

Objectively Monitored Physical Activity and Sitting Time in Bariatric Patients Pre- and Post-Surgery

Keywords: Physical activity; Sedentary behaviour; Bariatric surgery; Obesity; Activity monitoring

Abstract

Purpose: Sedentary time, or prolonged sitting/lying time, is an emerging risk factor for severe obesity, independent of physical activity (PA). The purpose of this study was to characterize ambulatory PA as well as sitting/lying time using accelerometry before and after bariatric surgery.

Material and methods: Seventeen participants (58.5% female) with a mean age of 46.5 ± 10.1 years, and a Body Mass Index (BMI) of 48.8 ± 6.2 kg/m² scheduled for bariatric surgery were included in the analysis. ActivPAL™ tri-axial accelerometers were attached to the participants' mid-thigh and worn for 24 hours a day for up to seven consecutive days before surgery, and at three, and six months following bariatric surgery. Mean steps, transitions from sitting-to-standing, as well as standing, walking and sitting/lying time per 24 hours were measured.

Results: Prior to bariatric surgery, participants spent 18.6 ± 1.5 hours per 24 hours sitting/lying, representing over 75% of their day. Total sitting/lying time per 24 hours did not change at three or six months after surgery. Baseline accumulated steps per day averaged 6139 ± 2720 and did not change over time.

Conclusions: Given that PA and sitting/lying time per 24 hours are believed to independently contribute to energy balance and health outcomes, clinicians and health professionals should intervene more rigorously to simultaneously reduce daily sitting time and increase levels of PA to help bariatric patients successfully manage their weight over the long-term post-surgery.

Abbreviations

PA: Physical Activity

Introduction/ Purpose

An active lifestyle is one of the strongest predictors of long-term weight control and is associated with improved health outcomes [1]. Sedentary behavior refers to a sitting or reclining posture during commuting, in the workplace, during home and leisure time, and is an emerging risk factor for obesity and cardiovascular disease that is independent of levels of physical activity (PA) [2-5]. Furthermore, severely obese individuals and bariatric surgery candidates seem to report higher levels of sedentary behavior and are less likely to acquire adequate amounts of daily PA compared to the general population [6,7].

A recent review of bariatric candidates awaiting surgery found that they spent 81% of their waking hours engaged in sedentary behaviors, 26% more than the average American adult [8,9]. While various levels of PA have been reported pre-operatively, overall it seems that bariatric patients remain in an inactive state following



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surgery [10,11]. A recent review found that self-reported levels of PA increased after surgery, however the authors stressed that objectively measured PA is required to better understand the PA and sedentary patterns for this population [12,13]. To the best of our knowledge, no studies have simultaneously examined objectively determined PA levels, sitting/lying time, and transitions from sitting-to-standing in bariatric surgery patients from pre- to post-surgery.

The primary aim of this study was to objectively monitor, with the use of wearable accelerometry, ambulatory PA and sitting/lying time per 24 hours before and after bariatric surgery. In addition, the secondary aim was to evaluate associations between sitting/lying time per 24 hours, daily steps, and transitions from sitting-to-standing to changes in body composition obtained from dual energy x-ray absorptiometry (DXA).

Materials and Methods

Participants were recruited from the McGill University Health Center, Montreal, Québec. All participants had been medically cleared for surgery and were recruited from orientation meetings where they received information about study objectives and protocols. Only participants who were ambulatory were eligible to participate in this trial. After having shown interest, patients who met the eligibility criteria for bariatric surgery were approached by the study coordinator [14]. A total of 34 patients were consented, assessed at baseline, and underwent surgery. The number of participants included in the analysis for this study was 17. Exclusion from analysis occurred due to failed recordings with the ActivPAL™ in 13 participants at the three-month, and 17 participants at the six-month post-surgical follow-ups. All participants underwent roux-en-y gastric bypass surgery. The protocol was reviewed and approved by the Institutional Review Board of McGill University and all participants provided informed consent.

Height and weight were measured using a wall-mounted stadiometer and a bariatric scale (SECA™ Medical Scales and Measuring Devices, U.S.) respectively. Body composition was assessed using the Lunar iDXA™ (GE Healthcare™, USA) whole body composition scanner previously described [15].

