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Self-reported and objectively-measured sedentary behavior in bariatric surgery candidates

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Abstract

Background—Sedentary behavior (SB), independent of physical activity, represents a significant health risk. We previously used objective measures to demonstrate that bariatric surgery candidates engage in high levels of SB overall, but supplementing these measures with subjective reports would provide information about time allocated to different forms of SB.

Objectives—To examine self-reported time spent performing specific types of SB, and discrepancy between self-reported and objectively-measured estimates of total sedentary time in bariatric surgery candidates.

Setting—University hospital, United States.

Methods—Fifty-two bariatric surgery candidates [87% female; Age=46.2±9.1 years; Body Mass Index (BMI)=45.3±6.7] completed the 9-item Sedentary Behavior Questionnaire (SBQ) as a subjective measure of SB and wore the SenseWear Armband (SWA) as an objective measure. Paired samples t-tests and the intraclass correlation coefficient (*ICC*) assessed measurement discrepancy.

Results—Television-viewing was the most frequently performed type of SB [2.7±1.6 hours per day (h/d)], followed by paper/computer work (1.9±1.8 h/d), driving/riding in automobile (1.2±1.1 h/d) and sitting talking on telephone (1.1±1.2 h/d). On average, the SBQ and SWA produced similar estimates of daily sedentary time (h/d) at the group level (9.6±4.8 vs. 9.3±1.9; *M* difference = −0.34±4.6; *p*=0.59), although agreement between the measures at the individual level was poor [Mean (*M*) absolute value of difference = 3.8±2.8 h/d; *ICC*=0.22, *p*=0.06].

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Conclusion—Television-viewing was the single SB in which participants most frequently engaged, and thus may be an important modifiable target for reducing total sedentary time in bariatric surgery candidates. The SBQ and SWA can be used similarly to describe SB levels in this patient population at the group level; however, ability of these measures to produce comparable estimates of sedentary time for any individual patient is limited.

Keywords

obesity; bariatric; sedentary; television; physical activity; measurement

Introduction

Sedentary behavior (SB), defined as any waking behavior performed while in a sitting or reclining posture that requires very low energy expenditure [≤ 1.5 Metabolic Equivalents (METs)], is an emerging focus of obesity research [1–3]. Substantial evidence indicates that SBs (e.g., watching television, sitting at a computer, and driving in a car) are associated with increased risk of obesity and related comorbidities, such as type 2 diabetes, cardiovascular disease, and metabolic syndrome, independent of physical activity [4–8]. Importantly, SB is also an independent risk factor for cardiovascular-related and all-cause mortality [6,9–11]. These data have contributed to a growing consensus that sedentary or “too much sitting” should be viewed differently than lack of physical activity with respect to health outcomes [1–3].

Given that SB poses a distinct and significant health risk, it is important to identify accurate assessment methods, particularly in populations at risk for being highly sedentary. Recent research conducted by our group using objective monitors indicates that severely obese bariatric surgery candidates are one group at considerable risk for engagement in high levels of SB [12–13]. Participants spent on average approximately 80% of their daily time in SBs [11–12], a percentage markedly higher than that reported in the general adult population (57%–69%) [14–17].

Use of objective monitors to quantify sedentary time is preferable over self-report questionnaires given that they provide real-time assessment of SB, thereby countering response bias and other threats to validity inherent in subjective monitoring methods [18]. However, unlike questionnaires, objective monitors are unable to differentiate time spent in different forms of SB. Currently, little is known about the amount of time that bariatric surgery patients allocate to specific SBs. Previous studies have assessed amount of time that bariatric surgery patients spend watching television [19–20], although assessment of television viewing time alone does not capture the full spectrum of SB and thus underestimates total sedentary time. Therefore, use of both subjective measures that assess time spent in multiple forms of SB and objective monitors that directly assess overall sedentary time may contribute to a better understanding of SB patterns in bariatric surgery patients.

The primary purpose of the current study was to examine the amount of time that bariatric surgery candidates report performing different forms of SB on weekdays, weekend days, and all days using the validated Sedentary Behavior Questionnaire (SBQ) [21]. Additionally, we sought to identify the form of SB to which participants allocated the greatest amount of sedentary time. Finally, we evaluated the level of agreement between self-reported (i.e. time spent in all forms of SB on the SBQ) and objectively-measured (i.e. via multi-sensor monitor) total daily sedentary time.

