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Physical activity in bariatric surgery patients: does temperament matter?

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Abstract

Objective: To investigate if physical activity (PA) in bariatric surgery patients is related to temperament. **Methods:** The Behavioral Inhibition System (BIS)/Behavioral Activation System (BAS) scales, the Effortful Control subscale of the Adult Temperament Questionnaire-Short Form, and the Patient Health Questionnaire-depression scale were administered to 70 pre- and 73 postoperative patients. They were categorized as being physically "active" if they accumulated ≥8000 steps/day based on objective monitoring. **Results:** Regressions adjusted for gender, age, BMI, and depression suggested an association between lower BMI and more PA in both groups. In postoperative patients, lower age and higher BIS - but not BAS - reactivity were related to PA. There was a significant interaction between BMI and BIS suggesting that low BMI was only associated with more PA in patients with high BIS compared to low BIS sensitivity. **Discussion:** The results indicate that in postoperative patients with anxious temperament lower BMI is associated with more PA. This finding needs further investigation within longitudinal studies.

Keywords: Obesity, bariatric surgery, physical activity, temperament

Introduction

Obesity is mainly caused by an imbalance of energy intake and energy expenditure (Thompson, Karpe, Lafontan, & Frayn, 2012). Following the global recommendations on physical activity (PA) of the World Health Organization, healthy adults aged 18 to 64 years should accumulate at least 2.5 h of moderate to vigorous physical activity (MVPA) in bouts ≥10 min (i.e. bout-related MVPA) throughout the week. It is well known that MVPA has a favorable effect on weight loss and weight loss maintenance in overweight/obese individuals (Andrade et al., 2010; Hamer et al., 2013). PA declines with increasing BMI (Elbelt et al., 2010) and individuals with morbid obesity display less MVPA than normal-weight individuals (Fernández-Aranda et al., 2014). In the context of bariatric surgery, studies using objective monitors to assess PA have shown that bariatric surgery patients are physically inactive and highly sedentary (Bond & Thomas, 2015). According to a longitudinal multicenter study conducted in the United States, most patients continue to have a sedentary lifestyle following bariatric surgery despite modest increases in PA (King et al., 2015). Lately, a longitudinal study from Sweden did not find significant increases in objectively measured PA in women before and 9 months after bariatric surgery (Berglind et al., 2016).

In a recent cross-sectional study, we compared the level of PA between a group of obese bariatric surgery candidates and a group of patients with a mean total weight loss of 33.2% (*SD*=8.9) following bariatric surgery using objective PA monitors (Bartsch et al., 2016). Against our hypotheses, we did not find meaningful between-group differences in PA (Bartsch et al., 2016). Both the pre- and the postoperative group showed low levels of PA and exhibited a sedentary lifestyle, which was not related to cognitive functioning, eating disorder symptoms, or depression (Bartsch et al., 2016; Langenberg et al., 2015). Besides the cross-sectional design, there were many other potential reasons for the lack of group differences in

PA. For example, the relatively brief average length of follow-up in the postoperative group (months postoperative *M*=8.2, *SD*=3.5), maintained physical strain, emerging excess skin, concerns about physical appearance, and/or low self-efficacy. Furthermore, some patients may have experienced substantial benefits from weight loss early after surgery such as improvement in physical health. This might have contributed to an unchanged sedentary lifestyle (Bartsch et al., 2016).

Taken together, the results of our cross-sectional study as well as the findings from the aforementioned longitudinal studies (Berglind et al., 2016; King et al., 2015) indicate enormous barriers for bariatric surgery patients to be physically active. An alternative explanation for the low PA can be found in the individual's temperament that is considered to be relatively stable over time and that can influence habitual PA (Allen, Magee, Vella, & Laborde, 2016; Brunes, Augestad, & Gudmundsdottir, 2013; Rhodes & Smith, 2006). A meta-analysis showed that PA is positively related to Extraversion, Conscientiousness and Openness, and negatively to Neuroticism (Wilson & Dishman, 2015). With regard to obesity, Fernández-Aranda et al. (2014) investigated the influence of temperament on objectively measured PA levels and BMI in a sample of 73 individuals with obesity and 116 healthy-weight controls by means of the Temperament and Character Inventory-Revised (Cloninger, 1999). Individuals with obesity reported higher scores on Harm Avoidance and Reward Dependence but lower scores on Novelty Seeking than normal-weight controls. Higher MVPA levels were related to lower BMI, whereas this relationship was partially mediated by high Novelty Seeking and low Harm Avoidance. This seemed to be plausible given that higher Novelty Seeking correspondents with an active lifestyle and exploratory behavior, while higher Harm Avoidance correlates with anxiety and inhibition of behaviors (Fernández -Aranda et al., 2014).

