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ORIGINAL CONTRIBUTIONS

# Changes in Bariatric Patients' Physical Activity Levels and Health-Related Quality of Life Following a Postoperative Motivational Physical Activity Intervention

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## Abstract

**Purpose** Self-determination theory (SDT) has been widely used as a useful motivational framework for improving long-term adherence to physical activity (PA) and health-related quality of life (HRQoL). The aim of this study was to examine the effects of a 6-month motivational PA intervention (MPAI) on bariatric patients' PA levels and HRQoL from pre-surgery to the end of the MPAI (7 months post-surgery). Additionally, a re-test was performed 13 months post-surgery.

**Methods** A total of 40 participants undergoing sleeve gastrectomy were assigned to a 6-month MPAI or to a control group. The MPAI was based on techniques and messages from SDT. At baseline and post-intervention measures, both groups wore accelerometers for one week and completed the SF-36 questionnaire.

**Results** A total of 32 participants (78.1% female) completed all measures and were included in the final analyses. PA levels did not significantly differ between groups as a consequence of the intervention. Clinically significant differences ($d \geq 0.5$) favoring the MPAI group were found for SF-36 domains of bodily pain (at pre-surgery, increasing at 7 and 13 months post-surgery), general health and vitality (7 months post-surgery), and physical functioning and physical component score (both 7 and 13 months post-surgery). Social functioning also showed clinically significant differences favoring the MPAI group at pre-surgery, increasing at 7 months post-surgery. These differences disappeared at 13 months post-surgery.

**Conclusions** SDT-based PA interventions could enhance several dimensions of bariatric patients' HRQoL after surgery. Further research is needed to understand what motivational processes are key aspects to promote PA participation in these patients.

**Keywords** Self-determination theory · Sleeve gastrectomy · Exercise · Accelerometry · SF-36 questionnaire

## Introduction

Patients seeking bariatric surgery commonly show reduced levels of physical activity (PA) and impaired health-related quality of life (HRQoL) compared with normal-weight individuals [1–3]. Within the first year after surgery, these patients not only experience a significant weight loss but also substantially improve their HRQoL [4, 5].

Postoperative PA is critical for the improvement of long-term weight and HRQoL outcomes. Research has shown

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positive associations between PA and greater weight loss at 12 and 24 months [6–8]. Meeting PA recommendations have also been associated with higher HRQoL 12 months post-surgery [9]. Nevertheless, in spite of the potential contribution of PA to further increases in weight loss and HRQoL, objectively measured post-surgery PA does not usually increase [10, 11]. Therefore, increasing the post-surgical PA habits of bariatric patients represents a major concern from a public health perspective.

Self-determination theory (SDT) [12] has been widely used as a useful motivational framework for improving long-term adherence to PA [13] and HRQoL outcomes [14, 15]. In health-care contexts, SDT establishes that social agents (e.g., health-care providers, exercise professionals) play an important role in supporting three basic psychological needs that are required for patients' optimal development, integrity, and well-being. These needs are competence, which represents feeling effective (e.g., by receiving feedback about their progress); autonomy, which makes reference to the feeling of being the origin of one's own behaviors (e.g., by receiving opportunities for choice in how treatment plans are enacted); and relatedness, which consists in feeling understood and cared for by others (e.g., by a professional who listens their perspectives). More autonomous forms of motivation, understood as processes of internalization that facilitate behavioral engagement and its maintenance, will appear if the basic psychological needs are satisfied by practitioners. Need satisfaction and autonomous regulation will lead to positive consequences, such as enjoyment, better physical and mental health outcomes, and positive attitudes toward PA [15].

SDT has been successfully applied in overweight and obese populations, promoting basic psychological need satisfaction in PA interventions [16, 17]. Nevertheless, SDT-based PA interventions aimed at improving both PA and HRQoL in the field of bariatric surgery are scarce. In this regard, the results of a qualitative study revealed promising results related to enjoyment, pain reduction, and intention to be physically active as a result of a 6-month postoperative intervention focused on SDT [18]. Regarding quantitative designs, only one randomized trial has tried to apply some SDT principles (e.g., supporting patients' competence and autonomy by providing feedback and reinforcement and increasing their knowledge about PA, respectively) within a preoperative 6-week behavioral PA intervention, finding positive changes in patients' PA levels 6 months post-surgery [19, 20]. Nevertheless, Bond et al. [19, 20] conducted face-to-face counseling, but not practical PA sessions in which bariatric patients have to exercise together under a need-supportive environment. In addition, although Bond et al.'s [19, 20] studies represent an illustrative example of theory-driven programs to increase bariatric patients' PA, they did not explore the isolated role of SDT to improve both PA levels and HRQoL. Consequently, the potential of behavioral PA interventions for further increases in PA and HRQoL still remains unknown.

