Measuring Sedentary Behavior During Pregnancy: Comparison Between Self-reported and Objective Measures

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Abstract

Objectives To quantify and compare the sedentary time estimated by the Sedentary Behavior Questionnaire (SBQ) and the sedentary time objectively measured by a multi-sensor monitor (SWA) in pregnant women. *Methods* One hundred eighty-six participants answered the SBQ and wore the SWA at least 7 valid days. The concordance, correlation, agreement and relative activity levels between both measures of sedentary time were examined. Differences of sedentary time between weekday and weekend and between groups stratified by sociodemographic and clinical characteristic were evaluated by one-way analysis of variance. *Results* Pregnant women were sedentary the 64% of their waking hours. Television viewing is the most prevalent sedentary behavior. The concordance, correlation, and agreement between SBQ and SWA were weak, yet a significant correlation in weekday and average day sedentary time ($r = 0.23$ and 0.20, $P = 0.001$ and 0.008, respectively) was observed. A significant linear trend was found for increasing sedentary time between both methods using a relative activity levels analysis. *Conclusions for Practice* Pregnant

women experience high amount of sedentary time, for approximately half of the day. The SBQ shows a low validity and agreement, but strong ability to rank individuals compared with SWA in pregnant women.

Keywords

Sedentary behavior
Pregnancy
Activity monitor
Self-report

Electronic supplementary material

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Significance

This study is the first to quantify and compare the sedentary time estimated by a specific multiple-domain questionnaire and objectively measured by a multi-sensor monitor in pregnant women. The SBQ shows a strong ability to rank individuals in respect to their sedentary activities. The combined use of SBQ and multi-sensor monitor may be appropriate to capture all aspect of sedentary behavior. The quantification of sedentary behaviors allows the exploration of associations between sedentary activities and maternal and fetal health outcomes and the assessment of the effectiveness of intervention strategies promoting health benefits for pregnant women.

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Introduction

Sedentary behavior can be defined as any waking behavior characterized by an energy expenditure of ≤ 1.5 metabolic equivalents (METs) while in a sitting or reclining posture (Tremblay et al. 2010). A sedentary lifestyle has been described as a major public health problem

of the twenty-first century (Blair 2009). Several longitudinal studies have shown the negative health consequences of a sedentary lifestyle (Thorp et al. 2011; Seguin et al. 2014; Pavey et al. 2015) independent of a lack of physical activity (Hamilton et al. 2008).

An increase in sedentary behavior during pregnancy has been associated with adverse perinatal health outcomes including lower birth weight (Both et al. 2010), abnormal glucose tolerance (Oken et al. 2006), increased risk for gestational diabetes mellitus (Oken et al. 2006; Zhang et al. 2006), decreased insulin sensitivity and increased insulin secretion (Gradmark et al. 2011), and excessive gestational weight gain (Jiang et al. 2012). Important strategies to manage healthy weight gain during pregnancy and reduce the prevalence of chronic disease include engaging in regular physical activity and reducing excessive sedentary time (Loprinzi et al. 2013).

It is in the interest of public health to have an objective and self-reported diagnosis of sedentary time because such a diagnosis helps to characterize the patterns of sedentary behavior for developing intervention studies aimed at improving maternal and fetal outcomes. Only one study with a modest sample size (n = 48) has objectively measured sedentary behavior during waking hours in pregnant women using multi-sensor monitors, which allow for a direct estimation of sedentary behavior according to METs for multiple and consecutive 24-h periods (Fabio et al. 2015). Other studies have used accelerometers as an objective indirect estimation of sedentary behavior based on the absence of whole-body movement periods during waking hours (Hawkins et al. 2014; Evenson and Wen 2011). However, considering sedentary behavior as the absence of whole-body movement instead of METs may limit the ability to discern between sedentary behavior and inactivity (Sedentary Behaviour Research Network 2012). Some studies have used single-item sitting time questions or physical activity questionnaires (Both et al. 2010; Oken et al. 2006) as self-report measures to quantify sedentary behavior during pregnancy. However, measuring sedentary behavior as the absence of physical activity is inappropriate (Owen et al. 2010), because sedentary behavior is a unique set of behaviors, with a range of potentially unique health consequences, as they influence obesity and other metabolic precursors