According to biologically driven conceptualizations of personality, temperamental features can be viewed as individual differences in emotional reactivity (reactive temperament) and self-control (regulative temperament) (Rothbart, Ahadi, & Evans, 2000). In terms of reactive temperament, Gray (1987) proposed two neurobiological systems underpinning behaviors and affect: the Behavioral Inhibition System (BIS) and the Behavioral Activation System (BAS). The BIS prevents or stops behavior that is expected to lead to punishment and non-reward and stimulates avoidance behavior; the BAS is sensitive to reward or non-punishment and instigates approach behavior. BIS and BAS reactivity have been related to the personality dimensions of Cloninger (1999): Harm Avoidance was positively correlated with BIS and negatively with BAS, Reward Dependence related positively to BIS and BAS, and Novelty Seeking correlated positively with BAS (Carver & White, 1994). BIS and BAS reactivity have also been related to the Big Five personality traits (McCrae & Costa, 2003), whereas BIS was linked to Neuroticism, and BAS to Extraversion (Smits & Boeck, 2006). The effect of punishment (BIS) and reward (BAS) sensitivity can be down-regulated by effortful control (regulative temperament) (Rothbart et al., 2000). According to Evans and Rothbart (2007) effortful control correspondents with high levels of Conscientiousness and low levels of Neuroticism of the Big Five model.

An investigation of temperament subtypes in 156 bariatric surgery candidates and obese inpatients admitted to a psychotherapy unit showed that patients belonging to the cluster with higher BIS and BAS and lower effortful control exhibited more psychopathology (i.e. depressive, eating disorder, and ADHD symptoms) than those belonging to the cluster with lower BIS and BAS and higher effortful control (Müller, Claes, Wilderjans, & de Zwaan, 2014). Another study in the same vein found two personality subtypes in female pre-bariatric surgery patients based on the Big Five personality traits: a 'resilient/high functioning' subtype and an 'emotional dysregulated/undercontrolled' subtype, characterized by high Neuroticism, and low Extraversion/Conscientiousness (Claes, Vandereycken, Vandeputte, & Braet, 2013).

To understand if individual differences in temperament may affect PA in bariatric surgery patients, we conducted a secondary analysis of our data from the aforementioned study (Bartsch et al., 2016) and analysed the relationship between the level of PA and temperament in the pre- and postoperative group. Given that punishment sensitivity (BIS) triggers avoidance behavior and reward sensitivity (BAS) stimulates approach behavior, we hypothesized that in both groups higher levels of PA will be related to lower BIS and higher BAS levels. Furthermore, we expected to find a positive association between effortful control and PA. Since effortful control might moderate the effect of BIS and BAS, we also explored potential interactions between reactive (BIS, BAS) and regulative (effortful control) temperamental features. Additionally, we examined if age, gender, or BMI influenced the hypothesized link between temperament and PA. With regard to weight and age, we expected an inverse relationship between these variables and PA. Furthermore, given that patients with obesity are at an increased risk for depression (Luppino et al., 2010) and that individuals with depression are more likely to be physically inactive (Gigantesco, Ferrante, Baldissera, Masocco, & group, 2015), the analyses were also controlled for depression.

Methods

Participants

Data were collected between March 2013 and August 2014 within a research project investigating PA, cognitive functions and eating disorder symptoms in pre- and postoperative bariatric surgery patients. The findings regarding the main research questions were already described in detail elsewhere (Bartsch et al., 2016; Langenberg et al., 2015). The present study represents a secondary data analysis of these data focusing on the relationship between temperament and PA.

