wear time was 45 minutes for 6 of these and 120 minutes for one person, of which 15 minutes were considered time for showering and getting dressed. However, VPA_{AR} could not be approximated and swimming was thus excluded from reported exercise activities for comparison with VPA_{AR}.

Statistical analysis

The characteristics of the sample and the distribution of variables were examined using descriptive statistics. Differences between groups were tested using an independent sample t-test for normally distributed data, and the Mann-Whitney U-test for non-normally distributed data. Correlations between ActiReg® measures and the **two measures based on the** questionnaire data **(sum of all weekly exercises and total MET-minutes per week from exercise)** were expressed as Pearson correlation coefficients and partial correlations. A square root transformation of the questionnaire derived variable ‘total MET-minutes’ was used to normalize the distribution. To account for potential confounding **we calculated partial Pearson** correlation coefficients adjusting for maternal age, **height,** BMI, parity, level of education and smoking. **The confounders were chosen on the basis of bivariate analyses and previous knowledge** (Owe et al., 2008). **In the multiple regression models used to obtain the partial correlation coefficients, age, height, and BMI were treated as continuous variables and parity, smoking, and education as dichotomous variables as defined in Table 1.**

The significance level was set at 5% (two tailed) and all analyses were performed using SPSS 14 (SPSS, Inc. Chicago, IL, USA).

Results

Of the 119 subjects included in the study, 112 completed four days of activity monitoring. Four women dropped out due to discomfort from the sensors and three did not wear the sensors as instructed.

The average interval between answering the MoBa questionnaire (range, 15-17 weeks of gestation) and monitoring in the validation study was 23 days (SD: 12 days, **range 1-59 days**). The study participants were on average 20 weeks pregnant at the time of the activity monitoring. The participants’ physical characteristics, lifestyle, and physical activity measures varied widely (Table 1). The participants reported on average 2 recreational exercise activities weekly apart from strolling. When strolling was included the activity increased by 1.5 times weekly. The most frequently reported activities were strolling (87%), brisk walking (65%), participation in aerobic or fitness class (36%), cycling (28%), and swimming (22%). The mean daily $PAEE_{AR}$ was 4,020 kJ, mean daily TEE_{AR} was 10,020 kJ, and the mean duration of VPA_{AR} was 20 min/d. The average PAL_{AR} was 1.66. $PAEE_{AR}$, PAL_{AR} and minutes of VPA_{AR} increased with the frequency of self-reported exercise activities (Table 2).

In nulliparous women, the frequency of recreational exercises and minutes of VPA_{AR} were 32% and 48% greater than in parous women (data not shown). Likewise, women with >12 years of education reported higher frequency of exercise activities (55%) and had higher $PAEE_{AR}$ (15%) than women with ≤12 years of education. The reported frequency of exercise activities was not associated with pregnancy smoking status, but women who were daily smokers prior to pregnancy had 15% lower $PAEE_{AR}$ and 34% lower VPA_{AR} than non-smokers. Age and BMI were negatively correlated with VPA_{AR} (r= -0.22, (CI: -0.34, -0.04) and r=-0.27, (CI: -0.43, -0.09), respectively). **Height and BMI were positively correlated with TEE_{AR} (r= 0.23, (CI: 0.04, 0.39) and r=0.34, (CI: 0.17, 0.49), respectively).**

The sum all self-reported recreational exercises correlated significantly with $PAEE_{AR}$, VPA_{AR}, and PAL_{AR}, but not with TEE_{AR} (Table 3). **The sum of weekly exercises correlated strongly with total MET-minutes (r=0.93, (CI: 0.93, 0.95)).** After assigning duration and MET-scores to each activity (total MET-minutes), the correlations increased slightly for $PAEE_{AR}$, PAL_{AR} and TEE_{AR} but decreased for VPA_{AR} (Table 3). Adjusting for parity increased the correlations between self-reported exercise and $PAEE_{AR}$, PAL_{AR} and TEE_{AR} but not VPA_{AR} (Table 3). Further adjustment for all the potential confounders (age, **height,** parity, BMI, education and smoking status) increased the partial correlation between self-reported exercise and TEE_{AR}, and slightly attenuated the others (Table 3). Additional adjustment for sick-leave at time of the questionnaire, working in a standing position and heavy lifting at work did not appreciably change the coefficients (data not shown).

If strolling was excluded from recreational exercise, the correlations were only marginally stronger (data not shown). We also examined the correlation between self-reported exercises with METs > 6 (e.g. running, skiing and high-impact aerobic classes) and VPA_{AR} (r=0.12, p=0.20).