Considering that postoperative PA programs have modestly improved patients' HRQoL [21] and failed to increase PA levels over time [21–23], guiding PA interventions by motivational frameworks, such as SDT, could help to address both objectives. For instance, Stolberg et al. [21] did not report significant increases in PA and for any HRQoL domain except for general health after a 26-week supervised physical training. Carnero et al. [22] reported no significant PA differences between a 6-month exercise training program and lifestyle educational classes. Herring et al. [23] found that PA declined in their exercise group after the end of a 12-week supervised exercise intervention. Some SDT tenets, such as the introduction of group sessions to improve relatedness or the training of social agents (e.g., instructors) to provide a need-supportive environment, might have increased the effectiveness of these interventions. The aim of this study was to examine the effects of a 6-month postoperative motivational PA intervention (MPAI) on bariatric patients' objective PA levels and HRQoL from pre-surgery to the end of the MPAI (7 months after surgery). Additionally, we explored the (possible) prolonged effects of the SDT-based intervention by performing a re-test 13 months after surgery. Previous research has shown that PA levels [22] and HRQoL [24] tend to decline over time in post-intervention follow-up measurements. Persistent postoperative non-related obesity barriers toward PA (e.g., lack of self-efficacy or knowledge to engage in PA) [25] and the high rates of physical inactivity after surgery [20] could help to explain this decrease. Thus, carrying out behavioral PA interventions in early postoperative stages could be crucial to counteract this phenomenon.

We hypothesized the following: (a) the MPAI group (MPAI-G) would present significantly higher post-intervention PA levels, decreasing sedentary activity, and increasing light and moderate-to-vigorous physical activity (MVPA) when compared with a control group (CG); (b) both MPAI-G and CG would obtain positive changes on HRQoL domains after surgery, but these changes would be greater in the MPAI-G; and (c) positive outcomes would decrease 13 months after surgery but they would remain higher for the MPAI-G compared with the CG.

## Methods

### Participants

The participants were 40 individuals aged between 31 and 60 years with morbid obesity (body mass index [BMI] ≥ 40 kg/m$^2$) seeking sleeve gastrectomy (SG). To be eligible for bariatric surgery, patients had to have a BMI greater than

40 kg/m$^2$ or greater than 35 kg/m$^2$ with an associated comorbidity. Additionally, patients had to be between 18 and 60 years old, having experienced previous failed obesity treatments with restrictive-caloric diets and medications, having followed endocrinology and nutritional monitoring, adequately adhering to the therapeutic instructions, and having no medical, physical, psychological, or social contraindications. To participate in the MPAI and to continue in it, all patients had to obtain the consent of the surgeon and the clinical psychologist. Consent implied favorable compliance with the usual postoperative medical evaluations of bariatric patients (e.g., regarding medication or nutrition). Exclusion criteria included unavailability to attend the program regularly, having any physical complication derived from SG, as well as suffering any other medical or psychological condition that prevented habitual participation in PA during the course of the study.

## Design

The participants were recruited from a Spanish hospital (University Hospital of Vinalopó, Elche) between November 2011 and May 2013. During their preoperative visit to the clinical psychologist, patients were asked if they wanted to participate in a follow-up intervention to improve their PA levels and various psychological variables related to exercise. Participants who showed interest after this interview (100% of patients asked) were assigned to the MPAI-G or the CG.

A quasi-experimental design with pseudo-random assignment was chosen to carry out this study. The first 10 participants who consulted the clinical psychologist were assigned to the MPAI-G, whereas the next 10 visitors were assigned to the CG. This procedure was repeated with the following 20 bariatric patients, such that the next 10 patients were assigned to the MPAI-G and started the PA program from the beginning after surgery, whereas the next 10 were assigned to the CG. We chose this pseudo-random assignment because, considering the tenets of SDT, participation in a group-PA program was a key aspect to improve relatedness, motivation, well-being, and adherence to PA. Taking into account that only 2 to 4 patients were operated per month, the most reasonable way to develop a group program with enough participants was to select patients for each group (MPAI-G and CG) in batches of 10 participants.

Patients were contacted by phone to arrange a baseline visit to the sport research center two weeks before surgery, during which they were informed about the aims and procedure of the study, provided written consent, and completed a questionnaire to assess HRQoL. Moreover, the participants were asked to wear an accelerometer at their right hip for seven consecutive days, warning them to take it off only to sleep, when having a shower, or performing activities that could damage the device (e.g., swimming), as reported in similar studies [9, 21].

The characteristics of the intervention in the MPAI-G are described in the subsequent texts. Regarding the participants in the CG, they only followed the usual exercise recommendations of their doctors. These recommendations focused on trying to maintain an active lifestyle after surgery (e.g., highlighting its importance to weight loss and maintenance), but without giving any more specific information or prescriptions related to exercise (e.g., type, frequency, duration, or intensity).

At post-intervention measurements (7 and 13 months post-surgery), the patients again completed the HRQoL questionnaire and wore an accelerometer during another week. Ethical approval was obtained from the hospital and from the Research Ethical Board of the first's author university (clinicaltrials.gov registration NCT03666481). All research was carried out in accordance with the Helsinki Declaration.

## Motivational Physical Activity Intervention

The MPAI began one month after surgery, when the surgeon and clinical psychologist gave permission and medical discharge to the patients belonging to this group. The MPAI was carried out during 6 consecutive months and took place in a public fitness center located at the first author's university. The sessions were directed and supervised by two exercise and sport science professionals (Degree in Sport Sciences, Master's degree in PA and Health). These professionals were trained by one of the researchers responsible for the study in the application of SDT-based techniques and messages for the satisfaction of the needs for competence, autonomy, and relatedness (Table 1). Specifically, instructors' training was divided into two parts. The first one consisted of a 10-h theoretical and practical lesson about SDT-based techniques and messages in exercise settings. The second part (2-month long) involved the application of these techniques in a real-world context, where an external observer, expert in SDT, rated the instructors' compliance with the techniques using an observation sheet. After that, feedback was provided to the instructors to enhance their need-supportive style.