The preoperative group consisted of 71 bariatric surgery candidates (age: *M*=41.4, *SD*=11.9) suffering from obesity grade 2 (7.1%) or grade 3 (92.9%) (BMI: *M*=46.9 kg/m^2, *SD*=6.0) who were recruited within the routine preoperative psychiatric evaluation at

Hannover Medical School. The postoperative group was recruited within the routine postoperative check-ups in the Department of Surgery of the Herzogin Elisabeth Hospital Braunschweig and included 73 patients (age: M=40.5, SD=10.9; 57 women, 16 men) with a mean BMI of 32.0 kg/m^2 (SD=4.1) (normal weight 2.8%, overweight 26.4%, obesity grade 1 45.8%, grade 2 19.4%, grade 3 5.6%). They were assessed on average 8.2 months (SD=3.5, *range* 2.0-25.1) after surgery. One male patient in the preoperative group did not answer the temperament questionnaires. Given that this was the main topic of the present study this patient was excluded from the analyses resulting in a final sample of 70 preoperative (78.6% women) and 73 postoperative (78.1% women) patients. The groups did not differ with regard to gender (women: preop 78.6% vs. postop 78.1%; χ^2=0.005; df=1, p=0.943) or age (M_{pre}=41.6, SD_{pre}=11.9 vs. M_{post}=40.5, SD_{post}=10.9 years; $t(141)$=0.56, p=0.575).

The protocol was approved by the Institutional Ethics Committee of the Hannover Medical School. All participants gave written informed consent and received a compensation of 50€. The main study was registered as a clinical trial conducted in Germany, number DRKS 00004834.

Assessments

Sociodemographic data, weight and height were based on self-reports. *Daily PA* was measured utilizing the SenseWear Pro$_2$ armband (SWA; BodyMedia, Inc., Pittsburgh, PA), a multi-sensor device including a biaxial accelerometer (for details see Bartsch et al., 2016; Langenberg et al., 2015). Patients were asked to wear the SWA for 24 hours on at least seven consecutive days. Data were evaluated as valid if the SWA was worn for a minimum of 12 hours per day on at least 3 days corresponding to best research and practice recommendations (Heil, Brage, & Rothney, 2012). The outcome variable used for the present study was *mean steps per day*. Tudor-Locke et al. (Tudor-Locke, Leonardi, Johnson, Katzmarzyk, & Church, 2011) suggested that 8000 steps per day may serve as “a good proxy for 30 min of daily

MVPA" (p. 31) and that this level of PA can be labelled as 'active'. Accordingly, patients were categorized as being physically 'active' if they accumulated at least 8000 steps per day. Piling less than 8000 steps per day was indicative for a sedentary lifestyle.

Reactive Temperament was measured by means of the Behavioral Inhibition System and Behavioral Activation System scales (BIS/BAS) (Müller, Smits, Claes, & de Zwaan, 2013; Strobel, Beauducel, Debener, & Brocke, 2001). The BIS/BAS scales consist of 24 items (including 4 filler items) to be rated on a four-point scale ranging from 1 (I strongly disagree) to 4 (I strongly agree). The BIS scale contains 7 items and assesses the dispositional sensitivity to aversive stimuli and punishment. Cronbach's α in the preoperative group was 0.77, and in the postoperative group 0.76. The BAS scale includes 13 items and assesses the dispositional approach tendency toward appetitive stimuli and potentially rewarding outcomes. Cronbach's α in the preoperative group was 0.76, and in the postoperative group 0.81. The BAS scale consists of the three subscales 'drive' (4 items, α_{pre}=0.62, α_{post}=0.78), 'fun seeking' (4 items, α_{pre}=0.66, α_{post}=0.52) and 'reward responsiveness' (5 items, α_{pre}=0.62, α_{post}=0.65).

