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ORIGINAL CONTRIBUTIONS

Impacts of Supervised Exercise Training in Addition to Interdisciplinary Lifestyle Management in Subjects Awaiting Bariatric Surgery: a Randomized Controlled Study

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Abstract

Background Experts recommend physical activity (PA) to optimize bariatric surgery (BS) results. However, evidence on the effect of PA before BS is missing. The aim of this study was to assess the impact of adding a Pre-Surgical Exercise Training (PreSET) to an interdisciplinary lifestyle intervention on physical fitness, quality of life, PA barriers, and anthropometric parameters of subjects awaiting BS.

Methods Thirty candidates for BS (43.2 ± 9.2 years, 47.5 ± 8.1 kg/m^2) have been randomized in two groups: one group following the PreSET (endurance and strength training) and another receiving usual care. Before and after 12 weeks, we assessed physical fitness with a battery of tests (symptom-limited exercise test, 6-min walk test (6MWT), sit-to-stand test, half-squat test, and arm curl test), quality of life with the laval questionnaire, and PA barriers with the physical exercise belief questionnaire.

Results One control group subject abandoned the study. Subjects in the PreSET group participated in 60.0 % of the supervised exercise sessions proposed. Results showed significant improvements in the 6MWT (17.4 ± 27.2 vs. −16.4 ± 42.4 m; $p = 0.03$), half-squat test (17.1 ± 17.9 vs. −0.9 ± 14.5 s; $p = 0.05$), arm curl repetitions (4.8 ± 2.3 vs. 1.0 ± 4.1; $p = 0.01$), social interaction score (10.7 ± 12.5 vs. −2.1 ± 11.0 %; $p = 0.02$), and embarrassment (−15.6 ± 10.2 vs. −3.1 ± 17.8 %; $p = 0.02$) in completers ($n = 8$) compared to the non-completers ($n = 21$). No significant difference between groups in BMI and other outcomes studied was observed after the intervention.

Conclusions Adding a PreSET to an individual lifestyle counselling intervention improved physical fitness, social interactions, and embarrassment. Post-surgery data would be interesting to confirm these benefits on the long term.

Keywords Physical activity · Severe obesity · Physical fitness · Quality of life · Bariatric surgery

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Introduction

For individuals with severe obesity, bariatric surgery (BS) is the most effective treatment for weight loss and maintenance, as well as for improving comorbidities and mortality [1]. Experts recommend physical activity (PA) to optimize BS results [2]. However, the majority of individuals awaiting BS are inactive and do not increase their PA level after BS [3]. The introduction of PA changes is not easy for individuals with severe obesity because of poor exercise tolerance and the presence of weight-related and unrelated barriers that can prevent them from reaching the recommended level of PA [4, 5]. Therefore, individualized interventions need to be developed to help them.

PA interventions before BS seem interesting since the motivation to practice PA increases as BS approaches [6]. Furthermore, preoperative beliefs about the benefits and barriers of exercising predict higher postoperative PA [7]. In addition, interventional studies suggest that PA interventions before BS have positive impacts on quality of life, embarrassment during PA, and physical fitness (PF) [8–10]. However, more high-quality studies are required to improve the level of evidence [8]. Thus, the aim of this study was to assess the impact of adding a Pre-Surgical Exercise Training (PreSET) to an interdisciplinary lifestyle intervention on PF, quality of life, PA barriers, and anthropometric parameters of subjects awaiting bariatric surgery.

Materials and Methods

Experimental Design

The study was conducted at the Centre hospitalier universitaire de Sherbrooke (CHUS). Participants were enrolled between June 2012 and May 2014. After the baseline assessment, participants were randomly assigned to the PreSET or usual care group using a 1:1 allocation ratio. Allocation was generated by a computer random sequence, stratified by sex and maximal aerobic capacity (> or ≤7 metabolic equivalent of task (MET)) and kept in sealed envelopes. Before and after 12 weeks, anthropometric variables, body composition, PF, quality of life, and PA barriers were assessed, and sociodemographic data were collected. Obesity-related comorbidities were identified in medical charts. A satisfaction questionnaire was completed during the final visit. The study protocol was approved by the Ethics Review Board of research on humans of the CHUS and Université de Sherbrooke. Informed consent was obtained from all individual participants included in the study. This trial was registered at clinicaltrials.gov (NCT01452230).