The frequency of patients' training, as well as the duration of the sessions, progressively increased throughout the 6 months. Thus, the MPAI consisted of two sessions per week during the first two months, three sessions per week during the intermediate two months, and four sessions per week during the last two months. The sessions lasted about 60 min in the first two months, whereas in the rest of the months the duration was about 90 min. Patient adherence to training was recorded through a follow-up sheet. The following two types of sessions were designed: (a) cardiorespiratory fitness and muscular strength training with machines and (b) sessions that introduced novelty and enhanced psychosocial aspects of the PA program. These sessions included body expression, dance,

**Table 1** Examples of strategies based on SDT applied by instructors

| Need | Strategies |
|---|---|
| Autonomy | Giving options to choose different activities, machines, and working ranges. |
| | Patients received training on how to perform healthy exercise by themselves. |
| | Asking participants for their opinion on the activities. |
| Competence | Providing positive feedback and information to the patients about their progress. |
| | Establishing short-term goals so that patients assess their progress every month. |
| | Follow-up of an individualized program with achievable goals. |
| Relatedness | Proposing physical and nonphysical tasks (e.g., a meeting to have lunch) in which patients had to interact. |
| | Participants were encouraged to correct each other's performance of exercises. |
| | The instructors smiled, supported, and encouraged patients. A caring climate was created, in which the instructors showed interest in patients' lives. |

directed activities (aerobic, spinning, etc.), beach and pool activities, core training, trekking, and traditional Spanish games. STD-based techniques and messages were implemented in both types of sessions. At-home exercises were also provided to the patients, so that they had enough knowledge to do PA without having large resources or joining a gym. For example, the participants were instructed to use quotidian materials (e.g., full bottles, shopping bags) to autonomously exercise at home (Table 1).

The MPAI, therefore, entailed two main purposes. First, to provide a need-supportive environment focused on the satisfaction of competence, autonomy, and relatedness to improve patients' attitudes toward PA and to increase their PA participation after the intervention. Second, to transfer the physical and psychosocial benefits of the MPAI on patients' perceived HRQoL.

## Measures

**Physical Activity** Actigraph™ GT3X accelerometers (Pensacola, FL) were used to measure PA levels. The participants were asked to wear the accelerometer at the right hip for 7 consecutive days. A total of ≥ 3 days with at least ≥ 10 h wear time per day at all measurements was required to estimate the PA of each participant [26]. Vector magnitude ($V_m$) activity counts, calculated as the square root of the sum of the vertical, medio-lateral, and antero-posterior axes, were used according to previous studies performed with this population [27, 28]. Non-wear time was defined as 60 min of consecutive zeros, allowing for 2 min of non-zero interruptions [29]. Cutoffs to classify different intensities of PA were based on the studies of Santos-Lozano et al. [30] and Hanggi et al. [31]. Time spent in sedentary activity was defined as all minutes showing equal or less than 100 counts per minute (cpm), light PA as 101–3027 cpm, and moderate-to-vigorous PA (MVPA) as the number of minutes showing equal or more than 3028 cpm.

**HRQoL** The 36-item Short-Form Health Survey (SF-36) was used to measure patients' quality of life in physical and mental domains. This questionnaire measures eight domains of functioning that can be employed to reflect (a) a physical component score (PCS), consisting of physical functioning, bodily pain, general health, and role limitations because of physical problems and (b) a mental component score (MCS), consisting of social functioning, vitality, mental health, and role limitations because of emotional problems. Scores ranged from 0 (worst possible level of functioning) to 100 (best possible level of functioning). The SF-36 has been widely used in obese and bariatric surgery populations [32, 33], showing high internal consistency, reliability, and validity [34].

**Other Measures** Socio-demographic characteristics (i.e., sex, age, race/ethnicity, educational level, socioeconomic status, marital status) were collected by the hospital's clinical psychologist, who provided us with the data. The BMI data were taken at the sport research center during the baseline visit and at each post-intervention measurement.

## Statistical Analysis

All statistical analyses were performed using SPSS 25.0 (IBM Corp., Armonk, NY, USA) software, excluding the effect sizes (ES) which were computed through an online ES calculator [35]. Descriptive participants' characteristics are presented as percentages (%) and means ± standard deviations (M ± SD).

Comparison of preoperative differences in PA levels and HRQoL between groups was assessed using analysis of covariance (ANCOVA), adjusting for sex, age, and BMI. The effects of the MPAI on the continuous outcome variables were assessed by mixed-effects model for repeated measures. The model was adjusted by sex, age, and percentage of excess weight loss (% EWL). % EWL was determined by using the midpoint of the 1983 Metropolitan Life Insurance tables for a medium frame: [(operative weight − follow-up weight) / operative excess weight)] × 100.

Effect sizes (Cohen's *d*) with 95% confidence intervals for the differences between groups at each assessment point were calculated. Magnitude of these differences was considered as not statistically significant when the confidence interval included the value zero [36]. Differences equal to or greater than $d = 0.5$ were considered as clinically relevant in the case of SF-36 dimensions [37]. Effect sizes and 95% confidence intervals of intra-group changes between assessment points are provided in the supplementary material.