Objective assessment of PA and sitting/lying time was obtained using a wearable tri-axial accelerometer known as the ActivPAL™ (PAL Technologies Ltd., Glasgow, UK). This device detects limb position using an inclinometer that samples at 10 Hz and provides output in 15 second epochs. This unobtrusive activity monitor has been validated and is reliable to evaluate steps/day (a strong indicator of physical activity and successful long-term weight loss [1]), time spent in sitting/lying behaviors (an emerging risk factor for obesity and cardiovascular disease that is independent of levels of PA [2-5]), sit-to-stand transitions (a marker of bouts of sedentary time [16]), standing, and walking time [17,18]. During the initial baseline visit, the ActivPAL™ was placed inside a finger cot and affixed on the participant’s mid-thigh using a Tegaderm™ adhesive patch. Participants were asked to remove the unit only upon bathing or undertaking any other prolonged underwater-related activity. Following the seven-day wear period, the unit was returned by mail and the participants’ data uploaded through ActivPAL™ v6.3.4 software. A valid wear period was defined as a minimum of three days with at least one weekend-day. The height, weight, body composition, and ActivPAL™ measures were assessed again at three, and six months after surgery. All accelerometer measures were examined for both weekdays and weekends for both evenings (6:00 PM to 12:00 AM, commonly an adult’s weekday leisure time), and the total 24 hours/day. For this analysis, sitting/lying time per 24 hours was used instead of daily sedentary time as sleeping logs were not used during the initial data collection period. Without a self-monitored sleep log, the ActivPAL™ is not capable of distinguishing between daily sedentary time and total sitting/lying time (PAL Technologies Ltd., Glasgow, UK).

Longitudinal changes in sitting/lying time per 24 hours, steps/day and sit-to-stand transitions were examined using a repeated measure analysis of covariance (ANCOVA), with adjusted means reported controlling for age and seasons. Relationships between variables of interest were assessed using Pearson’s correlation coefficient. Alpha was set at $p < 0.05$ and all analyses were conducted using IBM™ SPSS version 20. In order to identify a clinically meaningful change in sitting/lying time per 24 hours and PA, a modest Effect Size of 0.6 was used, alpha was set at 0.05, and β at 0.80 using a repeated measures design with three assessment points [19]. Along with previous findings, we estimated that with 17 participants, a clinically meaningful reduction in sitting/lying time per 24 hours of 1 hour/day, and increases of 1600 steps/day with 10 sit-to-stand transitions would be required.

Results

Seventeen severely obese individuals (ten female and seven male) with a mean age of 46.5 ± 10.1 years, BMI of 48.8 ± 6.2 kg/m², height of 168.7 ± 0.1 cm, total body weight of 140 ± 26.4 kg, and percent body fat of $50.5 \pm 4.8\%$, were included in the ANCOVA. Weight related measures are presented in Table 1 in addition to their changes at month’s three and six post-surgery. Weight was reduced significantly

at three-months ($p < 0.001$) and continued to decline at six-months ($p < 0.001$) after surgery.

Participants wore the ActivPAL™ across all time points on average 5.2 ± 0.7 days, including 3.3 ± 0.7 days during the week and 1.9 ± 0.3 on weekend days. Participants’ average sitting/lying time per 24 hours, sit-to-stand transitions, standing time, walking time, and steps/day are presented in Table 2.

As seen in Table 2, sitting/lying time per 24 hours demonstrated no change from baseline to three ($p = 0.969$) and six-months ($p = 0.308$) post-surgery. Age and season-adjusted total steps/day averaged 6139 ± 2720 and did not change over the six months post-surgery (Table 2). Prior to surgery, 41% of participants accumulated below the inactive lifestyle threshold of < 5000 steps/day, 29% were in the low-active category (5000-7500 steps/day), while 24% were classified as somewhat active (7500-9999 steps/day), and 6% as active (≥ 10000 steps/day) [20]. Post-surgery, no differences were observed in the step count activity classification categories mentioned above (Figure 1). At baseline, steps/day during the week and on weekends was similar, averaging 6213 ± 2732 and 6059 ± 3189 steps/day respectively ($p = 0.796$). This pattern of activity did not change at three- ($p = 0.237$), or six-months ($p = 0.733$) after surgery. In addition, the number of steps accumulated during evening leisure time averaged 1206 ± 532 at baseline, representing 22% of the total daily steps taken, which also did not change following surgery (Table 2).