Participants

Adult candidates for BS were eligible if they were expected to be operated on within 3 to 6 months and practiced less than two weekly supervised exercise sessions. Exclusion criteria for candidates were as follows: (i) unable to regularly attend supervised exercise sessions, (ii) with medical contraindication for PA, (iii) with functional limitations not allowing them to complete the 6-min walking test (6MWT), (iv) unable to understand French, or (v) with uncontrolled neuropsychiatric illnesses.

Interventions

The two groups continued to receive usual care, including individual lifestyle counselling sessions and access twice weekly to supervised educational group sessions called "the Motivated Club" (education and knowledge exchange to maintain motivation) [11]. When subjects started the program, at least 9–12 months before surgery, the dietician and PA specialist meet them individually during 15 min every 6 weeks for the first 6 months, then every 8 weeks until the surgery. The level of PA, stage of change, conviction and confidence levels, motivation, beliefs, barriers, and preferences are evaluated regularly by the two professionals. Several strategies (goal setting, cognitive restructuring, problem solving, self-reward, facilitation social supports, and relapse prevention) were used during appointments to help patients improve or maintain their lifestyle.

The detailed PreSET has been described elsewhere [10]. Briefly, exercise sessions consisted of three weekly 80-min sessions of endurance and strength training with monthly aquagym.

Physical Fitness

A symptom-limited cardiac exercise test was performed to assess aerobic maximal capacity and obtain peak heart rate used for exercise training. The stress test protocol (Cornell 0, 5, 10 or Bruce) [12, 13] was performed on a treadmill based on the baseline PF of participants to obtain a test between 8 and 12 min as recommended for optimal estimation [14]. One subject performed the test on a cyclo-ergocycle at 60–70 rpm, starting at 30 W with increments of 15 W per minute [15], because of knee pain. The MET of the peak exercise was calculated using the ACSM equations [14].

The 6-min walk test (6MWT) was performed to evaluate functional capacity [16]. The sit-to-stand test, the half-squat test, and the arm curl test were used to assess muscular endurance of the upper and lower limbs, as previously described [10].

At the end of each test, participants assessed their effort with the Borg rating scale perceived exertion ranging from 6 to 20 [17]. Participants were also asked to localize and rate their pain based on visual analog scales (0–10) after each PF test.

Weight-Related Quality of Life

The laval questionnaire validated in participants with severe obesity and sensitive to treatment changes was used [18]. Forty-four questions are divided into six domains: symptoms, activity/mobility, personal hygiene/clothing, emotions, social interactions, and sexual life. Final scores are expressed in percentage of maximal score and total score was created by adding all the subscales' scores.

Physical Exercise Beliefs and Barriers

PA benefits and perceived psychological barriers were assessed with the physical exercise belief questionnaire [4, 10]. Sixteen questions are divided into four areas: benefits of exercise, confidence, embarrassment, and fear of injury. The barriers to being physically active quiz was used to assess the following barriers: lack of time, social influence, lack of energy, lack of willpower, fear of injury, lack of skill, and lack of resources [19]. The scores of these questionnaires were transformed into percentages of maximal score.

Physical Activity Level

PA was evaluated with the International PA Questionnaire-Short Form (IPAQ-SF) [20]. Subjects were asked the number of minutes of walking, moderate and vigorous PA, and sitting time during the last 7 days. A total PA MET-minutes/week score was calculated according to IPAQ guidelines.

Anthropometric Measures, Body Composition, and Blood Pressure

Height and neck circumference were measured using standard protocols [10]. Body and fat mass were assessed in light clothing with a calibrated bipodal bioimpedance scale (Tanita TBF-300A®) [10, 21].

Blood pressure and HR were measured after 5 min of rest in sitting position with an automatic blood pressure device (Omron HEM 741®). The average of two measurements was used for analysis.

Satisfaction

A questionnaire using five-point Likert scales evaluated satisfaction with the PreSET [10] and the PA counselling sessions of the usual care.