## Results

### Demographic Data and Retention

Of the 40 patients who initially agreed to participate in the study, one participant eventually did not participate after the group assignment, alleging personal reasons. From this sample of 39 patients, 32 (82%) completed all the assessment measures and were subsequently included in the final analyses (Fig. 1). The retention rates for MPAI-G and CG at the second post-intervention measurement point (13 months post-surgery) were 89.4% and 75%, respectively. Comparison of baseline characteristics showed no statistically significant differences ($p > 0.05$) on any variable of completers compared with those who did not complete the post-intervention measurements. Therefore, the results are based on complete cases only. The attendance rate for the MPAI-G sessions was 80% on average (range, 68.1–88.9). The final disposition of the groups and the descriptive characteristics of the participants are presented in Table 2 and Table 3.

### Changes in PA Levels

Mean PA levels (expressed in minutes/day), effect sizes, and 95% confidence intervals (CIs) for all measurement points are presented in Table 3. Differences between groups in PA levels are shown in Fig. 2. MPAI-G showed more light PA than CG at preoperative time-point ($d = 0.86$, 95% CI [0.13, 1.58]), and this difference remained 7 months ($d = 0.84$, 95% CI [0.11, 1.56]) and 13 months after SG ($d = 0.86$, 95% CI [0.13, 1.58]). Nevertheless, CG showed more MVPA than MPAI-G before SG ($d = -2.99$, 95% CI [−4.01, −1.99]), and this difference was larger 7 months ($d = -4.47$, 95% CI [−5.77, −3.18]) and 13 months after SG ($d = -4.05$, 95% CI [−5.26, −2.84]). MPAI-G and CG did not differ significantly on sedentary activity or total PA throughout all time points.

### Changes in HRQoL

HRQoL mean scores, effect sizes, and 95% CIs for all measurement points are presented in Table 3. Group differences in the physical and mental domains of HRQoL are shown in Figs. 3 and 4, respectively. Regarding physical domains, no significant group differences were found for physical functioning at the preoperative time-point ($d = 0.35$, 95% CI [−0.35, 1.35]). Nevertheless, MPAI-G showed higher physical functioning than CG both 7 months ($d = 1.96$, 95% CI [1.12, 2.81]) and

**Fig. 1** CONSORT flow diagram

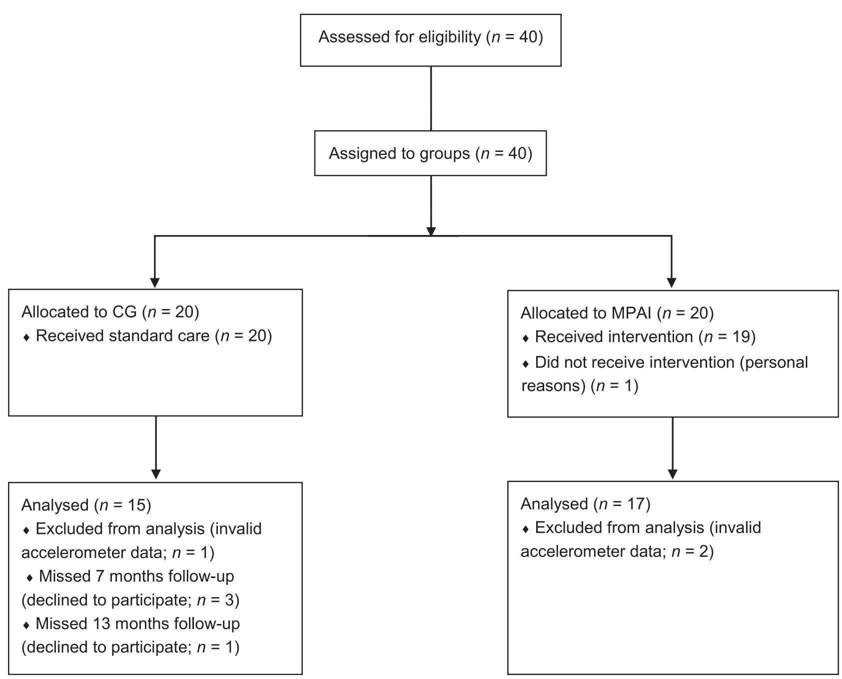

**Table 2** Final sample characteristics

| Variable | Full sample ($n = 32$) | CG ($n = 15$) | MPAI-G ($n = 17$) |
|---|---|---|---|
| Sex (%) | | | |
| Men | 21.9 | 26.7 | 17.6 |
| Women | 78.1 | 73.3 | 82.4 |
| Age (years) (M ± SD) | 45.2 (± 10.0) | 42.6 (± 10.9) | 47.5 (± 8.8) |
| Anthropometric characteristics (M ± SD) | | | |
| Weight (kg) | 115.7 (± 19.1) | 116.6 (± 16.8) | 114.9 (± 21.4) |
| BMI (kg/m$^2$) | 43.9 (± 4.9) | 43.1 (± 4.5) | 43.8 (± 5.3) |
| Race/ethnicity (%) | | | |
| White | 96.9 | 100.0 | 94.1 |
| Hispanic | 3.1 | – | 5.9 |
| Education (%) | | | |
| Without/incomplete primary school | 15.6 | 26.7 | 5.9 |
| Primary school | 34.4 | 33.3 | 35.3 |
| High school | 46.9 | 40.0 | 52.9 |
| College or university degree | 3.1 | – | 5.9 |
| Socioeconomic status (%) | | | |
| Low | 18.8 | 20.0 | 17.6 |
| Medium | 78.1 | 80.0 | 76.5 |
| High | 3.1 | – | 5.9 |
| Marital status (%) | | | |
| Single | 21.9 | 33.3 | 11.8 |
| Married/partnered | 68.7 | 60.0 | 76.5 |
| Divorced | 9.4 | 6.7 | 11.7 |