Regulative temperament was measured by means of the 19-item Effortful Control scale of the Adult Temperament Questionnaire-Short Form (EC; α_{pre}=0.81, α_{post}=0.72) (Wiltink, Vogelsang, & Beutel, 2006). The scale is divided into three subscales: inhibitory control (7 items; α_{pre}=0.64, α_{post}=0.49), attentional control (5 items; α_{pre}=0.68, α_{post}=0.56), and activation control (7 items; α_{pre}=0.63, α_{post}=0.63). Participants reported on the extent to which effortful control generally characterize their interactions with the environment (1 = not at all applicable; 7 = completely applicable).

The German version of the 9-item Patient Health Questionnaire-Depression Scale (PHQ-9) (Kroenke, Spitzer, & Williams, 2001) was used to measure depressive symptoms (α_{pre}=0.82, α_{post}=0.75). Participants were asked to assess how often they have been bothered by the particular symptoms during the past 2 weeks (0 = not at all, 3 = nearly every day).

Statistical Analysis

Statistical analyses were conducted using IBM Statistical Package for Social Sciences (SPSS, version 23.0 for Windows; SPSS, Inc., Chicago, IL). The following descriptive statistics were used to summarize sociodemographic, PA, and temperament variables: frequencies and percentages for categorical variables, means and standard deviations for continuous variables. The pre- and the postoperative group were compared using χ^2-tests for categorical variables and using *t*-tests for continuous variables, as appropriate. As effect estimates, Cohen's *d* was used for continuous variables and Cramer's φ coefficient for categorical variables. For Cohen's *d*, values <0.5 refer to a small effect, from 0.5 to 0.8 to a medium effect, and values >0.8 represent a large effect (Cohen, 1988). For φ, <0.3 suggests a small effect, 0.3-0.5 a medium effect, and >0.5 a large effect (Cohen, 1988). Given the unsatisfactory internal consistency of some of the BAS subscales and some of the EC subscales, only the total scores of these questionnaires were used.

The following analyses were performed separately for the pre- and the postoperative group. Multivariate analyses of variance (MANOVA) were conducted to identify differences in mean scores of temperament questionnaires (EC, BIS, BAS) between physically active and inactive patients for each group (i.e., pre- and postoperative). The between-subject factor was the level of PA (1=active, 0=inactive). The dependent variables comprised scores on the three different measures of temperament (EC, BIS, BAS). We further conducted multivariate analyses of covariance (MANCOVA) to adjust for potential confounding variables (such as age, gender, BMI, and depression). Partial η^2 was used as an effect estimate, whereas <0.06 refers to a small effect, 0.06 to 0.14 to a medium effect, and >0.14 to a large effect (Cohen, 1988).

To examine which temperamental variables were associated with the level of PA (1=active vs. 0=inactive), we performed stepwise logistic regression analyses in the pre- and the postoperative group. The first model included BIS, BAS and EC in the first step and the interaction terms between EC and BIS, and BAS in the second step. In subsequent regression analyses, age, gender, BMI, and PHQ-9 were entered in the first step in order to control for these variables. In the second step, BIS, BAS and EC were entered, and in the last step the interaction terms between EC and respectively BIS and BAS were entered. All continuous variables were z-standardized prior to performing the regression analyses and gender was coded as a dummy variable. Model fit was explored using the Hosmer-Lemeshow-test. All tests were two-sided and based on a significance level of $p<0.05$.

Results

Physical activity, temperament, and depressive symptoms in the pre- vs. postoperative group

Patients in the preoperative group wore the SWA on average 6.7 days (SD_{pre}=1.3), and in the postoperative group 6.8 days (SD_{post}=1.3; t=-0.62, df=141, p=0.533). The groups did not differ in mean wear time per day in hours (M_{pre}=21.4, SD_{pre}=2.4 vs. M_{post}=21.6, SD_{post}=2.1; t=-0.57, df=141, p=0.570). Preoperative patients accumulated on average 7120.8 steps per day (SD=3442.9) and postoperative patients 8420.7 steps per day (SD=3953.2; t=-2.09, df=141, p=0.038, d=0.35). Forty-five patients (64.3%) of the preoperative and 39 patients (53.4%) of the postoperative group were categorized as being physically inactive. This difference was not statistically significant ($\chi^2_{(1)}$=1.74, p=0.187, φ=0.11).