Statistical Considerations

Given the non-normality of the majority of variables (assessed with normal quantile plots and normal curves), non-parametric analyses were conducted. The results are presented as median values (25–75th percentiles). The only subject who abandoned the research project was in the usual care group and was excluded from all analyses. Baseline characteristics and the 12-week changes (pre-/post-test difference) were compared between groups with Mann-Whitney for scale data or chi-square tests for nominal data. The effects of training within groups were tested with Wilcoxon signed-rank tests for scale data and with the McNemar test for nominal data. The first analyses were conducted with an intention-to-treat approach, and the second compared completers with an attendance rate below or equal to two thirds (66.6 %) to non-completer participants. The attendance rate was calculated as reported elsewhere [10]. Data were analyzed with SPSS version 22.0 (SPSS Inc., Chicago, IL). The null hypothesis was rejected at $p \leq 0.05$.

Results

Population

The participant flow chart is presented in Fig. 1 and baseline characteristics of participants in Table 1. No significant difference between the completer and non-completer groups was noted, except that the completers had more sleep apnea compared to the non-completers (100 vs. 52.4 %; $p = 0.02$).

Physical Activity Intervention Attendance

The subjects attended a median of 60.0 % (42.4–90.6) of the total supervised exercise sessions and 68.4 % (52.8–92.1) of the total exercise sessions required at home or at the CHUS. Occasional muscle or joint pain and three cases of hypoglycemia (one patient) were reported during exercise sessions.

Physical Fitness

Significant 12-week changes were noted between the PreSET and usual care groups in the 6MWT distance (+7.5 (−4.8–19.5) vs. −20.0 (−57.8–1.8) m; $p = 0.013$), 6MWT heart cost (+0.2 (0.0–0.4) vs. −0.1 (−0.5–0.0) m/beats/min; $p = 0.001$), and arm curl repetitions (+7.0 (0.8–8.3) vs. +1.0 (−2.3–2.3); $p = 0.006$). Completers' results are presented in Table 2.

Among subjects who rated pain during tests, the vast majority suffered from knee pain ($n = 22$), followed by upper limbs ($n = 9$), feet ($n = 6$), hips ($n = 4$), and back pain ($n = 3$). Pain data in completers are presented in Table 2.

Weight-Related Quality of Life

Intention-to-treat analyses showed no significant difference in weight-related quality of life (WRQOL) changes between intervention groups. The completers reported greater improvement in social interactions compared to the non-completers (+6.1 (2.0–20.4) vs. 2.0 (−10.2–2.0); $p = 0.02$).