CG, control group; MPAI-G, motivational physical activity intervention-group

13 months after SG ($d = 1.34$, 95% CI [0.57, 2.11]). With regard to bodily pain, MPAI-G showed higher scores than CG before SG ($d = 0.92$, 95% CI [0.19, 1.65]), and these differences were greater 7 months ($d = 1.06$, 95% CI [0.32, 1.81]) and 13 months after SG ($d = 1.34$, 95% CI [0.57, 2.10]), indicating less pain in MPAI-G. In relation to the general health domain, no significant group differences were observed preoperatively ($d = 0.32$, 95% CI [− 0.38, 1.02]). Nevertheless, MPAI-G showed more general health than CG 7 months after SG ($d = 1.26$, 95% CI [0.50, 2.03]), although this difference was not maintained 13 months after SG ($d = 0.34$, 95% CI [− 0.36, 1.03]). No significant group differences were found for the physical role domain at any time point. Regarding PCS, no significant group differences were obtained at the preoperative time-point ($d = 0.46$, 95% CI [− 0.25, 1.16]). Nevertheless, MPAI-G showed a higher PCS compared with CG 7 months ($d = 1.32$, 95% CI [0.56, 2.09]) and 13 months after SG ($d = 1.10$, 95% CI [0.35, 1.84]).

Respecting mental domains, MPAI-G showed higher social functioning than CG before surgery ($d = 0.76$, 95% CI [0.04, 1.48]), and these differences were greater 7 months after SG ($d = 1.45$, 95% CI [0.67, 2.23]). No significant group differences were found in social functioning 13 months after SG ($d = -0.41$, 95% CI [− 1.11, 0.29]). For vitality, no significant differences between MPAI-G and CG were seen before SG ($d = 0.36$, 95% CI [− 0.34, 1.05]). Nevertheless, MPAI-G showed more vitality than CG 7 months after SG ($d = 0.72$, 95% CI [0.01, 1.43]). These differences were similar 13 months after SG ($d = 0.71$, 95% CI [− 0.01, 1.42]). No significant group differences were found for mental health, mental role, or MCS at any time point.

## Discussion

Bariatric patients' PA levels did not significantly differ between MPAI-G and CG after a 6-month SDT-based PA intervention. In contrast, we found clinically significant differences favoring MPAI-G for several SF-36 domains immediately after the intervention (7 months post-surgery), which included higher scores in physical functioning, bodily pain (indicating less pain), general health, PCS, social functioning, and vitality. Some of these differences remained 13 months after SG, as in the case of physical functioning, bodily pain, and PCS.

**Table 3** Physical activity (PA) levels measured by GT3X accelerometers (expressed in minutes per day) and health-related quality of life' scores measured by the SF-36 questionnaire at pre-SG, 7 months-after SG, and 13 months-after SG (M ± SD)