of chronic diseases (Tremblay et al. 2007). Currently, no standardized questionnaires that have been validated in pregnant women exist for the analysis of sedentary behavior. Validated self-report measurements of specific multiple-domains sedentary behaviors, such as the Sedentary Behavior Questionnaire (SBQ) (Rosenberg et al. 2010), can provide useful information to identify high-risk sedentary behavior in large-scale studies of pregnant women.

Therefore, we aimed to quantify and compare the sedentary time estimated by the SBQ and the sedentary time objectively measured by a multi-sensor monitor in a relatively large sample of pregnant women, stratified by age, body mass index (BMI), trimester of gestation, parity, occupational status, and educational level. We also compared the sedentary time among the aforementioned groups.

Methods

At their first prenatal care visit from eleven health clinics in the Sanitary Area of Seville (Spain), eligible participants (n = 273) received detailed information about the study aims and protocol and voluntarily gave their written informed consent prior to enrolling in the study. The exclusion criteria included physical illnesses or disabilities that affect normal daily routine and high risk pregnancy (i.e. diabetes or hypertension). Healthy singleton pregnant women aged 18–45 years old were included in the study sample (n = 203). Seventeen participants were excluded due to incomplete protocol. The study protocol obtained ethical approval from the Medical Research Ethics Committee of the University Hospital Virgen del Rocio (Seville, Spain) and were performed during two face-to-face sessions, separately by an interval of 8 days.

At the first session, sociodemographic characteristics (age, marital status, educational level and occupational status), clinical characteristics (pre-pregnancy BMI, trimester of gestation and parity), and anthropometric measurements were recorded (Seca 780, Hamburg, Germany), and BMI was calculated using standard procedures (Lohman et al. 1988). In this session, a multi-sensor monitor was placed on the

left arm of each participant who was asked not to change their habitual lifestyle.

A multi-sensor monitor, Sensewear Mini Armband (BodyMedia Inc., Pittsburgh, PA, USA) (SWA), validated in pregnant women (Smith et al. 2012), was used to objectively assess sedentary behaviors that involved levels of energy expenditure of ≤ 1.5 METs during waking hours. Monitor includes sensors to measure energy expenditure by monitoring the heat flow from the body, skin temperature, galvanic skin responses and 3-axis accelerometer for motion detection. The multi-sensor monitor was worn 8 completed days, including 5 weekdays and 2 weekend days, except during water-based activities like swimming or bathing. To be considered a completed day, the multi-sensor monitor was required to be carried for at least 95% of the entire day (1.368 min or longer). To avoid any kind of immediate reactivity that may altered their habitual lifestyle, we removed from the analysis the first day of monitoring.

At the second session, the multi-sensor monitor was removed and the Spanish version of the SBQ (Munguía-Izquierdo et al. 2013) was administered. The SBQ was designed to assess the amount of time spent engaging in 11 behaviors (specified in Table 1). Time reported in each behavior were converted into hours and were summed separately for weekdays and weekend days, and weekly estimates were calculated summing weekday hours multiplied by 5 and weekend hours multiplied by 2. The SBQ shown acceptable measurement properties in overweight adults (Rosenberg et al. 2010) and Spanish patients with fibromyalgia (Munguía-Izquierdo et al. 2013).