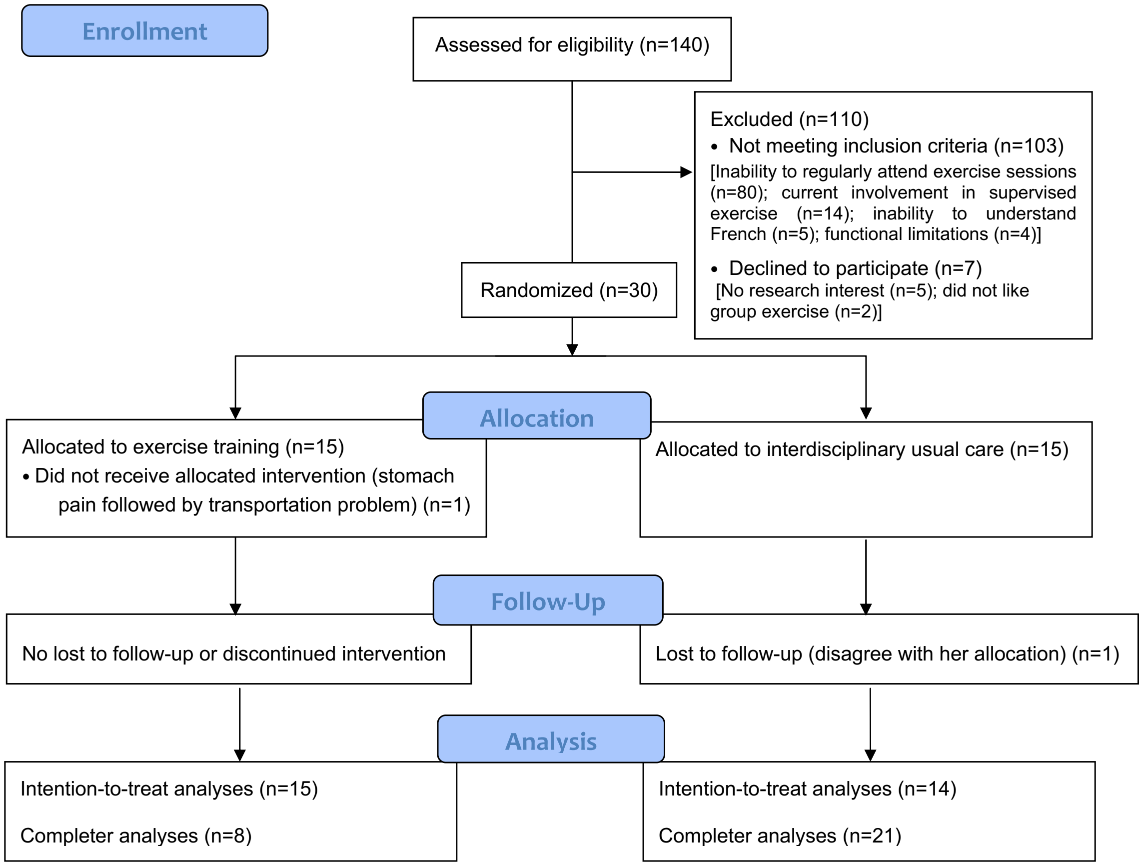

Fig. 1 CONSORT 2010 flow of participant enrollment, allocation, follow-up, and analysis

Physical Exercise Beliefs and Barriers

Intention-to-treat analyses indicated no significant difference in changes in physical exercise beliefs and barriers between groups. Embarrassment, lack of energy, and skills were significantly reduced in completers after the PreSET ($p < 0.05$) and PA benefits in the non-completers ($p = 0.049$). Analyses showed differences in embarrassment change between completers and non-completers (−12.5 (−27.5 to −6.3) vs. 0.0 (−13.8–7.5); $p = 0.02$), with a trend for difference in lack of skills (−22.2 (−30.6 to −2.8) vs. 0.0 (−22.2–11.1); $p = 0.075$).

Physical Activity Level

In the intention-to-treat and completers' analyses, there is no significant change or group interaction effect concerning the number of minutes per week of walking and moderate PA, sitting time, and total energy expenditure. The number of minutes per week of vigorous PA was significantly increased in the PreSET (+107.5 (0.0–247.5) min; $p = 0.05$) and completer groups (+107.5 (43.8–225.0) min; $p = 0.02$) with a trend for group interactions in the intention-to-treat ($p = 0.06$) and completer analyses ($p = 0.09$).

Anthropometric Measures, Body Composition, and Blood Pressure

No change was found in anthropometric, body composition, and blood pressure in the PreSET and usual care groups. No difference in changes between groups was noted. Completers' results are presented in Table 2.

Satisfaction

All the participants were very satisfied or satisfied by the coaching and advice provided by the PA specialist, training infrastructure, intensity and level of difficulty, frequency, and available material during the PreSET. Only one subject was only moderately satisfied by the evening schedule and the training place.

The level of satisfaction during usual care PA counselling sessions was high. No significant difference was found between groups concerning the PA counselling satisfaction.

Discussion

In accordance with our pilot study results [10], a PreSET is feasible and effective to improve PF, social interactions, and

