Published in final edited form as:

Eat Behav. 2016 August ; 22: 10–15. doi:10.1016/j.eatbeh.2016.03.033.

Examining the Effect of Binge Eating and Disinhibition on Compensatory Changes in Energy Balance following Exercise among Overweight and Obese Women

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Abstract

Some women behaviorally compensate for the energy expended during exercise by increasing their energy intake or becoming more sedentary, thereby decreasing their energy expenditure. Although behavioral compensation can attenuate or even reverse the energy deficit generated by exercise, few data are available on predictors of compensatory responses to exercise. The present study aimed to identify eating-related predictors of compensatory changes in energy balance following exercise. Overweight and obese, physically inactive women ($N = 48$) completed self-report measures of disinhibition and binge eating and participated in two experimental conditions, exercise and rest, in counterbalanced order. Energy intake and expenditure were measured for 24-hours following each experimental condition to estimate energy balance. On average, women were 21.33 ± 2.09 years old and 63% were white. Of the sample, 63% compensated for the energy expended during exercise by increasing their energy intake or decreasing their energy expenditure. Linear mixed effects modeling with repeated measurement showed that disinhibition was not predictive of behavioral compensation. However, there was a significant difference between the

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Contributors: All authors contributed to the design of the study and assisted writing the study protocol. RLE conducted literature searches, provided summaries of previous research studies, and conducted the statistical analysis. RLE and MDL wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

Conflict of Interest: JMJ is a co-investigator on research grants awarded to the University of Pittsburgh by Ethicon/Covidien, Weight Watchers International, and HumanScale. JMJ also is the principal investigator on a research grant awarded to the University of Pittsburgh by Jawbone, Inc. and BodyMedia, Inc. JMJ is a member of the Weight Watchers International Scientific Advisory Board for 2015 and served on the ILSI North American Energy Balance and Active Lifestyle Committee through August 10, 2015. All other authors declare that they have no conflicts of interest.

Role of Funding Sources: Funding for this study was provided by NHLBI Grant T32 HL07560 (to RLE). NHLBI had no role in the study design, collection, analysis or interpretation of the data, writing of the manuscript, or the decision to submit the paper for publication.

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negative energy balance observed following the rest condition and the positive energy balance observed following the exercise condition among women who reported binge eating, which was driven by a tendency to spend less time being physically active and more time being sedentary following exercise. These findings indicate that women who binge eat may be at greatest risk of compensating for exercise. Future research is needed to better understand psychosocial predictors and common mechanisms through which behavioral compensation is promoted.

Keywords

Behavioral compensation; Energy balance; Exercise; Disinhibition; Binge eating

1.0 Introduction

Obesity is a disorder of positive energy balance (EB), which occurs when the amount of energy consumed is greater than the amount of energy expended (Blundell & Cooling, 2000). EB is determined by variability in energy intake (EI) and energy expenditure (EE), which are driven by a variety of psychological and biological mechanisms (Blundell & Cooling, 2000; DeLany, 2012). Exercise is a modifiable component of EB that can lead to an acute energy deficit and is often prescribed, in combination with dietary restriction, as a means of weight loss and control (Jakicic et al., 2001). However, exercise alone typically fails to produce expected weight loss (Catenacci & Wyatt, 2007), which partly may result from maladaptive behavioral responses to exercise that impede the ability of exercise to produce a sustained energy deficit (Blundell & King, 2000).

Women tend to respond less favorably to exercise interventions than do men (Ballor & Keese, 1991; Donnelly et al., 2003). For example, Donnelly and colleagues (2005) found that, among a sample of overweight and obese adults participating in a 16-month supervised exercise intervention, the majority of men lost weight whereas women were equally likely to lose or gain weight. Given that exercise compliance was maintained under supervision throughout the intervention, the authors posited that women who exhibited weight gain likely had behaviorally compensated for the energy expended during exercise by increasing their dietary intake or decreasing their lifestyle physical activity. Indeed, behavioral compensation can attenuate or even reverse the energy deficit generated by exercise and is estimated to result in 55% to 64% less weight loss than predicted during exercise interventions (Dhurandhar et al., 2014). As such, behavioral compensation may partly explain the difficulty women have in losing weight during exercise interventions.