No significant between group differences were found with respect to BIS (M_{pre}=2.9, SD_{pre}=0.4 vs. M_{post}=2.9, SD_{post}=0.3; t=0.79, df=141, p=0.431, d<0.1) and BAS reactivity (M_{pre}=3.0, SD_{pre}=0.4 vs. M_{post}=3.1, SD_{post}=0.4; t=-1.17, df=141, p=0.244, d=0.25), but patients in the preoperative group exhibited on average less effortful control (M_{pre}=4.3, SD_{pre}=0.8 vs. M_{post}=4.6, SD_{post}=0.7; t=-2.34, df=141, p=0.021, d=0.40) and more depressive symptoms

(M_{pre}=9.2, SD_{pre}=5.0 vs. M_{post}=4.0, SD_{post}=3.3; t=7.41, df=140, p<0.001, d=1.23) compared to patients of the postoperative group.

Comparison of physically active with physically inactive patients in the pre- and postoperative group

Table 1 displays the comparison of physically active with physically inactive patients, separately by group (pre/postoperative). In both groups, the mean BMI of patients who were physically active was lower than of those with a sedentary lifestyle. In addition, the results indicated that in the postoperative group higher levels of PA were related to lower age. No differences between physically active and inactive patients were found with respect to gender, depression, and temperament. It is noteworthy that although mean BIS scores did not differ significantly between active and inactive patients in the postoperative group, Cohen's *d* indicated a medium effect.

The MANOVA with PA grouping (1=active, 0=inactive) as between-subject factor and the means of temperament questionnaires (BIS, BAS, EC) as dependent variables did not suggest significant differences between physically active and inactive patients in the preoperative [F(3, 66)=1.70, p=0.176, Wilk's λ=0.93, partial η^2=0.07] and postoperative [F(3, 69)=1.59, p=0.200, Wilk's λ=0.93, partial η^2=0.06] group. Similarly, no group differences were found by performing MANCOVAs with age, gender, BMI, and PHQ-9 as control variables (results not reported).

Tables 2 and 3 present the results of the logistic regression analyses. With respect to the unadjusted model, temperament variables and their interaction were not related to PA (active=1, inactive=0) pre- as well as postoperatively (Table 2). According to Nagelkerke's R^2, the data were better explained by the model adjusted for gender, age, BMI, and depression. As can be seen in Table 3, a lower BMI was associated with more PA in the pre- (p=0.017) and the postoperative (p=0.038) group. In the postoperative group, in addition to lower BMI also lower age (*p*=0.008) and a higher level of BIS reactivity (*p*=0.034) contributed to PA grouping (active=1, inactive=0), with the latter having the highest effect (*OR*=2.07). To explore possible interaction effects between age and reactive temperament, and BMI and reactive temperament in the postoperative group, we conducted a subsequent regression analysis for predicting PA (active=1, inactive=0). Age, BMI, BIS, and BAS were entered in the first step, and the two-way interactions between age and BIS/BAS, and BMI and BIS/BAS in the second step (see Table 4). The result indicate that age, BMI, BIS level, and the interaction of BIS and BMI significantly predicted PA grouping (active=1, inactive=0). As can be seen in Figure 1, low BMI (based on median-split) was associated with more PA at high levels of BIS (based on median-split), but not at low levels of BIS in the postoperative group. BAS levels or the interaction between BAS and age/BMI were not associated with PA grouping.