Table 1 Baseline characteristics of participants

	PreSET group ($n = 15$)	Usual care group ($n = 14$)
Sociodemographic data		
Age (years)	41.4 (38.3–54.3)	43.3 (36.5–47.1)
Female (%)	80.0	78.6
Married/in a civil union (%)	60.0	50.0
Post-secondary education (%)	46.7	28.6
Employed (%)	73.3	57.1
Family annual income ≥$60,000 (%)	23.1 ($n = 13$)	50.0 ($n = 12$)
Smoker (%)	0	7.1
km from Sherbrooke	0.0 (0.0–26.2)	0.0 (0–8.5)
Anthropometric and medical data		
Body mass index (kg/m^2)	44.8 (42.1–53.0)	47.8 (40.3–54.0)
Neck circumference (cm)	42.5 (38.4–45.2)	42.7 (39.7–46.0)
Fat mass (%)	48.6 (45.1–52.8)	49.6 (46.0–51.5)
Systolic blood pressure (mmHg)	123.5 (113.0–134)	118.3 (112.0–124.9)
Diastolic blood pressure (mmHg)	75.0 (66.5–81.5)	75.8 (70.0–85.1)
Resting heart rate (beats/min)	72.0 (65.0–72.0)	77.0 (68.5–83.0)
Hypertension (%)	53.3	21.4
Dyslipidemia (%)	46.7	50.0
Type 2 diabetes (%)	33.3	35.7
Prediabetes (%)	20.0	21.4
Sleep apnea (%)	66.7	64.3
Heart and vascular diseases (%)	13.3	7.1
Asthma (%)	20.0	14.3
Hypothyroidism (%)	0	35.7*
Anxiety and/or depression (%)	26.7	35.7
Arthritis and/or arthrosis (%)	26.7	28.6
Physical fitness		
6MWT distance (m)	458.0 (432.0–532.0)	475.5 (412.0–520.0)
6MWT heart cost (m/beats/min)	3.7 (3.2–4.0)	3.7 (2.9–4.0)
Sit-to-stand repetition	13.0 (10.5–18.5) ($n = 14$)	13.5 (8.8–19.3)
Half-squat duration (s)	19.0 (9.8–41.0) ($n = 14$)	26.0 (14.5–45.5) ($n = 13$)
Arm curl repetition	21.0 (16.0–23.0)	22.0 (19.8–25.3)
Maximal aerobic capacity (METS)	7.5 (5.3–9.2)	6.6 (5.0–8.9) ($n = 13$)
Physical activity		
Intense (min/week)	0 (0–30)	13 (0–248)
Moderate (min/week)	90 (30–240)	210 (83–300)
Walking time (min/week)	90 (30–180)	133 (86–245)
Total (MET-min/week)	1017 (560–2534)	1940 (920–3755)
Sitting time (min/day)	370 (240–540)	510 (285–638)

Data are presented with median (25–75th percentiles)

6MWT 6-min walk test, *METS* metabolic equivalent tasks, *PreSET* Pre-Surgery Exercise Training

*$p = 0.02$ compared to PreSET group

embarrassment. PF improvements are relevant, given that good PF is associated with a decrease in cardiometabolic risk markers, premature mortality, length of hospital stay after surgery, and short-term complications in individuals with severe obesity [22, 23]. Nevertheless, the extent of PF change required to reduce operative risk and improve cardiometabolic risks needs to be investigated in this population.

Social interaction score also improved after 12 weeks of PreSET, in accordance with another study on preoperative PA counselling [9]. We suppose that group interactions [5], the

Table 2 Impacts of 12 weeks of pre-surgical exercise training in completers and non-completers