We examined potential effects on our results of the time lag between the self-reported and objective measures. Excluding women with more than 31 days between filling in the

questionnaire and motion sensor assessment (n=35, 31%) did not improve the associations between weekly activities and the ActiReg® measures (data not shown). We also identified participants who were grossly misclassified by the two methods. Six women (5%) reported exercise less than once weekly but were ranked in the upper quartile of any of the objective measures, whereas 12 women (11%) reported 5 or more weekly exercises but were ranked into the lowest quartile of any of the objective measures. These 12 reported significantly higher frequencies of strolling (p=0.03) and brisk walking (p=0.01) than the other 100 women. We found no differences between those misclassified by the two methods (n=18) and the remaining women (n=94) with regard to parity, height, BMI, education, age or smoking status (p>0.05).

Discussion

The main finding in this study was the positive association between self-reported recreational exercise and objectively measured physical activity in pregnant women. The results of the present study support the validity of the questions used to quantify regular exercise activity in pregnant women in MoBa.

A wide range of results have been obtained in validation studies like ours. Such validation studies have increasingly used accelerometers or motion sensors as "gold standards". In non-pregnant adults, the associations between questionnaire data and objective measures have been relatively low (Table 4) and lower than associations between questionnaire data and physical activity records (Cust et al., 2008; Richardson et al., 1995). Modest associations were reported regardless of whether the self-reported method was a full physical activity questionnaire or just a few questions about physical activity as part of a lifestyle questionnaire (Table 4).

Similarly, in pregnant women, a range of associations between self-reported and objective measures of physical activity have previously been reported (Chasan-Taber et al., 2004; Rousham et al., 2006; Stein et al., 2003). In a validation study of a physical activity questionnaire among women enrolled at various points during pregnancy, the correlation between the questionnaire total activity and accelerometer data (n=54 women for 7 days) was 0.08, 0.32, or 0.43, depending on the cut-point used to define moderate to high activity with the accelerometer (Chasan-Taber et al., 2004). The cut points for that study are not directly comparable to our study. In a longitudinal study, physical activity was assessed in nulliparous pregnant women (n=57) by both self-report and accelerometer at gestational weeks 12, 16, 25, 34 and 38. The self-report was conducted as a 7-day recall interview and an accelerometer was worn for 72 hours at each time point. Correlations between self-report and accelerometer data were highest at 12 weeks of gestation (r=0.55), decreased by 16 weeks of gestation (r=0.26), and were lower thereafter as physical activity declined as pregnancy progressed (Rousham et al., 2006). In 28 habitually active and 28 sedentary pregnant women studied at 20 and 32 weeks of gestation, 1-week physical activity record and accelerometry results measured for two consecutive days each time were correlated, with r=0.55-0.74 (Stein et al., 2003). Although the results in the present study are not markedly different from most of what has been reported previously, the results tended towards the lower end of reported validity, and several factors may account for this.

Variation in results across validation studies is likely due to differences in the design of the validation study, including the self-report format, the "gold standard" used, and the subject population. Pre-pregnant exercise level has been shown to decline in pregnancy, and this may be a result of physical changes of pregnancy and social and psychological factors. Clarke and Gross (2004) reported that rest and relaxation were perceived as being significantly more important during pregnancy than was regular exercise or the maintenance of an active lifestyle. In the present study, even the group reporting exercise 5 or more times weekly had on average less than 30 minutes daily of vigorous physical activity (Table 2), indicating an overall low physical activity level. Low level of physical activity was also found in a study investigating the association between physical activity and exercise by questionnaire and weight gain in 467 pregnant Norwegian women (Haakstad et al., 2007). In a population with a low level of physical activity only a small proportion will exercise vigorously and this **may** decrease the apparent validity of a questionnaire. Furthermore, the correlations reflecting validity in the present study are likely to be underestimates because the motion sensor collected information about occupational and household activity in addition to recreational exercise, and because of the different time frames covered by the self-reported and the objective measures of physical activity. The questionnaire addressed activity "during this pregnancy", which should reflect the average over the first 16 weeks or so, whereas the motion sensor covered only 4 days at about week 20 of pregnancy. The decrease in activity that occurs during pregnancy would have caused our estimates to be lower than if the time periods addressed had overlapped. Furthermore, our correlations might have been decreased by having only frequency of activities, but not time spent at each. Moreover, among women whose total reported exercise activities was less than weekly, the daily average VPA_{AR} was 15 minutes, indicating that important contributors to total activity level were not captured by the list of exercise activities in the questionnaire. This could be in part because physical activity in transport might not have been reported by some subjects, who did not regard it as exercise. **In Norway, however, we have yearly campaigns promoting walking and cycling between home and workplace as a way of increasing recreational exercise.** Finally, four days of motion monitoring may have been insufficient for capturing habitual weekly exercises. Nonetheless, the degree of validity of the physical activity questions in the first MoBa questionnaire are similar to those in questionnaires in other studies that have revealed important relations with health outcomes (Cust et al., 2008).