Participants spent 18.6 ± 1.5 hours per 24 hours in sitting/lying positions, representing over 75% of their day. In addition, sitting/lying time per 24 hours did not differ between the week and weekend at baseline ($p = 0.926$), three-months ($p = 0.621$), or six-months ($p = 0.449$) after surgery respectively. Changes in daily and evening leisure sitting/lying times at baseline, three, and six-months are displayed in Table 2.

Transitions accumulated per day did not change over time, as participants before surgery made 54.8 ± 19.7 transitions per day, and at three, and six-months after surgery averaged 49.1 ± 14.3 and 49.6 ± 12.6 transitions per day respectively. In addition, no changes in sit-to-stand transitions were observed between weekdays or weekends before surgery ($p = 0.125$), at three ($p = 0.672$), or six- ($p = 0.246$) months after surgery.

No relationships were observed between body fat percentage and changes in steps/day or overall sitting/lying time (all r values < 0.20) at either three- or six-months after surgery. While the number of sit-

Table 1: Weight and body composition related variables before and after bariatric surgery.

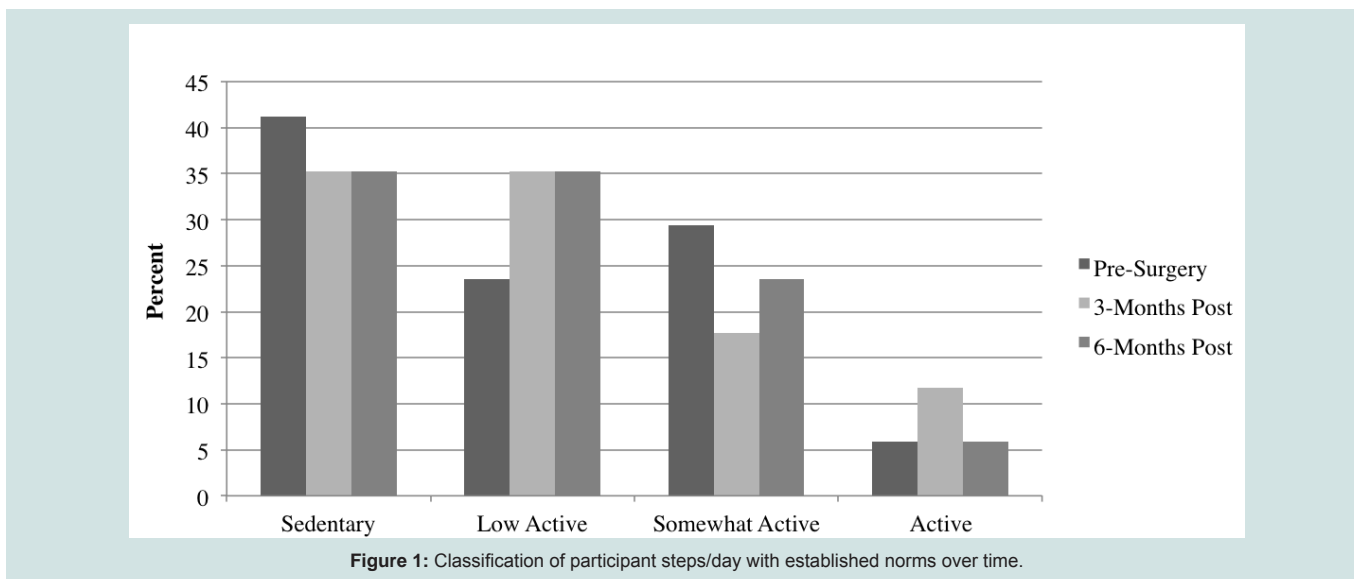
Parameter	Baseline	Postoperatively	
		3 Months	6 Months
Body Weight (kg)	140.0 ± 26.4	110.0 ± 24.4*	99.7 ± 26.1*†
BMI (kg/m ²)	48.8 ± 6.2	38.4 ± 6.8*	34.8 ± 7.5*†
Percent Body Fat (%)	50.5 ± 4.8‡	46.4 ± 6.0*	41.1 ± 7.0*†
Weight Loss (kg)	-	30.2 ± 9.8	40.3 ± 13.0†
Weight Loss (%)	-	21.6 ± 6.1	29.1 ± 8.8†