(Please insert Table 2 to 4 about here)

(Please insert Figure 1 about here)

Discussion

The main result of the present study indicates that temperament per se does not contribute to the level of PA in pre- and post-bariatric surgery patients, which is in contrast to our hypotheses. Adjusting analyses for gender, age, BMI, and depression revealed a somewhat different picture indicating a link between PA and BIS, age, and BMI in postoperative patients. Subsequent regressions revealed a significant interaction between BMI and BIS suggesting that low BMI was only associated with more PA in postoperative patients with high BIS compared to low BIS sensitivity. Postoperative patients with low BIS sensitivity were likely to be physically inactive, regardless of their BMI. A possible explanation for the positive association between punishment sensitivity and PA in postoperative patients with low BMI can be assumed in the tendency of patients with anxious temperament to avoid weight regain and to prevent reoccurrence or deterioration of comorbid somatic conditions (such as DM-2, hypertension). Given that temperament is considered to predict the course of cognitions, emotions, and behaviors (Rothbart et al., 2000), anxious temperament might have facilitated better adherence to postoperative lifestyle recommendations in the postoperative group. However, such reasoning remains speculative due to the cross-sectional design that prevents conclusions about causal relationships between temperament and other variables.

Not surprisingly, the findings suggest an inverse relationship between BMI and PA in both pre- and postoperative patients which is in accordance with our hypotheses and with previous observations (Elbelt et al., 2010; Fernández-Aranda et al., 2014). Of interest is the finding that - at least in the postoperative group - younger age was related to more PA. We may conclude that younger persons are more likely to change their PA habits and that they engage more often in MVPA following surgery than older age groups. Though, this assumption is also tentative due to the cross-sectional design of our study.

Against our expectations, effortful control and BAS levels did not contribute to PA grouping (1=active, 0=inactive). This result is not in line with earlier findings that suggested a positive association between PA and Extraversion (BAS), Conscientiousness (EC) and Openness, and a negative relationship of PA with Neuroticism (BIS) (Allen et al., 2016; Brunes et al., 2013; Rhodes, 2006) or an association between low PA and low Novelty seeking (BAS), and high Harm avoidance (BIS) (Fernández-Aranda et al., 2014). Methodological differences between the present and past studies may have caused the mixed results. Past studies relied on the personality theory of Cloninger (1999) or the Big Five personality model (McCrae & Costa, 2003). However, as mentioned above, links between personality traits of Cloninger or the Big Five model and BIS, BAS, and effortful control have been reported (Carver & White, 1994; Evans & Rothbart, 2007; Smits & Boeck, 2006).

Another discrepancy between the present and past studies refers to differences in sample characteristics such as the male/female ratio or age range of the patient samples. For example, the study of Fernández -Aranda et al. (2014) included only female individuals, distributed along the BMI continuum from healthy weight to morbid obesity, who were on average younger than the patients in our study. Also, the heterogeneity of obesity and temperament subtypes in treatment-seeking obese patients may have contributed to discrepant findings (Claes et al., 2013; Müller et al., 2014).

To our knowledge, the present investigation is the first study that examined effortful control and BIS/BAS reactivity in relation to PA focusing exclusively on bariatric surgery patients (males and females). We cannot exclude that the levels of BIS/BAS and effortful control in our samples were particularly typical for bariatric surgery patients and different from other obese samples. Hence, the proposed relationship between temperament and PA may have been less pronounced in our patients. However, when comparing the BIS/BAS means of the present samples with those from an earlier population-based study (Müller et al., 2013), it appears that our patients did not score substantially higher or lower on the BIS/BAS scales compared to individuals from the community. Possibly, other variables beyond temperament that were not assessed in the present study may have influenced the level of PA.

The postoperative group differed from the preoperative group with regard to the mean number of steps per day, whereas the size of this effect was quite small (d=0.35). It seems important that more than half of each group was categorized as being physically inactive, and that the rate of inactive patients did not differ significantly between the two groups. The result referring to the equally high rate of inactive patients in the pre- and postoperative group is in line with the findings of previous longitudinal studies (Berglind et al., 2016; King et al., 2015). Of note, the average lengths of follow-up assessment in the Swedish study (Berglind et al., 2016) and our study were both relatively short (9 and 8 months), which might have contributed to the lack of differences in PA.

The major strength of the present investigation is the objective measurement of PA in both groups. As already mentioned above, the findings are limited by the cross-sectional design. Other weak points are that PA recommendations were not specifically controlled or operationalized in this study, and that both groups consisted of mostly female patients.