Methods

Participants and Procedures

Participants [21–65 years of age, Body Mass Index (BMI) ≥ 35 kg/m², inactive, ambulatory, non-smoking] were adult bariatric surgery candidates who enrolled in a randomized controlled trial examining the effects of a preoperative behavioral intervention to increase physical activity. All data for this study were collected at an initial study visit prior to randomization.

Participants were recruited during initial surgical consultation clinic visits and at patient support groups. Patients in these settings were initially provided with a flyer that briefly described the study. Patients who expressed interest in participating were asked to sign their name on the flyer and provide a telephone number to be contacted by research staff to receive additional study information and be screened for initial eligibility. Additionally, participants had to receive signed permission from a surgeon to participate in the study. Of 94 patients who met initial eligibility requirements and were invited to a study orientation visit, 64 attended the research laboratory to provide informed consent, complete questionnaires, have their height and weight measured, and receive an objective activity monitor to wear for 7 consecutive days. Of these 64 participants, 12 did not fulfill valid objective monitor wear time requirements (described below), leaving a sample of 52 participants. Participants were not compensated for assessment completion. All study procedures were approved by XXX institutional review board.

Measurement of sedentary behavior (SB)

Subjective measurement of SB—The SBQ assesses the amount of time spent performing 9 common forms of SB: watching television, playing computer or video games, sitting while listening to music, sitting and talking on the phone, doing office paper or computer work, sitting and reading, playing a musical instrument, doing arts and crafts, and sitting and driving/riding in a car, bus or train ^[21]. The 9 items are completed separately for weekdays and weekend days. Participants respond to the question, “On a typical weekday (or weekend day), how much time do you spend (from when you wake up until you go to bed) doing the following?”, with response options of: none, 15 minutes or less, 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, or 6 hours or more. Sedentary hours per day (h/d) were first summed separately for weekdays and weekend days. Average sedentary hours across all days was calculated using a weighted average: (weekday hours $\times$ 5) + (weekend hours $\times$ 2) $\div$ 7.

Objective measurement of sedentary behavior—The SenseWear Pro² Armband (SWA, BodyMedia, Inc., Pittsburgh, Pennsylvania) is a wireless multi-sensor monitor worn on the upper arm over the right triceps muscle that simultaneously integrates motion data from a triaxial accelerometer and physiological metrics from skin temperature, galvanic skin response, and heat flux sensors to provide minute-by-minute estimates of energy expenditure. Data are processed with proprietary software algorithms that match each recorded minute of data with an activity class (e.g., walking, running, rest). Each activity class has a linear regression model that enables mapping of values from motion and physiologic sensors to energy expenditure ^[22]. The SWA has been shown to accurately estimate energy expenditure when evaluated against doubly labeled water or indirect calorimetry and provide similar estimates of time spent in SB as other commonly used monitors ^[13,22–23].

The Sensewear Professional software (Version 6.1) was used to calculate the number of days and hours participants wore the SWA monitor. Time spent in SBs (< 1.5 METs) was

expressed in h/d to correspond with the subjective SBQ measure. For SWA data to be valid and analyzed in the current study, a minimum of 2 weekdays and 1 weekend day on which the SWA was worn for ≥ 8 h/d was required. The 8 h/d wear time criterion has been employed in previous studies of bariatric surgery patients [12–13, 24].

Analytic Plan

Statistical analyses were conducted using the Statistical Package for Social Sciences, version 17.0 for Windows (SPSS, Chicago, Illinois). Descriptive statistics were generated for all variables. Continuous and categorical variables were expressed as means $\pm$ standard deviations and proportions, respectively. Paired sample t-tests were used to test for statistically significant differences between the SBQ and SWA in sedentary h/d. Average discrepancy between the two measures was calculated by taking the mean of the absolute value of the difference for each participant. The intraclass correlation coefficient (ICC) was also used to quantify the level of agreement between the two measures.