Data presented as mean ± SD, * $p < 0.05$ from baseline, † $p < 0.05$ from 3 months to 6 months, ‡ $n = 15$, Two patients exceeded weight limit for iDXA at baseline. BMI: Body Mass Index

Table 2: Bariatric surgery patients daily steps and time-spent sitting/lying across time.

Parameters	Baseline	Postoperatively	
		3 Months	6 Months
Sitting/Lying Time (hours/day)†	18.6 ± 1.5	18.3 ± 1.7	18.1 ± 1.6
WeekdaySitting/Lying Time (hours/day)	18.5 ± 1.8	18.3 ± 1.8	18.2 ± 1.8
Week-End Sitting/Lying Time(hours/day)	18.7 ± 1.9	18.1 ± 1.9	17.8 ± 1.9
Steps/day†	6139 ± 2720	6068 ± 3034	6913 ± 3073
Weekday Steps/day	6212 ± 2732	6303 ± 3227	6979 ± 3527
Week-End Steps/day	6059 ± 3189	5967 ± 3277	6739 ± 3109
Transitions/day†	54.77 ± 19.70	49.1 ± 14.28	49.59 ± 12.65
Weekday Transitions/day	57.16 ± 22.28	50.36 ± 15.29	51.26 ± 16.57
Week-End Transitions/day	49.76 ± 18.04	47.46 ± 17.93	47.32 ± 10.55
Walking Time (hours/day) †	1.42 ± .56	1.38 ± .58	1.54 ± .57
Weekday Walking Time (hours/day)	1.43 ± .56	1.43 ± .63	1.54 ± .66
Week-End Walking Time (hours/day)	1.43 ± .68	1.32 ± .69	1.53 ± .61
Standing Time (hours/day) †	5.41 ± 1.51	5.69 ± 1.66	5.92 ± 1.62
Weekday Standing Time (hours/day)	5.53 ± 1.80	5.66 ± 1.81	5.82 ± 1.76
Week-End Standing Time (hours/day)	5.28 ± 1.87	5.94 ± 1.93	6.16 ± 1.92

*Variables are expressed as mean ± S.D., † represent values averaged across all days



to-stand transitions per day did not increase after surgery, a negative correlation between the number of transitions per day and body weight was displayed across all time points (baseline: $r = -0.49$; $p = 0.044$; three-months post; $r = -0.51$; $p = 0.038$; six-months post; $r = -0.6$; $p = 0.011$).

Discussion

An active lifestyle including structured exercise as well as recreational activities along with active transportation [21] is associated with long-term weight control among individuals who have lost and successfully maintained great amounts of weight over time [22]. This investigation objectively measured time spent sitting/lying per 24 hours, steps as well as sit-to-stand transitions,

and confirmed that participants were not sufficiently active while awaiting bariatric surgery. Moreover, steps/day, sitting/lying time per 24 hours, and sit-to-stand transitions did not change at the third or even sixth-month following surgery as compared to baseline values, despite dramatic and significant weight loss. Participants who were already overly sedentary and not meeting PA guidelines failed to become more active and reduce sitting/lying time after bariatric surgery. These findings are consistent with other studies examining the PA habits of bariatric patients before surgery where low levels of PA and elevated levels of sedentary behaviors are common [6,23].