Apart from the specific limitations of the population, questionnaire, and scheme for assessing validity in the present study, studies of this sort face many challenges. The relatively low validity may be a reflection of the difficulty in capturing with simple questions the between-individual differences in energy-expenditure associated with a given activity, and use of a single estimate of the energy cost of an activity taken from a published compendium, applied to all individuals (Wareham et al., 2002). **In this study, we identified 12 women who were active by questionnaire, but not by the ActiReg® measures. This discrepancy may be because activities in pregnancy, e.g., walking, may have associated MET scores that are not reflected well in values listed in standard tables that do not take pregnancy into account.** Furthermore, predicting energy expenditure in pregnancy is especially imprecise as doubly labelled water studies have shown large differences in metabolic and behavioural adaptation to pregnancy (Goldberg et al., 1993; Prentice & Goldberg, 2000). However, VPA and PAL by the ActiReg® is independent of the estimated REE, and the average PAL of 1.66 (SD ± 0.13) in our study is in good accordance with that of 1.65 (SD ± 0.67) measured by the doubly labelled water method in 22 pregnant women in Sweden at gestational weeks 16-18 (Forsum et al., 1992).

One issue not addressed in the present study is the validity of reporting specific physical activities. Special aspects of specific physical activities in pregnancy could affect health outcomes. For example, a specific activity might interfere with uterine blood flow, in which case the validity of the reported weekly frequency of that specific activity would be of special interest; unfortunately, we did not have sufficient sample size to address this.

Women in the validation study were slightly older, slimmer, better educated and smoked less than MoBa participants overall (Brantsæter et al., 2008). MoBa women who were older, slimmer, more educated, smoked less and pregnant with their first child reported higher frequency of recreational exercise (Owe et al., 2008). As a result, the participants in the validation study included a larger proportion of women who exercised regularly. However, the aim of the present study was to compare associations between self-reported and objective measures within the same subjects, and there is little reason to believe these associations would have been very different in a random sample of MoBa participants.

Perspectives

Pregnancy is a particularly difficult time for assessment of physical activity, including recreational exercise, due to the continuous physiological changes. Because of the lack of consensus regarding the effects of exercise during pregnancy, further research is needed on how different exercise regimens affect pregnancy and the offspring. MoBa is a large pregnancy cohort with participants from both urban and rural regions, representing all age groups and all socioeconomic groups (Magnus et al., 2008). The linkage to the medical birth registry of Norway provides unique information on relevant health outcomes, and information about the health of mother and child will be accessible through questionnaires throughout childhood. The results of this validation study confirmed that the MoBa questions used at gestational weeks 15-17 to assess recreational exercise are useful for ranking pregnant women according to level of recreational exercise. This is important as future studies, like the one which reported a beneficial effect of recreational physical activity on the risk of preeclampsia (Magnus et al., 2008), will use the same questions to explore potential associations between recreational exercise during pregnancy and a number of health outcomes in mother and child.

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Table 1

Physical characteristics, lifestyle and physical activity and energy expenditure in 112 pregnant women in the validation study

	Mean (SD)	Median	Min-max
Age (year)	31.2 (4.0)	31	23-42
Body weight[a] (kg)	69.9 (9.9)	69	21-111
Body height (m)	1.68 (0.07)	1.70	1.50-1.81
BMI (kg m^2)	24.8 (3.5)	24.1	18-41
REE_{WHO} (kJ/day)	6,000 (510)	5,900	4,880-7,640
Motion sensor assessment:			
TEE_{AR} (kJ/day)	10,020 (1,015)	10,100	7,870-12,880
(kcal/day)	2,400 (240)	2,420	1,890-3,080
$PAEE_{AR}$ (kJ/day)	4,020 (820)	4,080	2,080-6,150
PAL_{AR} (TEE/REE)	1.66 (0.13)	1.66	1.29- 1.96
VPA_{AR} (min/day)	20.2 (13.5)	16.9	0.5-62.5
Questionnaire information			
Recreational exercises excluding strolling (times/week)	2.1 (2.1)	1.5	0 -11
Sum of recreational exercises including strolling (times/week)	3.5 (2.6)	3.1	0 -13
Total MET-minutes from exercise (minutes/week)	560 (230)	350	0 - 2450
	N (%)		
Daily smoker prior to pregnancy	9 (8)		
No previous children	63 (56)		
Education > 12 years	94 (84)		

[a] weight at the time of motion sensor assessment
REE_{WHO} = resting energy expenditure calculated according to the WHO-equation
TEE_{AR} = total energy expenditure computed by the motion sensor ActiReg®
$PAEE_{AR}$ = physical activity energy expenditure computed by the motion sensor ActiReg®
PAL_{AR}=Physical activity level
VPA_{AR} = minutes of vigorous physical activity corresponding to 6+ **metabolic equivalents (METs)**
Total MET-minutes=metabolic equivalent (MET) of each activity (intensity) multiplied by duration (in minutes) and summed across all activities