Table 1

Demographic characteristics of study sample (n = 186)

Variables	Mean ± SD (% cases)
Age (years)	32.5 ± 4.4

[a]One missing data on prepegnancy BMI

[b]Three student excluded of occupational status on total sample

Variables	Mean ± SD (% cases)
Prepregnancy body mass index (BMI) (kg/m^2)	24.2 ± 3.7
Total objective sedentary time (h/day, % waking time)	10.0 ± 2.1 (64%)
Total objective sleep time (h/day)	6.5 ± 1.1
Total self-reported sedentary time (h/day)	8.7 ± 3.5
Specific self-reported sedentary behaviors (h/day)	
Watching television	2.3 ± 1.2 (99%)
Eating	1.8 ± 1.2 (100%)
Lying/resting	1.7 ± 1.2 (99%)
Playing computer/video games	0.4 ± 0.7 (43%)
Listening to music	0.1 ± 0.2 (22%)
Talking with others	0.8 ± 1.0 (94%)
Doing paper/office work	1.0 ± 1.6 (48%)
Reading	0.6 ± 0.9 (73%)
Playing a musical instrument	0.0 ± 0.2 (3%)
Doing arts and crafts	0.1 ± 0.4 (14%)
Driving/travelling in a motor vehicle	0.6 ± 0.4 (97%)
	n (%)
Ethnicity	
Caucasian	186 (100)
Trimester of gestation	
Second trimester	109 (58.6)
Third trimester	77 (41.4)
Prepregnancy BMI[a]	
< 25 kg/m^2	120 (64.9)
> 25 kg/m^2	65 (35.1)[a]

[a]One missing data on prepegnancy BMI

[b]Three student excluded of occupational status on total sample

Variables	Mean ± SD (% cases)
Marital status	
Single without couple	3 (1.6)
Single with couple	64 (34.4)
Married	116 (62.4)
Divorced or separated	3 (1.6)
Parity	
0	103 (55.4)
1	76 (40.9)
> 1	7 (3.8)
Educational level	
Non-tertiary	
Unfinished studies	36 (19.3)
Polytechnic school	38 (20.4)
High school	23 (12.4)
Tertiary	
Medium academic degree	31 (16.7)
Highly academic degree	58 (31.2)
Occupational status[b]	
Workers	91 (48.9)
Non-workers	
Unemployed	49 (26.3)
Sick leave from work	43 (23.1)
[a]One missing data on prepegnancy BMI	
[b]Three student excluded of occupational status on total sample	

We calculated estimated means for the objective and subjective measures in weekday, weekend, and average day sedentary time across sociodemographic and clinical variables: age, BMI, trimester of

gestation, parity, occupational status and educational level. Differences among the above mentioned groups were analyzed by a one-way analysis of variance. Differences in sedentary time levels on weekdays versus the weekend were estimated with a one-way analysis of variance for repeated measures. Systematic differences between both measures of sedentary time were calculated using paired t-tests. Concordance between both measures was examined using concordance correlation coefficients (Lin 1989). Pearson correlation coefficients were used as additional information to form comparisons with previous validity studies of sedentary behavior questionnaires. The agreement between both measures of sedentary time was assessed using Bland–Altmant plots (Bland and Altman 1986), including the 95% levels of agreement. The association between the difference and the magnitude of the measurement was examined using regression analysis. We tested the significance of the differences between methods against zero using a one-sample t-test. To assess relative activity levels, we used the Jonckheere–Terpstra test to evaluate whether the tertile groups of SBQ total sedentary time ranked activity from the objective measurement in an anticipated graded order. A receiver operating characteristic curve was constructed to analyze the validity of the SBQ in predicting $\geq$ 8 h/day and $\geq$ 11 h/day of sedentary behaviors, which are associated with high health risks (Seguin et al. 2014; Pavey et al. 2015). We determined the areas under the curve (AUC) and 95% confident intervals, and the specificity and sensitivity of the SBQ.

Floor or ceiling effects were calculated from the percentage of participants showing the highest (24 h/day) or lowest (0 h/day) value in average day sedentary time on the SBQ (Terwee et al. 2007). We used parametric statistics because of the large sample size; however, some of the study variables were non-normally distributed. We repeated the analyses using nonparametric statistics, and the results did not substantially change. Data were analyzed using SPSS package version 20.0 for windows (IBM Corporation) with statistical significance set at $P < 0.050$.