	Non-completer group				Completer group				
	N	Baseline	After 12 weeks	*p* time values	*N*	Baseline	After 12 weeks	*p* time values	*p* value interaction
Anthropometric and medical data									
Body mass index (kg/m^2)	21	45.6 (39.9–53.1)	45.7 (38.5–54.7)[a]	0.46	8	45.3 (43.7–53.5)	45.5 (43.3–53.3)[b]	0.21	0.75
Neck circumference (cm)	21/20	42.5 (39.0–45.7)	42.4 (38.3–44.5)	0.51	8	40.9 (37.5–44.5)	40.6 (37.2–45.7)	0.78	0.33
Fat mass (%)	21/20	49.2 (44.9–51.6)	47.5 (42.0–50.4)	0.02	8	49.5 (45.7–52.7)	49.8 (46.7–53.7)	0.04	0.009
Systolic blood pressure (mmHg)	21	119.5 (112.8–129.0)	115.0 (113.3–127.0)	0.46	8	122.0 (111.9–134.0)	123.8 (106.3–128.9)	0.26	0.63
Diastolic blood pressure (mmHg)	21	75.0 (70.0–85.3)	77.0 (69.5–84.3)	0.66	8	74.8 (66.1–80.6)	73.0 (61.8–79.8)	0.44	0.45
Resting heart rate (beats/min)	21	76.0 (68.0–82.0)	77.0 (71.0–86.0)	0.52	8	72.0 (64.8–85.0)	73.0 (64.0–79.8)	0.30	0.35
Physical fitness									
6-min walk test									
Distance (m)	21/20	462.0 (427.5–512.0)	457.5 (405.5–509.0)	0.13	8	489.0 (418.8–582.3)	502.0 (466.5–576.5)	0.12	0.03
Heart cost (m/beats/min)	21/20	3.6 (3.1–4.0)	3.6 (3.2–3.8)	0.31	8	3.8 (3.3–4.1)	4.0 (3.6–4.5)	0.02	0.006
Perceived exertion	18/20	13.0 (11.0–15.0)	12.3 (11.0–13.8)	0.48	8/7	13.0 (13.0–16.0)	14.0 (12.0–16.5)	0.32	0.85
Pain (% of subjects)	21/20	28.6	60.0	0.03	8	12.5	50.0	0.25	0.88
Pain intensity scores	21/20	0.0 (0.0–5.0)	3.8 (0.0–5.8)	0.07	8	0.0 (0.0–0.0)	1.5 (0.0–6.3)	0.14	0.96
Sit-to-stand test									
Repetition (*n*)	20/19	13.5 (9.0–19.8)	12.0 (10.0–17.0)	0.20	8	13.0 (11.5–14.0)	16.0 (16.0–18.5)	0.049	0.11
Perceived exertion	20/19	12.0 (11.0–13.0)	13.0 (11.0–13.0)	0.68	8	12.5 (10.3–13.8)	12.5 (12.0–13.8)	0.55	0.89
Pain (% of subjects)	20/19	50.0	57.9	0.73	8	37.5	37.5	1.0	0.79
Pain intensity scores	20/19	1.0 (0.0–5.8)	4.0 (0.0–6.5)	0.23	8	0.0 (0–7.8)	0.0 (0.0–6.5)	0.59	0.41
Half-squat test									
Time (s)	19	26.0 (13.0–43.0)	28.0 (17.0–38.0)	0.92	8	19.0 (9.8–34.3)	38.5 (25.5–54.8)	0.04	0.05
Perceived exertion	19/18	15.0 (15.0–17.0)	15.0 (110–16.6)	0.07	8	15.0 (15.0–17.0)	15.0 (12.3–15.8)	0.18	0.86
Pain (% of subjects)	19/18	47.4	66.7	0.13	8	37.5	37.5	1.0	0.23
Pain intensity scores	19/18	0.0 (0.0–7.0)	6.0 (0.0–8.3)	0.01	8	0.0 (0.0–8.8)	0.0 (0.0–8.0)	0.56	0.14
Arm curl test									
Repetition (*n*)	21/20	22.0 (19.5–25.0)	22.5 (17.0–27.0)	0.28	8	18.0 (15.3–22.5)	25.0 (20.3–29.0)	0.02	0.01
Perceived exertion	21/20	8.0 (7.0–11.0)	9.5 (7.0–11.0)	0.28	8	9.0 (7.0–12.0)	10.5 (9.3–11.0)	0.09	0.44
Pain (% of subjects)	21/20	4.8	20.0	0.38	8	12.5	12.5	1.0	0.23
Pain intensity scores	21/20	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.08	8	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.32	0.57
Symptom-limited cardiac exercise									
Maximal aerobic	20/19	7.0 (5.3–8.7)	7.2 (6.1–10.0)	0.10	8	7.4 (5.4–10.3)	8.4 (6.3–12.6)	0.02	0.08

Table 2 (continued)

	Non-completer group				Completer group				
	N	Baseline	After 12 weeks	*p* time values	*N*	Baseline	After 12 weeks	*p* time values	*p* value interaction
capacity (METS)									
Pain (% of subjects)	20/19	70.0	55.6	0.13	8	62.5	50.0	1.0	0.52
Pain intensity scores	20/18	6.0 (0.0–8.0)	3.0 (0.0–8.0)	0.18	8	3.5 (0.0–7.4)	1.0 (0.0–7.0)	0.36	0.72