Results

Participants

On average, participants were 46.2 ± 9.1 years of age, with BMI = 45.3 ± 6.7 kg/m², and weighed 122.0 ± 22.8 kg. The majority of participants were female (86%), White (79%), non-Hispanic (87%), and had at least some college education (73%). Participants wore the objective SWA monitor for an average of 12.0 ± 1.9 h/d on 5.0 ± 1.3 weekdays, 11.2 ± 1.9 h/d on 1.8 ± 0.5 weekend days, and 11.5 ± 1.7 h/d across 6.8 ± 1.5 total days.

Reported time spent in different forms of sedentary behavior (SB)

Average reported time (h/d) spent performing different forms of SB assessed by the SBQ on weekdays, weekend days, and all days is presented in Table 1. Overall, participants on average reported spending a significantly greater amount of time ($+1.3 \pm 3.6$ h/d) in SBs on weekdays versus weekend days (10.0 ± 5.3 vs. 8.7 ± 4.6 h/d, $p = 0.02$). On weekdays, two SBs (television-viewing and paper/computer work) were performed for more than 2 h/d and two SBs (sitting and talking on the phone, and sitting driving or riding in a car, bus or train) were performed for more than 1 h/d. Together, these four behaviors accounted for nearly three-quarters (72%) of total sedentary hours. Similar to weekdays, participants on average spent nearly 3 h/d on weekend days watching television. However, only one other SB (sitting driving or riding in a car, bus or train) was performed for more than 1 h/d. Across all days, television-viewing was the most frequently performed SB, followed by office/computer work, sitting driving or riding in a car, bus or train, and sitting talking on the phone. Together, these four behaviors accounted for 71% of total daily sedentary hours.

Discrepancy between subjective and objective measurement of total daily sedentary time

The subjective SBQ measure and the objective SWA measure were significantly correlated with one another for average time (h/d) spent sedentary on weekdays ($r = 0.32$, $p = 0.02$) and all days ($r = 0.33$, $p = 0.02$), but not for weekend days ($r = 0.27$, $p = 0.06$). Paired samples t-tests detected no significant differences between the SWA and SBQ for mean hours/day spent sedentary on weekdays (9.46 ± 2.06 vs. 9.98 ± 5.28 , $p = 0.46$), weekend days (8.78 ± 1.98 vs. 8.71 ± 4.62 , $p = 0.90$), and all days (9.27 ± 1.85 vs. 9.61 ± 4.83 , $p = 0.59$).

To examine individual level agreement between the SWA and SBQ, we calculated the absolute difference between measures, and the ICC. Figure 1 presents both the mean difference and mean absolute difference in daily sedentary hours between the SWA and SBQ on weekdays, weekend days, and all days. The mean difference in daily sedentary hours between the SWA and SBQ was quite small on weekdays (-0.51), weekend days

(0.08), and all days (−0.34). However, the degree of individual variability was quite large, with the difference between measures ranging from 0.2 to 13.6 h/d on weekdays, 0.1 to 11.5 h/d on weekend days, and 0.2 to 13.1 h/d on all days. The mean absolute difference in daily sedentary hours between the SWA and SBQ was 4.05 ± 2.94 on weekdays, 3.37 ± 2.96 on weekend days, and 3.81 ± 2.80 on all days. Across all days, the SBQ produced higher estimates of sedentary time in 53% of participants. The mean difference and mean absolute difference between the SWA and SBQ on all days were not associated with daily monitor wear time ($p > 0.25$). The level of agreement between the two measures was quite low on weekdays ($ICC = 0.22$, $p = 0.06$), weekend days ($ICC = 0.19$, $p = 0.08$) and all days ($ICC = 0.22$, $p = 0.06$). Thus, approximately 80% of the variation in measurements was due to variation in the two methods and 20% was due to ‘true’ variability in sedentary time.

Discussion

Given mounting evidence that SB is an independent risk factor for several adverse health outcomes [10], measurement of SB has become a health research priority. The current study investigated reported time spent by bariatric surgery candidates, a highly sedentary population [12,13], in multiple forms of SB. Results showed that across all days, participants on average spent 1 h/d in each of four different types of SB: television viewing (2.7 h/d), paper/computer work (1.9 h/d), sitting driving or riding in a car (1.2 h/d) and sitting talking on the telephone (1.1 h/d). Together these behaviors accounted for nearly three-quarters (71%) of reported total sedentary time, with television viewing alone comprising more than one-quarter (28%) of total sedentary time. The amount of time that participants in the current study reported devoting to watching television was similar to estimates (range: 2.5 to 3.0 h/d) from previous studies that assessed this behavior preoperatively [19,20]. However, the present study is the first to suggest that bariatric surgery patients allocate more of their daily time to watching television than other common forms of SB. Consequently, television viewing may be an important modifiable target for reducing total sedentary time in bariatric surgery patients.