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Results

The one hundred eighty-six participants who were included in the analysis provided written consent, wore the SWA for seven valid days, and completed the SBQ (response rate: 74%). The characteristics of the sample are shown in Table 1. No floor/ceiling effects were presented for the average sedentary time of SBQ (2% ceiling effect and 0% floor effect).

Participants reported an average of 8.7 ± 3.5 h of sedentary behaviors while awake. The highest mean time reported for individual items was for watching television, followed by eating, and lying and resting. The lowest reported time was for playing musical instruments, followed by sitting listening to music, and arts and crafts (Table 1). A total of 35% of the participants reported watching television for more than 20 h/week (~ 3 h/day). Approximately 45% and 36% of pregnant women reported watching television during the weekend and weekdays, respectively, for more than 3 h/day.

Pregnant women spent a mean of 10.0 ± 2.1 h/day in objectively measured sedentary behavior, comprising 63.5% of their waking time. This proportion of time was slightly higher on weekdays than on weekends ($P = 0.326$). The subgroups with more time spent in objectively measured sedentary behavior were pregnant women with BMI > 25 kg/m^2 (10.7 h/day, 68.2% of waking time), tertiary education (10.6 h/day, 66.1% of waking time) and women in their third trimester (10.5 h/day, 65.9% of waking time). The subgroups with less time spent in sedentary behavior were younger pregnant women (9.3 h/day, 60.3% of waking time) and women with BMI < 25 kg/m^2 (9.7 h/day, 61.0% of waking time) (Table 2).

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Table 2

Descriptive sedentary time data from the SBQ and SWA by age, BMI, and trim educational level in pregnant women

Participants	Weekdays sedentary time (h/day)			Weekend sedentary time (h/day)		
	Estimated (SWA)	Self-reported (SBQ)	P value between methods	Estimated (SWA)	Self-reported (SBQ)	P value between methods
All (n = 186)	10.1 (2.3)	8.8 (3.9)	< 0.001	9.9 (2.4)	8.7 (3.6)	< 0
Age (years)						
20–30 (n = 47)	9.3 (2.3)	8.7 (4.3)	0.442	9.4 (2.6)	8.6 (3.6)	0.2
31–44 (n = 139)	10.4 (2.2)	8.8 (3.7)	< 0.001	10.1 (2.3)	8.8 (3.6)	< 0
P value between groups	0.003	0.983		0.068	0.686	
BMI (kg/m^2)						
< 25 (n = 120)	9.7 (2.2)	8.5 (3.6)	< 0.001	9.7 (2.4)	8.4 (3.4)	0.0
≥ 25 (n = 65)	10.8 (2.2)	9.3 (4.2)	0.012	10.5 (2.2)	9.3 (3.8)	0.0
P value between groups	0.002	0.149		0.021	0.108	
Trimester						
Second (n = 109)	9.8 (2.4)	8.7 (4.0)	0.006	9.6 (2.4)	8.3 (3.4)	0.0
Third (n = 77)	10.5 (1.9)	8.9 (3.7)	< 0.001	10.4 (2.4)	9.4 (3.7)	0.0
P value between groups	0.022	0.708		0.022	0.040	
Parity						
0 (n = 103)	10.3 (2.3)	9.5 (4.0)	0.061	10.1 (2.4)	9.0 (3.3)	0.0
> 1 (n = 83)	9.9 (2.2)	7.8 (3.5)	< 0.001	9.8 (2.4)	8.4 (3.9)	0.0
P value between groups	0.212	0.004		0.411	0.290	