Data are presented with median (25–75th percentiles). Half-squat ($n = 2$) and sit-to-stand ($n = 1$) missing data are explained by the inability to perform the test by participants because of knee pain. One usual care participant did not perform the symptom-limited cardiac exercise because of functional limitations due to a knee prosthesis. One PreSET participant did not come to the final assessment because of pneumonia, but completed questionnaires at home (except IPAQ), and weight and blood pressure were extracted from the medical chart

[a] Change in BMI = −0.37 (−1.0–0.15), % excess weight loss = −2.0 (−3.7–0.7), % total body weight loss = −0.9 (−2.1–0.3)

[b] Change in BMI = −0.24 (−1.0–0.6), % excess weight loss = −1.1 (−4.9–2.6), % total body weight loss = −0.4 (−2.2–1.3)

greatest attention, and encouragements provided by the PA specialist during the PreSET can partly explain these benefits. Nevertheless, unlike Bond et al. [9], we did not find other score improvements. Our small sample size (statistical power <40 %) or the obese-specific WRQOL questionnaire used in our study in comparison to the SF-36 used by Bond [9] could explain this discrepancy.

In addition, the PreSET improved several PA barriers. However, no change in confidence or fear of injury was noticed after the PreSET. The length or type of our intervention, the sample size (statistical power <30 %), and the absence of weight loss could explain these non-significant changes in these secondary outcomes. Weight loss seems to play an important role to improve confidence, since it is significantly improved after BS [7]. Long-term data exploring if the PreSET PA barrier improvements are maintained after BS, and result in an improved PA level, are needed given the emergence of other potential PA barriers, such as excess skin, after BS [24]. Our results did not show an improvement in pain during exercise after 12 weeks of PreSET, but it seems that completers were protected from a worsening of pain. Additional studies are required to confirm the impact of PA on musculoskeletal pain before and after BS [25].

No significant improvement was noted in the usual care group following the interdisciplinary individual lifestyle counselling in contrast with other studies [26]. However, participants in our study were receiving lifestyle counselling for an average of 10.4 ± 4.0 months (5.8 ± 1.8 dietician and 5.6 ± 1.8 PA specialist visits) before inclusion in the study. Thus, significant changes have possibly occurred before the inclusion in surgical treatment option.

In addition, the modest significant weight loss (−4.1 kg) found in the pilot study was not reproduced in this trial. However, the usual care intervention and the PreSET focus on weight maintenance before BS. Our results are concordant with the literature, which showed that weight loss induced by PA in obese populations ranges from 0.1 to 5.2 kg [27]. The absence of significant weight loss may be explained by the large interindividual variability in weight loss for the same energy expenditure, due to compensatory mechanisms of the energy deficit resulting in increased food intake [28].

Surprisingly, completers significantly increased their fat mass and non-completers significantly reduced it. However, the clinical significance of these changes (0.7 ± 0.8 vs. −1.4 ± 2.3 %; $p = 0.009$) is questionable, since the change is small and the error for estimating fat mass changes with bioimpedance is approximately 2 % [29].

Although the randomized design is a strength of our study, several limitations have to be considered. First, small sample size and exclusion criteria prevent the generalization to all subjects awaiting BS. The PreSET was limited to volunteers able to come frequently to the facility and without major functional limitations. In addition, only 36 % of surgery programs offers PA counselling in Canada [30], meaning that our sample at baseline did not reflect general candidates for BS. Moreover, the small sample size limited our ability to detect significant differences between groups for secondary outcomes. Second, the results on PA barriers have to be interpreted with caution, since our questionnaire is not a validated tool. Finally, subjects were aware of the objectives of the study, and trainers as well as assessors were aware of the allocation of subjects.

To conclude, a PreSET in addition to an interdisciplinary individual lifestyle counselling is effective to improve PF, social interactions, and PA barriers in severely obese volunteers able to come frequently to the facility and without major functional limitations. Long-term data are now required to understand the impact of pre-surgery PA intervention on post-surgery health outcomes and PA level. Post-surgery exercise training is also a suitable and effective treatment option

[8]. Nevertheless, more studies are needed to provide information about the best timing to help candidates for BS to improve their lifestyle and health on the long term.

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Compliance with Ethical Standards Informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest The authors declare that they have no conflict of interest.

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