To conclude, the present study indicates that only in postoperative patients higher levels of anxiety in combination with lower BMI are associated with more PA. This finding needs further investigation by using a longitudinal design, and including a higher proportion of male patients. Overall, the result supports the concept that individual differences in reactive temperament may affect PA in postoperative patients. Therapeutic approaches aiming at optimizing weight loss maintenance and achieving sufficient levels of PA following bariatric surgery should consider temperamental aspects in addition to behavioral, physiological, and environmental factors. It may be assumed that tailored PA recommendations relative to temperament subtype could be helpful in improving patients' attitude towards daily PA.

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Table 1 Comparison of physically active with physically inactive patients in the pre- and postoperative group

	Preoperative group				Postoperative group			
	Inactive	Active			Inactive	Active		
	n=45	*n*=25			*n*=39	*n*=34		
	n (%)	*n* (%)	$\chi^2_{(1)}$	φ	*n* (%)	*n* (%)	$\chi^2_{(1)}$	φ
Gender, female	37 (82.2)	18 (72.0)	0.99	0.12	29 (74.4)	28 (82.4)	0.68	0.10
	Mean (SD)	*Mean (SD)*	$t_{(68)}$	*d*	*Mean (SD)*	*Mean (SD)*	$t_{(71)}$	*d*
Age	40.8 (11.6)	43.0 (12.3)	-0.75	0.18	43.6 (11.3)	37.0 (9.5)	2.65*	0.63
Body Mass Index	47.9 (5.9)	44.7 (5.6)	2.25*	0.56	33.1 (4.3)	30.8 (3.5)	2.41*	0.59
PHQ-9	8.7 (4.9)	10.2 (5.1)	-1.19	0.30	3.9 (3.2)	4.0 (3.5)	-0.10	0.03
BIS	2.9 (0.4)	3.0 (0.4)	-1.50	0.25	2.8 (0.3)	3.0 (0.4)	-1.70	0.57
BAS	3.0 (0.4)	3.1 (0.4)	-1.74	0.25	3.1 (0.4)	3.2 (0.4)	-1.08	0.25
EC	4.4 (0.8)	4.2 (0.8)	1.195	0.25	4.7 (0.7)	4.5 (0.8)	1.15	0.27

Note. PHQ-9 = Patient Health Questionnaire-Depression, BIS = Behavioral Inhibition System, BAS = Behavioral Activation System, EC = Effortful Control. *$p<0.05$

Table 2 Summary of logistic regression analysis with level of daily physical activity as dependent variable (active=1, inactive=0) and temperament

	Preoperative group (*n*=70)							Postoperative group (*n*=73)						
	B	SE	Wald	df	p	Odds Ratio	95% CI	B	SE	Wald	df	p	Odds Ratio	95% CI
BIS	0.45	0.32	1.98	1	0.159	1.57	0.84-2.96	0.42	0.28	2.18	1	0.140	1.52	0.87-2.67
BAS	0.33	0.31	1.19	1	0.275	1.40	0.77-2.55	0.25	0.26	0.95	1	0.331	1.29	0.77-2.14
EC	-0.22	0.28	0.61	1	0.436	0.81	0.47-1.39	-0.24	0.28	0.72	1	0.395	0,79	0.45-1.37
EC x BIS	0.35	0.33	1.11	1	0.291	1.42	0.74-2.74	-0.31	0.30	1.02	1	0.313	0.74	0.40-1.34
EC x BAS	-0.10	0.26	0.16	1	0.692	0.90	0.53-1.51	-0.04	0.29	0.02	1	0.884	0.96	0.54-1.69
	Hosmer-Lemeshow-test $\chi^2_{(8)}$=7.82, *p*=0.451							Hosmer-Lemeshow-test $\chi^2_{(8)=}$11.06, *p*=0.20						
	Nagelkerke’s R^2=0.12							Nagelkerke‘s R^2=0.10						

Note. PHQ-9 = Patient Health Questionnaire-Depression, BIS = Behavioral Inhibition System, BAS = Behavioral Activation System, EC = Effortful Control.