Values are mean (SD). The difference of SBQ versus SWA is shown using a pa

BMI body mass index

Participants	Weekdays sedentary time (h/day)			Weekend sedentary time (h/day)		
	Estimated (SWA)	Self-reported (SBQ)	P value between methods	Estimated (SWA)	Self-reported (SBQ)	P v be me
Occupational status						
Workers (n = 91)	10.2 (2.3)	9.1 (4.1)	0.015	9.9 (2.5)	8.5 (3.3)	0.0
Non-workers (n = 92)	10.0 (2.2)	8.4 (3.6)	< 0.001	10.0 (2.3)	9.0 (3.8)	0.0
P value between groups	0.570	0.236		0.656	0.349	
Educational level						
Non-tertiary (n = 97)	9.5 (2.2)	8.2 (3.8)	0.003	9.7 (2.4)	8.5 (3.7)	0.0
Tertiary (n = 89)	10.7 (2.2)	9.3 (3.8)	0.001	10.2 (2.3)	9.0 (3.4)	0.0
P value between groups	0.000	0.057		0.124	0.445	

Values are mean (SD). The difference of SBQ versus SWA is shown using a pa

BMI body mass index

Table 2 summarizes sedentary behavior levels, according to the SBQ and SWA, stratified by age, BMI, trimester of gestation, parity, occupational, and educational level. The SBQ presented significantly lower sedentary time compared with the SWA across all stratified groups, except the younger age subgroup (< 30 years). No differences between weekday and weekend sedentary time were found across all stratified subgroups, except for women with tertiary education who presented higher sedentary time during weekdays than weekends using the SWA ($P = 0.030$). The subgroups of age > 30 years, BMI > 25 kg/m^2, third trimester of pregnancy, and tertiary education presented significantly higher sedentary time using the objective measure (SWA) to measure sedentary time in an average day ($P = 0.001$–0.014)

compared with their respective counterparts. Only nulliparous pregnant women reported significantly higher average day sedentary time than parous pregnant women using the SBQ ($P = 0.010$).

Compared to the SWA, the SBQ underestimated by 12–13% (1.2 −1.3 h/day) the weekday, weekend, and average day sedentary time. The difference in weekday, weekend, and average day sedentary time between the two methods was significant ($P < 0.001$ for all). A low but significant correlation was observed between self-reported (SBQ) and objective (SWA) weekday sedentary time and average day sedentary time ($r = 0.23$ and 0.20, $P = 0.001$ and 0.008, respectively), whereas no correlation was found for weekend sedentary time ($r = 0.12$, $P = 0.103$) (Table 3).

Table 3

Comparison of total weekday, weekend, and average day sedentary time between trimester of gestation, parity, occupational and educational level in pregnant wome

Participants	Weekday sedentary time				Weekend sedentary time		
	DM (SD) (h/day)	CCC	Pearson	$P_{Pearson}$	DM (SD) (h/day)	CCC	Pearson
All (n = 186)	− 1.33 (3.99)	0.19	0.23	0.001	− 1.20 (4.07)	0.10	0.12
Age (years)							
20–30 (n = 47)	− 0.52 (4.57)*	0.17	0.17	0.260	− 0.83 (4.46)*	0.01	0.01
31–44 (n = 139)	− 1.60 (3.74)	0.21	0.27	0.001	− 1.32 (3.93)	0.13	0.16
BMI (kg/m^2)							
< 25 (n = 120)	− 1.26 (3.71)	0.22	0.27	0.003	− 1.22 (4.13)	0.04	0.04
≥ 25 (n = 65)	− 1.45 (4.51)	0.09	0.12	0.357	− 1.18 (4.0)	0.17	0.21

*Mean difference not significantly different from zero using a one-sample t-tes

BMI body mass index, *DM* difference mean between methods, *SD* standard dev
coefficient, *Pearson* Pearson correlation coefficient, $P_{Pearson}$ P value for Pearson