Table 2

Physical activity measures by the motion sensor ActiReg® according to categories of weekly exercise

	N (%) total= 112	TEE_{AR} (kJ/day)	$PAEE_{AR}$ (kJ/day)	PAL_{AR}	VPA_{AR} (min/day)
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Less than weekly	18 (16)	9,690 (1,180)	3,560 (1,040)	1.57 (0.16)	14.6 (12.6)
1 - 2 times weekly	27 (24)	10,070 (944)	4,030 (665)	1.66 (0.11)	16.1 (12.3)
3 – 4 times weekly	37 (33)	10,050 (977)	4,140 (789)	1.68 (0.12)	21.4 (13.1)
5 times or more	30 (27)	10,140 (1030)	4,160 (779)	1.69 (0.12)	25.8 (13.8)
P for trend		*0.20*	*0.02*	*0.003*	*<0.001*

TEE_{AR} = total energy expenditure computed by the motion sensor ActiReg®
$PAEE_{AR}$ = physical activity energy expenditure computed by the motion sensor ActiReg®
PAL_{AR}=Physical activity level
VPA_{AR} = minutes of vigorous physical activity corresponding to 6+ metabolic equivalents (METs)
* p<0.05 **p<0.01

Table 3

Pearson correlations (crude and adjusted) between the ActiReg® measures and the questionnaire data in 112 pregnant women in the validation study

	TEE_{AR} (kJ/day)	$PAEE_{AR}$ (kJ/day)	PAL_{AR}	VPA_{AR} (min/day)
	Pearson r			
Sum of all **weekly** exercises	r=0.17	r=0.26**	r=0.30**	r=0.32**
Total **weekly** MET-minutes, exercise	r=0.18	r=0.29**	r=0.34**	r=0.25**
Adjusted for parity	Partial correlation r			
Sum of all **weekly** exercises	r=0.19*	r=0.28**	r=0.33**	r=0.28**
Total **weekly** MET-minutes, exercise	r=0.20*	r=0.31**	r=0.37**	r=0.22*
Adjusted for age, **height,** parity, BMI, education, and smoking status	Partial correlation r			
Sum of all **weekly** exercises	r=**0.27****	r=0.26**	r=0.27**	r=0.25**
Total **weekly** MET-minutes, exercise	r=**0.33****	r=0.32**	r=0.32**	r=0.19*

TEE_{AR} = total energy expenditure computed by the motion sensor ActiReg®
$PAEE_{AR}$ = physical activity energy expenditure computed by the motion sensor ActiReg®
PAL_{AR}=Physical activity level
VPA_{AR} = minutes of vigorous physical activity corresponding to 6+ metabolic equivalents (METs)
Total MET-minutes=metabolic equivalent (MET) of each activity (intensity) multiplied by duration (in minutes) and summed across all activities
*p<0.05 **p<0.01

Table 4

Validation studies of self-reported recreational (leisure) physical activity (PA) in non pregnant populations using accelerometer (Caltrac) or motion sensor (ActiReg®) as an evaluation tool.

Reference	Self-reported instrument	Study population	Objective measure	Outcome	Result (correlations)
(Richardson et al., 1995)	Full PA Questionnaire	28 men and 50 women, age 20-59 y	14 48-hour Caltrac accelerometer readings	Leisure physical activity time	♂ r=0.24 ♀ r=0.19
(Cust et al., 2008)	Full PA Questionnaire	100 men and 82 women, age 50-65 y	3 7-day accelerometer readings	Non-occupational activity	♂ r=0.24** ♀ r=16
(Kurtze et al., 2007)	Two questions about leisure PA	108 men Age 20-39 y	7 days motion/position sensor (ActiReg®)	Light activity vs TEE_{AR}	r=0.21*
				Light activity vs PAL_{AR}	r=0.08
				Vigorous activity vs TEE_{AR}	r=0.11
				Vigorous activity vs PAL_{AR}	r=0.31**
(Kurtze et al., 2008)	Three questions about leisure PA, frequency, intensity and duration	108 men Age 20-39 y	7 days motion/position sensor (ActiReg®)	Questionnaire PA vs TEE_{AR}	r=0.03
				Questionnaire PA vs PAL_{AR}	r=0.07
				Questionnaire PA vs VPA_{AR}	r=0.39**
(Matthiessen et al., 2008)	Full PA questionnaire	138 men and women Age 20-59 y	7 days motion/position sensor (ActiReg®)	Very light activity	r=0.36**
				Light activity	r=0.17^{s}
				Moderate activity	r=0.45**
				Vigorous activity	r=0.33**

*p<0.05 **p<0.01