On average, participants did not achieve the active threshold of ≥ 10000 steps/day [20] at any time before or after bariatric surgery (Table 2), which is comparable to the results of 5784 steps/days obtained

for obese individuals through the National Health and Nutrition Examination Survey (NHANES) [24]. Although no participants reached the active threshold of ≥ 10000 step/day [20] before surgery, one participant did at month three, and another at month six after surgery, albeit different participants at each time point. This indicates that because no singular participant maintained this recommended level of activity throughout both post-surgical evaluations, that these single active threshold breaks within each assessment period may be more indicative of temporary short-term activity bouts, than the desired change in lifestyle habits required for long-term post-surgery weight loss maintenance. This observation is strengthened by the lack of post-surgical changes in any of the accelerometer derived activity data even when examined for week-days, weekend-days, during the day, and throughout evening leisure time (Table 2).

Alarming, nearly one quarter of participants failed to exceed even the 5000 steps/day sedentary threshold before and after surgery. Similarly, the Longitudinal Assessment of Bariatric Surgery Study found that before surgery, 41% of patients were somewhat active or active, 34% were low active, and 20% were sedentary [10] using Tudor-Locke's step/day activity index [20]. In 2012, King et al. followed up with the aforementioned cohort and found them insufficiently active one-year after surgery [11]. This extreme level of inactivity is associated with multiple health risks including poorer lipid profiles and weight gain [2-5].

Interventions to increase PA and reduce sedentary time are needed to convey the connection between lifestyle changes and long-term weight loss maintenance for individuals who undergo this surgical procedure [25-27]. A recent study by Bond et al. underlined the importance of considering the intention to exercise in individuals who had undergone the surgery six-months prior. Results indicated that few participants intended to be active on most days of the week and nearly all participants had difficulty achieving the intended levels of PA. These findings suggest that the intention to exercise is not sufficient and that future research should involve tailored interventions to promote and reinforce active living through lifestyle and behaviour change [28]. As walking is one of the easiest and safest ways to establish an exercise program for obese individuals [8], steps/day may be the optimal prescription immediately following surgery. However, the intensity, duration and type of PA should be considered throughout the entire lifetime in order to obtain optimal long-term results [29]. Additionally, this study suggests that encouraging severely obese individuals to increase the number of their sit-to-stand transitions may be an important behavior to target through such an intervention. There is evidence that breaking up long periods of sitting time is beneficial for avoiding weight gain independent of total daily sedentary time [16], and therefore should be incorporated as another potential area of reducing overall sedentary behaviour, specifically for long-term weight loss maintenance.

We acknowledge that a small sample size may limit the interpretation of these data. However, this study demonstrated that following standard of care, individuals who have undergone bariatric surgery remained inactive even after a major medical procedure designed to reduce weight and improve mobility. Moreover, strength of our study is that it is one of the first investigations to objectively measure the transitions, walking time, and standing time of individuals

undergoing bariatric surgery. At the time of data collection, sleeping journals were not used which is why all measures of sitting/lying time (i.e., sedentary time) include sleep time. Studies have reported that in this short time following surgery that few to no changes in sleep length and quality occur [30] leaving us confident that the lack of change in sitting/lying time per 24 hours, sit-to-stand transitions and steps/day from pre-to post-surgery describe a lack in behaviour change as a whole. Moreover, analysis of NHANES data show that 36.4% of Americans spend ≤ 6 hours/ 24 hours sleeping and 56.1% average only 7 to 8 hours/ 24 hours sleeping [31]. Subtracting even the maximum of 8 hours of sleep from this study's recorded sitting/lying time per 24 hours still identifies that the participants of this study were sitting/lying considerably more than that of the national average of 7.7 waking hours [9]. However, future investigations should seek to more accurately quantifying sleep time through sleep journals. A relatively equal number of men and women took part in this study.

Conclusions

In conclusion, individuals who have undergone bariatric surgery receiving standard care did not change their PA or sitting/lying time per 24 hours in the first three and six-months following surgery. Since both PA and sedentary behavior are believed to independently contribute to energy balance and weight control, combined messages to increase activity levels while simultaneously reducing sedentary time may help bariatric surgery patients achieve optimal weight loss maintenance and health outcomes in the long-term. Further research is needed to determine how health professionals can best intervene with this population in order to develop effective strategies that will promote long-term weight loss maintenance among individuals who have undergone bariatric surgery.

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