Participants	Weekday sedentary time				Weekend sedentary time		
	DM (SD) (h/day)	CCC	Pearson	P_Pearson	DM (SD) (h/day)	CCC	Pearson
Trimester							
Second (n = 109)	− 1.10 (4.10)	0.21	0.25	0.009	− 1.31 (3.95)	0.10	0.11
Third (n = 77)	− 1.65 (3.82)	0.14	0.20	0.085	− 1.03 (4.24)	0.07	0.08
Parity							
0 (n = 103)	− 0.79 (4.23)	0.14	0.17	0.090	− 1.01 (4.12)*	0.00	0.00
> 1 (n = 83)	− 2.00 (3.57)	0.21	0.29	0.007	− 1.35 (4.02)	0.20	0.24
Occupational status							
Workers (n = 91)	− 1.13 (4.36)	0.14	0.17	0.105	− 1.38 (3.95)	0.08	0.10
Non-workers (n = 92)	− 1.62 (3.59)	0.24	0.31	0.003	− 1.04 (4.22)	0.12	0.14
Educational level							
Non-tertiary (n = 97)	− 1.28 (4.16)	0.11	0.14	0.183	− 1.13 (4.44)	0.02	0.02
Tertiary (n = 89)	− 1.38 (3.81)	0.22	0.28	0.007	− 1.27 (3.64)	0.20	0.24

*Mean difference not significantly different from zero using a one-sample t-test

BMI body mass index, *DM* difference mean between methods, *SD* standard dev: coefficient, *Pearson* Pearson correlation coefficient, $P_{Pearson}$ P value for Pearson

Focusing on groups stratified by sociodemographic and clinical characteristics, the differences between the two methods in weekday, weekend, and average day sedentary time was significant among all subgroups ($P < 0.050$), except the younger age subgroup and during the weekday for the nulliparous subgroup. The subgroups of parous pregnant women, BMI < 25 kg/m^2, second trimester of pregnancy, non-workers, and tertiary education presented slightly stronger correlations

between SBQ and SWA measurements compared with their respective counterparts (Table 3).

The Bland–Altman plots and the wide limits of agreement between the SBQ and SWA measurements for the weekday (6.0, − 8.6), weekend (6.5, − 9.1), and average day sedentary time (6.8, − 9.2) are shown in Supplemental Fig. 1. No significant association was found between the difference and the magnitude of both methods for the weekday, weekend, and average day sedentary time ($P > 0.050$). Analysis of the receiver operating characteristic curve identified the SBQ as a poor predictor of the proportion of patients achieving more than 8 and 11 h/day of sedentary activities, showing high sensitivity (88% true positive) but low specificity (21% true negative) for 8 h/day, and low sensitivity (40% true positive) but high specificity (68% true negative) for 11 h/day. The assessment of relative activity levels presented a significant linear trend for increasing total sedentary time based on SWA data across tertiles of sedentary time based on SBQ scores ($P = 0.009$).

Discussion

This study is the first to quantify and compare the sedentary time estimated by a multiple-domain questionnaire and objectively measured by a multi-sensor monitor in pregnant women. The findings suggest adequate operational qualities for the SBQ but a low validity and agreement when the self-reported sedentary time measured by the SBQ was compared with the objectively measured sedentary time by the SWA in a convenient sample of low-risk pregnant women.

Our pregnant women spent the 64% of their waking hours in objectively measured sedentary behavior. Our results are slightly lower than the 76% of time spent in sedentary behavior found by the one study among pregnant women that used the same objective measurement monitor to assess sedentary time according to METs (Fabio et al. 2015). Similar findings were found in a study that used the same measurement instrument in patients with fibromyalgia (Munguía-Izquierdo et al. 2013). Contrary, the non-pregnant adult population has been reported to spend approximately 55–60% of their waking hours in sedentary

behavior (Matthews et al. 2008). Consequently, pregnant women appear to represent a population that engages in high levels of sedentary behavior. The SBQ provides information about the pattern of specific sedentary behaviors suitable for analyzing high-risk sedentary behavior during the week in specific contexts. The primary purpose of sedentary time reported by pregnant women was watching television, consistent with findings from other studies in pregnant women (Padmapriya et al. 2015), clinical (Munguía-Izquierdo et al. 2013) and general populations (U.S. Department of Labor. Bureau of Labor Statistics 2016). More than one-third of our participants watched television for more than 20 h/week, which has been shown to be associated with detrimental health outcomes (Tremblay et al. 2010) and could increase their risk of developing gestational diabetes mellitus (Zhang et al. 2006). In line with other populations (Wood et al. 2015), this excessive television watching was most prevalent on the weekends, with almost half of the pregnant women watching television for more than 3 h/day.