| Variable | Pre-SG* | | | | 7 months—after SG** | | | | 13 months—after SG** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CG | MPAI-G | *d* | 95% CI | CG | MPAI-G | *d* | 95% CI | CG | MPAI-G | *d* | 95% CI |
| GT3X (min/day) | | | | | | | | | | | | |
| Sedentary activity | 623.96 (± 37.74) | 624.21 (± 35.33) | 0.01 | [− 0.69, 0.70] | 603.74 (± 33.15) | 612.30 (± 25.36) | 0.29 | [− 0.40, 0.99] | 626.27 (± 32.20) | 631.65 (± 24.46) | 0.19 | [− 0.51, 0.89] |
| Light PA | 337.03 (± 33.70) | 365.04 (± 31.56) | 0.86[a] | [0.13, 1.58] | 357.81 (± 30.31) | 380.28 (± 23.36) | 0.84[a] | [0.11, 1.56] | 338.25 (± 29.57) | 360.69 (± 22.64) | 0.86[a] | [0.13, 1.58] |
| MVPA | 48.91 (± 6.87) | 29.02 (± 6.43) | − 2.99[a] | [− 4.01, − 1.99] | 50.04 (± 5.84) | 27.16 (± 4.38) | − 4.47[a] | [− 5.77, − 3.18] | 47.09 (± 5.46) | 27.84 (± 4.04) | − 4.05[a] | [− 5.26, − 2.84] |
| Total PA | 385.94 (± 37.80) | 394.06 (± 35.39) | 0.22 | [− 0.47, 0.92] | 407.94 (± 33.23) | 406.75 (± 25.42) | − 0.04 | [− 0.73, 0.65] | 385.65 (± 32.23) | 387.22 (± 24.49) | 0.05 | [− 0.64, 0.75] |
| SF-36 scores (0–100) | | | | | | | | | | | | |
| General health | 53.41 (± 5.46) | 55.11 (± 5.11) | 0.32 | [− 0.38, 1.02] | 64.55 (± 3.52) | 68.84 (± 3.27) | 1.26[a,b] | [0.50, 2.03] | 65.55 (± 3.79) | 66.78 (± 3.55) | 0.34 | [− 0.36, 1.03] |
| Physical role | 55.80 (± 11.10) | 56.65 (± 10.40) | 0.08 | [− 0.61, 0.77] | 76.92 (± 5.83) | 77.72 (± 5.20) | 0.14 | [− 0.55, 0.84] | 76.53 (± 5.60) | 78.13 (± 5.09) | 0.30 | [− 0.40, 1.00] |
| PCS | 37.28 (± 2.56) | 38.41 (± 2.40) | 0.46 | [− 0.25, 1.16] | 45.19 (± 1.58) | 47.19 (± 1.45) | 1.32[a,b] | [0.56, 2.09] | 44.58 (± 1.66) | 46.33 (± 1.54) | 1.10[a,b] | [0.35, 1.84] |
| Social functioning | 77.68 (± 5.11) | 81.45 (± 4.79) | 0.76[a,b] | [0.04, 1.48] | 83.47 (± 2.96) | 87.57 (± 2.69) | 1.45[a,b] | [0.67, 2.23] | 82.64 (± 3.29) | 81.34 (± 3.05) | − 0.41 | [− 1.11, 0.29] |
| Vitality | 51.33 (± 6.40) | 53.53 (± 5.99) | 0.36 | [− 0.34, 1.05] | 60.59 (± 3.83) | 63.22 (± 3.53) | 0.72[a,b] | [0.01, 1.43] | 59.28 (± 3.90) | 61.94 (± 3.62) | 0.71[b] | [− 0.01, 1.42] |
| Mental health | 69.68 (± 4.63) | 71.69 (± 4.33) | 0.45 | [− 0.25, 1.15] | 73.10 (± 3.20) | 74.51 (± 2.99) | 0.46 | [− 0.25, 1.16] | 72.40 (± 3.29) | 72.00 (± 3.08) | − 0.13 | [− 0.82, 0.57] |
| Mental role | 79.24 (± 9.36) | 79.10 (± 8.76) | − 0.01 | [− 0.71, 0.68] | 81.28 (± 6.23) | 80.97 (± 5.80) | − 0.05 | [− 0.75, 0.64] | 81.43 (± 6.69) | 80.25 (± 6.28) | − 0.18 | [− 0.88, 0.51] |
| MCS | 50.31 (± 2.53) | 51.16 (± 2.37) | 0.35 | [− 0.35, 1.05] | 49.62 (± 1.68) | 49.99 (± 1.57) | 0.23 | [− 0.47, 0.92] | 49.52 (± 1.86) | 49.12 (± 1.75) | − 0.22 | [− 0.92, 0.47] |

*Adjusted by sex, age, and BMI

**Adjusted by sex, age, and %EWL

[a] Significant differences considering that the 95% CI did not include the value zero

[b] Denotes clinically relevant differences between groups as per criterion of Norman et al. [37]

SG, sleeve gastrectomy; CG, control group; MPAI-G, motivational physical activity intervention-group; PA, physical activity; MVPA, moderate-to-vigorous physical activity; PCS, physical component score; MCS, mental component score

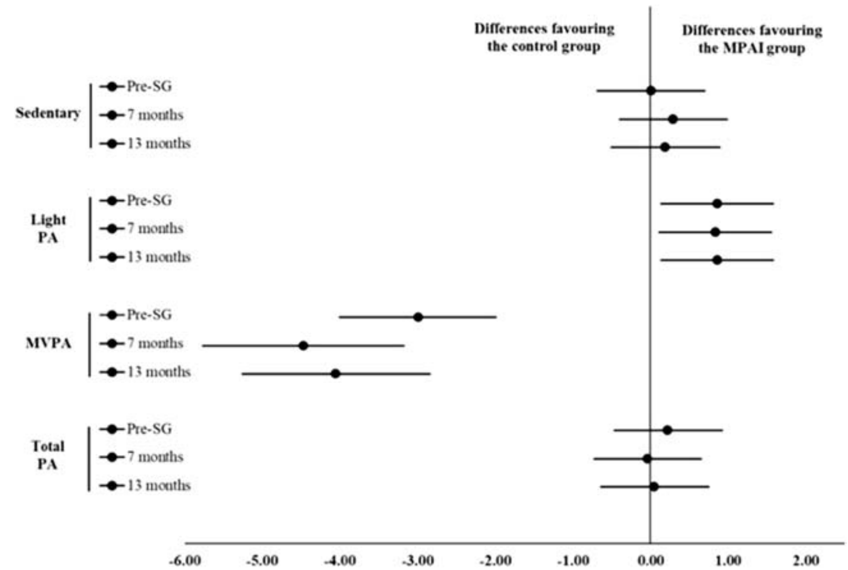


**Fig. 2** Forest plots of differences (95% confidence intervals) between groups in sedentary activity, light physical activity, moderate-to-vigorous physical activity, and total physical activity at the different time points. Dots represent Cohen's effect sizes; error bars represent confidence intervals. MPAI, motivational physical activity intervention; SG, sleeve gastrectomy; sedentary, sedentary activity; PA, physical activity; MVPA, moderate-to-vigorous physical activity

## Effects of the MPAI on Bariatric Patients' PA Levels

Previous research has indicated the need to conduct interventions focused on improving patients' PA after bariatric surgery [21]. Our study was based on SDT, a commonly used framework to promote active behaviors in health-impaired populations [12, 15]. Nevertheless, we found no additional PA improvements favoring MPAI-G at any of the assessment points when compared with CG. These results contradict one of our pre-established hypotheses but are consistent with similar studies [21–23]. For instance, Stolberg et al. [21] reported non-significant increases in step count, light PA, and MVPA immediately after a 26-week supervised physical training intervention, which failed to persist 24 months after surgery. In contrast, Bond et al. [19, 20] found that preoperative increases in bout-related MVPA after a 6-week behavioral intervention remained 6 months post-surgery.