Few interventions to reduce time spent watching television and/or other forms of SB have been conducted in adults. Otten et al. [25] randomized 36 overweight and obese adults to 3 weeks of either intervention to reduce television viewing time using an electronic lock-out system, or no-intervention control. Objectively-measured viewing time was reduced on average by 2.93 h/d in the intervention group compared to 0.79 h/d in the control group. However, the large reduction in TV viewing time among intervention participants translated into only a modest decrease of roughly 16 minutes in overall time spent sedentary, suggesting that other forms of SB were substituted for television viewing. To date, no interventions to reduce television or other forms of SB in bariatric surgery patients have been conducted. However, a recent observational study found that self-reported television viewing time decreased from 3 h/d preoperatively to 2.4 h/d at 1-year postoperatively, and that this change was independently associated with favorable changes in body composition [20]. These positive findings warrant additional studies conducted within a treatment controlled framework to determine the magnitude of reduction in both time spent watching television and total sedentary time necessary to improve and maintain bariatric surgery outcomes.

The current study also examined the average discrepancy between self-reported and objectively-measured estimates of the total volume of SB via the SBQ and SWA monitor, respectively. The means for time spent in SB per day produced by the two measures were very similar (within 20 minutes of each other). However, the standard deviation of the difference between the two measures was very large (4.6 h/d), and the average discrepancy between the two measures (i.e., ignoring the direction of the discrepancy) was a difference

of nearly 4 h/d. Furthermore, the ICC suggests that agreement between the two measures is poor. Taken together these findings suggest that there is a large amount of random measurement error that tends to balance out across an entire sample, but may make accurate estimation of any single participant's SB highly unreliable.

The above findings highlight the challenges in obtaining accurate information about types and patterns of SB. These challenges are particularly concerning from a treatment perspective given that accurate assessment and self-monitoring are core strategies for behavior change. One potential vehicle for facilitating more accurate self-monitoring of SB as well as reducing sedentary time in bariatric surgery patients is mobile smartphone technology. For example, smartphones allow for a patient's sedentary behavior to be monitored automatically via an on-board accelerometer. These data can be used to deliver individually-tailored behavioral prompts and feedback in a patient's natural environment to modify SB in real time. Additionally, instead of asking individuals to recall information about different types of SB and the context in which they are performed, a measurement approach based on Ecological Momentary Assessment (EMA) via smartphone can be used to prompt individuals to provide this information in real time, thereby limiting bias and improving accuracy^[18]. Future studies are needed to test whether smartphones offer an efficacious approach to both measuring and changing SB in bariatric surgery patients.

The present study has notable strengths. While previous studies conducted in bariatric surgery patients have objectively assessed total sedentary time or self-reported time spent watching television, this study is the first to provide a more comprehensive assessment of self-reported SBs in this population. Additionally, this study is the first to evaluate whether self-reported estimates of total sedentary time are accurate, compared to an objective criterion measure. These findings warrant further research to identify better ways to monitor and intervene on SB in bariatric surgery patients.