The SBQ presented lower values of sedentary time compared with the SWA across all stratified groups. Similar to our results, the SBQ (Munguía-Izquierdo et al. 2013; Bond et al. 2013) and other self-reported questionnaires (Scholes et al. 2014) underestimated the average day sedentary time. Contrary, other studies conducted in populations of non-pregnant adults (Busschaert et al. 2015; Wijndaele et al. 2014) overestimated the sedentary time using domain-specific questionnaires. This overestimation may be explained by the use of different questionnaires and/or different objective monitors as criterion measures. Studies using accelerometers with inclinometers, which identify sedentary behavior based on posture allocation, usually show an overestimation of self-reported sedentary time (Busschaert et al. 2015; Wijndaele et al. 2014). While studies using multi-sensor monitors (SWA), which identify sedentary behavior according to METs, usually show an underestimate of self-reported sedentary time (Munguía-Izquierdo et al. 2013; Bond et al. 2013). The use of accelerometers with inclinometer or multi-sensor monitors as criterion measure may produce measurement discrepancies due to possible misclassification of sedentary time because they are unable to differentiate between time sleeping and awake, and between postures (i.e., sitting), respectively.

Further studies using both tools simultaneously are likely to provide interesting data to validate sedentary behavior questionnaires.

The validity of the SBQ was better for weekdays than for weekend days, suggesting that weekend sedentary time may not be suitable as the sole measure of sedentary behaviors. These findings concur with those of other studies in the adult population (Busschaert et al. 2015) and may be explained by less structured daily activities during weekend days compared to weekdays, making it more difficult to recall weekend sedentary time. Both the subjective and objective measures did not show differences between weekend and weekday sedentary time, except for women with tertiary education who presented higher sedentary time during weekdays than weekends using the SWA. This reduction of sedentary time during weekends is consistent with findings from previous study in non-pregnant women (Ruiz et al. 2013) and can be partially explained by reduced work-related sitting time, since almost half of women with tertiary education perform sedentary office work.

Very few studies have used SWA monitors as the criterion measure for self-reported measures of sedentary time. One other study that used this criterion measure and this questionnaire in a clinical population of women with fibromyalgia found greater accuracy at the group level, as evidenced by a small mean difference but lower correlation (Munguía-Izquierdo et al. 2013). The weak relations and agreement between objective and subjective methods in the present study could suggest that the SBQ fails to adequately capture sedentary behaviors in low-risk pregnant women. In addition, the results of the specificity and sensitivity analysis suggest that the SBQ poorly discriminated people who surpassed 8 and 11 h of sedentary activities, characteristics that are associated with high health risks (Seguin et al. 2014; Pavey et al. 2015). Nevertheless, the significant linear trend presented on the assessment of relative activity levels suggests the ability of the SBQ to discriminate relative activity levels, reflecting the true ranking of sedentary time and allowing for the examination of its association with health-related variables during pregnancy. Our results suggest that the use of both tools may be appropriate for capturing all aspects of sedentary behavior, but whether the low correlations in the current study were caused by the nature of the survey questions or the types of referent measure is

uncertain. The reasons for the low correlations between both methods in pregnant women are unclear and require more studies with additional indicators of validity.