A possible explanation of why we did not find differences in PA levels in favor of the MPAI-G with respect to the CG could be that approximately 75% of patients belonging to CG accumulated ≥ 150 min of MVPA per week preoperatively, as recommended by the American College of Sports Medicine [38]. Nevertheless, only 41% of MPAI-G patients accomplished these recommendations at the same stage. This fact could potentially limit the group comparisons, as the initial heterogeneity between them was high. Second, we could also speculate that MPAI-G's PA levels did not increase because we did not include a follow-up intervention, which could have facilitated the increase of the patients' PA levels after the intervention [18]. Although part of our primary goal was to

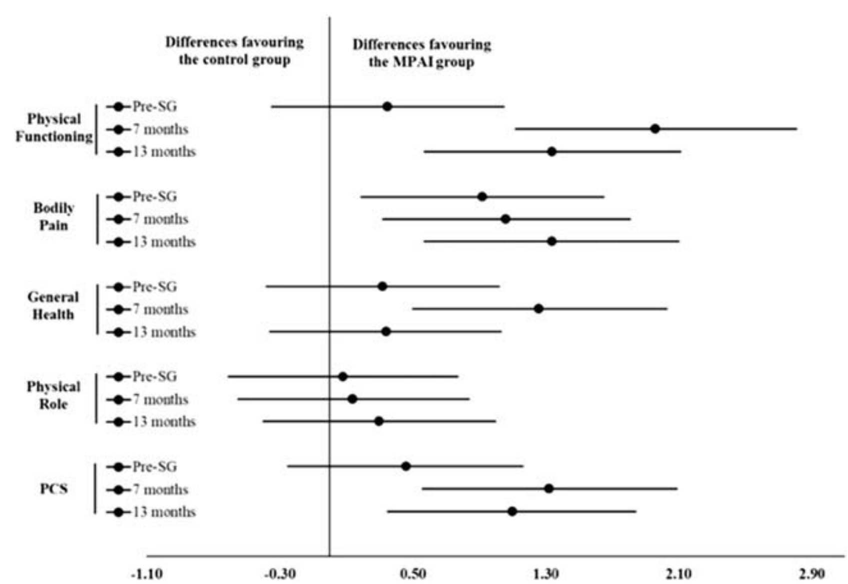


**Fig. 3** Forest plots of differences (95% confidence intervals) between groups in physical functioning, bodily pain, general health, physical role, and physical component score (PCS) at the different time points. Dots represent Cohen's effect sizes; error bars represent confidence intervals. MPAI, motivational physical activity intervention; SG, sleeve gastrectomy

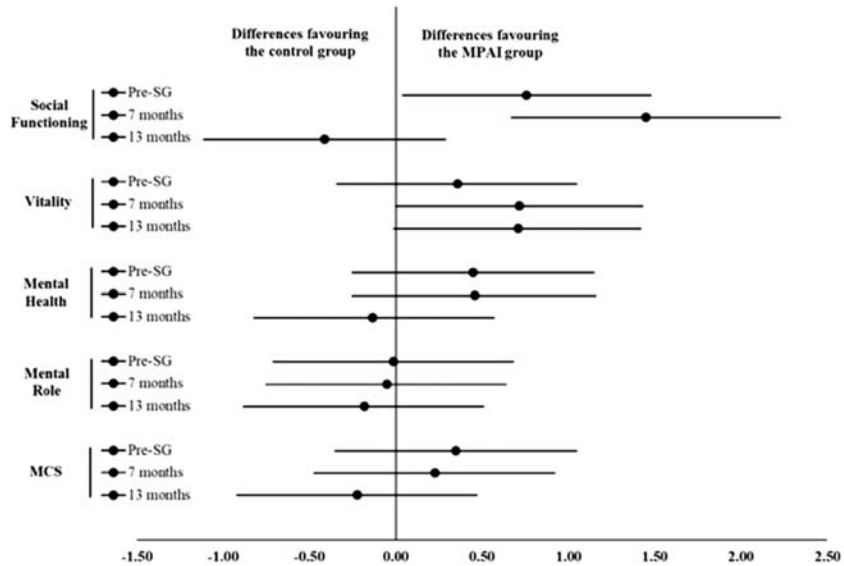


**Fig. 4** Forest plots of differences (95% confidence intervals) between groups in social functioning, vitality, mental health, mental role, and mental component score (MCS) at the different time points. Dots represent Cohen's effect sizes; error bars represent confidence intervals. MPAI, motivational physical activity intervention; SG, sleeve gastrectomy

develop a positive predisposition toward PA that would lead to PA maintenance over time, we must acknowledge that life for these patients after surgery is complex, with many barriers/factors that can interfere with the maintenance of long-term behaviors [39–41]. Therefore, holding periodic follow-up meetings (e.g., face-to-face or by phone) could have been an appropriate strategy after completing the PA program. Moreover, we have to take into account that we provided MPAI-G patients with an ideal environment to participate in PA immediately after SG. In fact, they participated in four sessions per week during the MPAI. Nevertheless, although we tried to develop a need-supportive climate, patients may have felt ignored or neglected when they finished the MPAI. According to these results, a key aspect of this type of interventions should be to design strategies that facilitate patients' transition from the intervention to real life. This point is particularly important, taking into account that the services offered by conventional sport centers are usually far from the special needs of bariatric patients.