This study also has limitations. Our sample was relatively homogeneous with respect to gender (female) and race/ethnicity (White Non-Hispanic) and age (predominantly middle-aged) which may affect generalizability to more diverse samples. The SWA has been shown to accurately measure daily energy expenditure, particularly at lower levels, relative to the doubly labeled water method in mostly lean, healthy individuals^[22]. However, this monitor has not been validated specifically as a measure of SB in bariatric surgery patients. While a previous study^[21] showed that the SBQ has both construct (i.e. inversely related to BMI) and concurrent validity (i.e. related to another validated self-reported measure of SB) in overweight and obese individuals, the level of agreement with objective measures was low. Specifically, there were no significant correlations between accelerometer-assessed sedentary time and SBQ-assessed time spent in and across different forms of SB for men, and for women, the strongest correlation was $r = 0.26$. The discrepancy in sedentary time assessed by the SBQ and objective monitors may be due in part to limitations of the SBQ. For example, participants are not asked about time spent sleeping and can report up to 24 hours of sedentary time per day, thereby potentially contributing to overestimation of sedentary time during waking hours. Also, total sedentary time is calculated by summing separately hours per day spent in each type of SB. However, some of these behaviors may be performed simultaneously (e.g., television-viewing and computer work, computer games and listening to music, etc.) rather than separately which could inflate actual sedentary time. For example, when data from the most extreme case was examined, the participant reported spending 6 h/d in each of 3 SBs (watching television, playing computer/video games, and sitting listening to music) and 3.5 h/d across another 3 SBs for a total of 21 sedentary h/d, whereas the objective monitor only estimated 10 sedentary h/d. Finally, regarding the SBQ, it is also possible that the non-ratio scale of measurement (i.e. 15-minute increments at the low end and a maximum category of 6 hours) may have accounted for additional error and

the low level of agreement between measures. Thus, one possible way to improve the accuracy of this measure is to allow participants enter the number of hours they spend in various SBs, rather than from selecting a category, which would provide a more precise estimate of the amount of time spent per day at smaller increments of time. Despite the SBQ's apparently poor agreement with the objective measure, it is important to note that this measure may still be appropriate to use in larger samples or on a population level, particularly when budget and resources for accelerometers, smartphones, etc. are limited.

It is also possible that the weak associations between measures may be due in part to factors associated with the objective measure. For example, similar to a previous study [21], all of the participants in the current study were severely obese and variability in objectively-assessed sedentary time was low, which could have resulted in poorer agreement. It is also possible that our objective measure misclassified certain activities as sedentary time. For example, it is not known whether the armband is capable of differentiating sitting and lying from standing, which may have resulted in misclassification of standing as sedentary time.

In conclusion, we found that bariatric surgery candidates report engaging in many different types of SB, although on average they allocate nearly 30% of their sedentary time to a single SB—watching television. Consequently, interventions that help patients to substitute television watching with physical activities that are of a light or higher intensity may be efficacious in reducing total sedentary time. Additionally, our results show that while self-reported and objectively-determined estimates of total sedentary time are comparable at the group level, the ability of these different measures to produce similar estimates of total sedentary time at the individual level is limited. Additional research is needed to identify measurement approaches that more accurately assess the secondary characteristics of SB such as the *type* and the *context* in which it is performed, given that this information cannot be obtained from objective measures such as accelerometers.

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Figure 1.

Discrepancy between objectively-monitored and self-reported hours per day spent in sedentary behaviors

Note. SD = Standard deviation. Participants completed the Sedentary Behavior Questionnaire [21] as a self-report measure of daily sedentary time and wore the SenseWear Armband (BodyMedia, Inc, Pittsburgh, Pennsylvania) monitor as an objective measure of daily sedentary time.

Table 1

Reported average hours per day spent by bariatric surgery candidates in different forms of sedentary behavior assessed by the Sedentary Behavior Questionnaire (SBQ)

Behavior	Weekdays		Weekend Days		All Days	
	Mean (median)	SD	Mean (median)	SD	Mean (median)	SD
Television viewing	2.62 (2.00)	1.66	2.85 (3.00)	1.81	2.68 (2.29)	1.64
Computer games	0.81 (0.13)	1.34	0.85 (0.25)	1.27	0.82 (0.25)	1.29
Sit listen to music	0.97 (0.50)	1.42	0.77 (0.50)	1.08	0.91 (0.50)	1.25
Sit talk on the phone	1.12 (0.50)	1.42	0.86 (0.50)	0.97	1.05 (0.50)	1.22
Office/paper work	2.29 (1.00)	2.35	0.83 (0.50)	1.12	1.87 (1.14)	1.80
Sit and read	0.77 (0.50)	0.97	0.81 (0.50)	0.95	0.78 (0.50)	0.92
Play musical instrument	0.01 (0.00)	0.07	0.04 (0.00)	0.28	0.02 (0.00)	0.93
Arts and crafts	0.25 (0.00)	0.73	0.36 (0.00)	0.83	0.28 (0.00)	0.73
Sitting driving in a car	1.15 (1.00)	1.19	1.35 (1.00)	1.27	1.21 (1.00)	1.13