Regarding the stratified groups, the younger subgroup was the only subgroup that presented no significant differences between both methods, indicating, in line with other studies (Ferrari et al. 2007) that younger participants could present fewer difficulties when reporting their sedentary behavior levels. The subgroups of pregnant women who were parous and had the lowest age, BMI and trimester of gestation presented slightly stronger correlations and/or smaller mean differences than their counterparts, demonstrating better levels of validity when sedentary time measurements were compared between both methods. This finding might be partially explained by the fact that above mentioned subgroups are more sedentary than their counterparts, thus allowing for a lower margin of error in estimating sedentary time and a lower tendency to reflect social desirability. However, estimates were poor at an individual level, as suggested by wide limits of agreement displaying discrepancies up to approximately 7 h/day in sedentary time. The SBQ may be most suited for use in large-scale studies than for studies requiring estimates at an individual level, and in subgroups of women with the following characteristics: parous, BMI < 25 kg/m^2, second trimester of pregnancy, non-workers, and tertiary education.

Overall, only the objective measure (SWA) found significant differences in time spent in sedentary behaviors between age, BMI, trimester of gestation, and educational level subgroups. However, both the subjective and objective measures showed that the subgroups of pregnant women who were in their third trimester, had higher BMI, were tertiary educated, were nulliparous, and were over 30 years old were the most sedentary subgroups. This finding highlights that these subgroups may be aware of their high levels of sedentary behaviors. Although pregnant women under 30 years old and with lower BMI presented the lowest sedentary time, both subgroups engaged in sedentary behavior with a duration that exceeded the 60% of their waking hours. Our findings on the increase in sedentary time with age, BMI, trimester of gestation, and education are consistent with findings from other studies among pregnant women (Fabio et al. 2015;

Padmapriya et al. 2015), establishing these subgroups at high risk of a sedentary lifestyle.

A first limitation of the study is the inclusion of pregnant women who met eligibility criteria and volunteered to participate, which may result in a self-selection bias. High-risk pregnant women were excluded from the current study. There were no women in their first trimester due to the location of recruitment. The number of participants in the subgroup of overweight and obese women was much lower than the number of participants in the < 25 kg/m^2 subgroup. Since overweight and obese and/or mobility-impaired pregnant women may be at an increased risk for high levels of sedentary time, future research should investigate the measurement properties of sedentary behavior questionnaires in this subgroup. The cross-sectional design of our study precludes the identification of any causal relations. Longitudinal studies are also needed to further understand the predictive value of sedentary behaviors over the course of the pregnancy and to examine the utility of this questionnaire to evaluate change after interventions. The known limitations of nonprobability samples, including their lower representativeness and unknown levels of sampling error, are further limitations.

One strength of the present study was the strict standardization of the methodology used to measure sedentary time. All women had measurements for seven consecutive valid days and reactivity was minimized. The use of SWA may solve the main limitations of accelerometers and inclinometers through heat production measurements, differentiation between sleep and waking time, and placement on the upper arm. The examination of a sedentary behavior questionnaire that included an extensive list of specific sedentary behaviors is another strength. However, a suggestion to further refine the SBQ is to remove or combine certain questions with very low levels of responses (e.g., playing musical instrument) thus minimizing the participant burden and shortening the completion time.

Conclusion

Pregnant women experience high amount of sedentary time, for approximately half of the day. Pregnant women aged ≥ 30 years, with a pre-pregnancy BMI > 25 kg/m², with tertiary education, and in their third trimester of pregnancy are objectively more sedentary than their respective counterparts. Television viewing is the most prevalent sedentary behavior, with more than one-third of pregnant women watching television for more than 20 h/week. We find a low validity of self-reported estimates of average day sedentary behavior in pregnant women, but a stronger validity for weekdays than for weekend days. The SBQ shows a strong ability to rank individuals with respect to their sedentary activities. This continuous improvement of self-report measure of sedentary time will be important to obtain a better understanding of the relationship between sedentary behavior and health in pregnant women.

Acknowledgements

Electronic supplementary material

Below is the link to the electronic supplementary material.

Supplemental Figure 1. Bland and Altman plots of the differences between SWA and SBQ for (a) week days, (b) weekend days, and (c) average day sedentary time. The means of the differences (solid lines) and limits of agreement (dashed lines) within ± 2 SDs are shown. Abbreviations: SWA (Sensewear) and SBQ (Sedentary Behaviors Questionnaire) (TIF 251 KB)

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