## Effects of the MPAI on Bariatric Patients' HRQoL

The current study was conducted at an early postoperative stage, characterized by a phase of active weight loss associated with extensive improvements in HRQoL. Consequently, both MPAI-G and CG showed remarkable increases on several HRQoL domains from pre-SG to immediately after the intervention (7 months post-SG), in accordance with our hypothesis. These improvements were especially evident in those dimensions related to the physical component of the SF-36, which coincides with previous research [4, 5]. Nevertheless, when comparing both groups, we observed significant and clinically relevant differences favoring MPAI-G for physical functioning, bodily pain, general health, PCS, social functioning, and vitality. Previous PA interventions (without a motivational component) have obtained modest results even in improving variables related to the physical component of the perceived HRQoL, when compared with the control groups [21]. To our knowledge, this is the first quantitative study that analyzes the effects of an SDT-based PA intervention in the HRQoL of this population. The design of interventions attending to motivational frameworks could help researchers to better structure ideas and strategies in line with psychological mechanisms and, therefore, to achieve greater positive outcomes [42]. A meta-analysis examining the role of SDT on health contexts supports this view, as need-supportive health-care climates were essential predictors of patients' psychological well-being [15].

At 13 months post-SG, the significant and clinically relevant differences favoring MPAI-G remained only for the domains of bodily pain, physical functioning, and PCS, compared with CG. Bodily pain showed an improvement with respect to the values found 7 months post-SG, whereas physical functioning and PCS showed a decrease with respect to the same assessment point. These results coincide with the last hypothesis set out at the beginning of this study and highlight the need to carry out similar studies with longer interventions and/or with longer follow-ups, in order to observe the functioning of the HRQoL variables over time.

In this line, an unexpected result was found for social functioning, which showed clinical differences favoring MPAI-G at pre-surgery and 7 months post-surgery, but disappeared at 13 months post-surgery. We performed a group intervention where patients were always accompanied by their peers, with activities adapted to them, and with exercise professionals always fully available. It was an "ideal" situation in which they felt accepted and cared for by the people around them. Therefore, although an increase in social functioning was found just after finishing the intervention, an adverse effect may have been generated in patients after completing the PA program and going back to "real life." This aspect could have limited the potential benefits of the program in the long term. Future studies should also consider the deferred effects of SDT interventions on patients' perceptions.

### Strengths and Limitations

The current study has notable strengths. To our knowledge, this is the first study carried out with bariatric surgery patients that has developed a supervised PA intervention based on a motivational framework (SDT). More research is needed to explore the role of theoretical/motivational frameworks in PA interventions with this population. In this sense, directing programs not only toward biological/physical objectives but also toward psychosocial objectives would be desirable to increase patients' well-being and PA adherence. The high attendance rate of patients to the MPAI sessions could be an argument supporting this idea. The use of the $d = 0.5$ criterion to determine clinically relevant differences between groups and to better understand the magnitude of these differences was another strength [37].

This study also has some limitations that must be considered. First, the fact of employing a quasi-experimental design with pseudo-random assignment prevents us from inferring causality between the MPAI and PA/HRQoL results. Second, we failed to retain several participants at the post-intervention measures, especially in the CG. Although there were no differences in the baseline characteristics between completers and non-completers, carrying out retention strategies over time could have prevented this sample loss. Third, we were also limited by the small number of participants involved in the study. The restricted number of bariatric surgeries performed in a small hospital during the intervention period hindered the recruitment of more participants. Consequently, further studies involving MPAI with larger samples are warranted. Finally, despite using accelerometer PA intensities (i.e., cut-offs) that have been commonly used with bariatric patients [9, 27, 28], Santos-Lozano et al. [30] validated their cut-offs points in normal-weight adults and not in obese or bariatric populations. Moreover, these authors validated their equations in laboratory settings, instead of free-living conditions. Regarding this argument, we agree with other authors about the lack of consensus to establish accelerometer PA intensities, which limits comparability between studies [9]. All these advise interpreting the accelerometer data with caution.

## Conclusions

Findings from the present study suggest that an SDT-based PA intervention could enhance several HRQoL dimensions of bariatric patients after surgery. These findings suggest that SDT could be applicable for the development of programs framed in health-care settings to enhance bariatric patients' HRQoL. Health-care practitioners, biomedical ethicists, exercise professionals, and public health authorities could benefit from the principles of SDT for delivering their messages toward patients. Nevertheless, the intervention did not result in greater PA levels for the MPAI-G, when compared with the CG. Further research is needed to understand what motivational processes, and personal, social, physical, and environmental factors are key aspects to promote PA in these patients.

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## Compliance with Ethical Standards

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

**Ethical Approval** All procedures 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.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

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