Table 3 Summary of logistic regression analysis with level of daily physical activity as dependent variable (active=1, inactive=0) and temperament, adjusting for gender, age, body mass index (BMI), and depression

	Preoperative group (*n*=70)							Postoperative group (*n*=73)						
	B	SE	Wald	df	p	Odds Ratio	95% CI	B	SE	Wald	df	p	Odds Ratio	95% CI
Gender (female)	1,16	0.74	2.42	1	0.120	3.18	0.74 – 13.69	-0.20	0.68	0.08	1	0.775	0,82	0,21 – 3.14
Age	0.19	0.27	0.45	1	0.501	1.21	0.69 – 2.12	-0,90	0.34	7.13	1	0.008	0.41	0.21 – 0.79
Body Mass Index	-1.46	0.61	5.65	1	0.017	0.23	0.07 – 0.77	-1.65	0.79	4.32	1	0.038	0.19	0.04 – 0.91
PHQ-9	0.03	0.33	0.01	1	0.926	1.03	0.54 – 1.97	-0.33	0.49	0.46	1	0.497	0.72	0.28 – 1.87
BIS	0.48	0.39	1.58	1	0.208	1.62	0.76 – 3.46	0.73	0.34	4.50	1	0.034	2.07	1.06 – 4.06
BAS	0.56	0.37	2.34	1	0.126	1.76	0.85 – 3.61	0.05	0.29	0.03	1	0.860	1.05	0.60 – 1.84
EC	-0.31	0.32	0.95	1	0.329	0.73	0.39 – 1.37	-0.10	0.32	0.10	1	0.745	0.90	0.48 – 1.68
EC x BIS	0.46	0.36	1.63	1	0.201	1.58	0.78 – 3.21	-0.30	0.35	0.75	1	0.387	0.74	0.37 – 1.47
EC x BAS	-0.13	0.29	0.21	1	0.647	0.88	0.50 – 1.54	0.06	0.32	0.03	1	0.858	1.06	0.57 – 1.97
	Hosmer-Lemeshow-test $\chi^2_{(8)}$=12.99, p=0.112							Hosmer-Lemeshow-test $\chi^2_{(8)}$=6.34, p=0.609						
	Nagelkerke's R^2=0.30							Nagelkerke's R^2=0.32						

Note. PHQ-9 = Patient Health Questionnaire-Depression, BIS = Behavioral Inhibition System, BAS = Behavioral Activation System, EC = Effortful Control.

Table 4 Summary of logistic regression analysis with level of daily physical activity as dependent variable (active=1, inactive=0) and age, BMI, and reactive temperament in the postoperative group

	Postoperative group (*n*=73)						
	B	SE	Wald	df	p	Odds Ratio	95% CI
Age	-1.19	0.41	8.34	1	0.004	0.30	0.13 – 0.68
BMI	-3.17	1.20	6.94	1	0.008	0.04	0.00 – 0.44
BIS	-2.87	1.42	4.13	1	0.042	0.06	0.00 – 0.90
BAS	1.10	1.08	1.03	1	0.309	3.00	0.36 – 24.92
Age x BIS	-0.24	0.48	0.26	1	0.613	0.78	0.30 – 2.02
Age x BAS	0.20	0.38	0.29	1	0.590	1.23	0.58 – 2.57
BMI x BIS	-4.21	1.62	6.70	1	0.010	0.01	0.00 – 0.36
BMI x BAS	1.33	1.25	1.12	1	0.290	3.77	0.32 – 43.95
	Hosmer-Lemeshow-test $\chi^2_{(8)}$=6.58, p=0.582						
	Nagelkerke's R^2=0.47						

Note. BMI = Body Mass Index, BIS = Behavioral Inhibition System, BAS=Behavioral Activation System

Figure 1 The interaction effect of BIS sensitivity (median split) and BMI (median split) on physical activity (i.e. patients accumulating ≥ 8000 steps per day in percent) among postoperative patients.

Note. The interaction indicates that postoperative patients with low BIS sensitivity are likely to be physically inactive, regardless of their BMI. In contrast, postoperative patients with high BIS sensitivity accumulate more often ≥ 8000 steps/day when they have a low BMI.

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