A recent review highlighted the need to better understand who is susceptible to behaviorally compensate for exercise (Melanson, Keadle, Donnelly, Braun, & King, 2013). To date, investigations designed to identify predictors of behavioral compensation following exercise have focused on the role of disinhibition, a personality trait associated with a failure to resist urges to eat despite satiation and an inability to control dietary intake as well as a tendency to opportunistically overeat in response to food palatability, negative affect, and social settings (Stunkard & Messick, 1985). The characteristics of disinhibition may promote the reestablishment of a positive EB following exercise, and several studies have shown that

overweight women high on disinhibition are more likely to engage in dietary compensation following exercise than are those low on disinhibition (Keim, Canty, Barbieri, & Wu, 1996; Visona & George, 2002). Similarly, binge eating is a behavior associated with a susceptibility to emotional eating (Ricca et al., 2009) and a preference for palatable foods (Mathes, Brownley, Mo, & Bulik, 2009) but is further characterized by intense psychological distress (American Psychological Association, 2013). Whereas disinhibition is a trait factor that influences general eating behavior, binge eating is a pathological eating disturbance characterized by the consumption of a large amount of food accompanied by a sense of loss of control over eating.

Given that the dispositional and behavioral aspects of these factors may relate to predict a greater likelihood to behaviorally compensate for exercise, we sought to evaluate the independent and synergistic effects of disinhibition and binge eating on compensatory changes in EB following a single bout of supervised aerobic exercise among overweight and obese, physically inactive women. Relative to women lower on disinhibition, we hypothesized that women higher on disinhibition would demonstrate greater compensatory increases in EI and decreases in EE following exercise, resulting in a more positive EB, and that this effect would be enhanced among women who also reported binge eating.

2.0 Material and Methods

2.1 Participants and Procedures

Participants were female, overweight or obese (body mass index [BMI] ≥ 25 kg/m²), nonsmokers, not pregnant or lactating, not currently taking medications that affect weight or food intake, free of chronic diseases, and physically inactive, defined as having participated in fewer than 30 consecutive minutes of aerobic exercise no more than twice per week for the past six months (Visona & George, 2002).

Study procedures were approved by an Institutional Review Board and written informed consent was documented. Women completed an exercise and rest condition 7 days apart in counterbalanced order. Women were instructed to abstain from eating or drinking anything aside from water on the morning of each assessment and arrived at the laboratory at 10:00 a.m. Women received a standard breakfast bar upon arrival (160 kcal, 72% carbohydrate, 23% fat, and 5% protein) and 6 fluid ounces of water.

2.1.1 Experimental Conditions—For the exercise condition, women engaged in moderate-intensity exercise by walking on a treadmill for 30-minutes. Heart rate was recorded at 1-minute intervals using a Polar Pacer heart rate monitor (Polar Electro Inc., Port Washington, NY), and women were maintained at 60% to 70% of their age-predicted maximal heart rate. All women began the exercise condition by walking at 3 miles per hour with a 0% grade. If heart rate dropped below 60% of the age-predicted maximal heart rate for 2 consecutive minutes, the treadmill grade was increased until heart rate was sufficiently elevated. If heart rate rose above 70% of the age-predicted maximal heart rate for 2 consecutive minutes, either the treadmill speed or grade was decreased until heart rate was sufficiently reduced. For the rest condition, women sat quietly in a private exam room for 30-minutes.

2.1.2 First Experimental Visit—Women were provided the standard breakfast and completed a questionnaire battery. Height and weight were recorded. Women were fitted with an activity monitor to measure EE and completed the experimental condition. Women were instructed to wear the activity monitor for 24-hours and were contacted by the experimenter the following day to complete a food recall.

2.1.3 Second Experimental Visit—Seven days following the first experimental visit, women returned to the laboratory for their second experimental visit. Women again were provided the standard breakfast and fitted with the activity monitor. Women completed the remaining experimental condition and were instructed to wear the activity monitor for 24-hours. Women were contacted by the experimenter the following day to complete a second food recall.

2.2 Measures

2.2.1 Demographic Information—Women reported age, race and ethnicity, job status, and income.

2.2.2 Body Mass Index—Height and weight were measured while women were dressed in street clothes without shoes and BMI (kg/m^2) was calculated.

2.2.3 Binge Eating—The Eating Disorder Examination Questionnaire, a 38-item, self-report measure assessing eating pathology over the previous 28 days (Fairburn & Beglin, 1994), was used to assess pathological eating behavior. Women reported whether they engaged in objective binge eating (i.e., the consumption of an objectively large amount of food accompanied by a sense of loss of control over eating) or subjective binge eating (i.e., the experience of loss of control over eating without the necessary consumption of an objectively large amount of food) during the previous 28 days. As in prior research (Emery, King, Fischer, & Davis, 2013), a single dichotomous variable was created to indicate the presence or absence of any binge eating during the previous 28 days.

2.2.4 Disinhibition—The Disinhibition subscale of the Three Factor Eating Questionnaire consists of 16-items measuring responsiveness to emotional and situational stimuli that trigger eating behavior (Stunkard & Messick, 1985). The items consist of true or false and Likert scale response options. Each item is assigned a binary code and summed, with higher scores indicating higher disinhibition.

2.2.5 Energy Intake—EI was assessed using the Nutrition Data System for Research (NDSR; University of Minnesota, Minneapolis, MN). The NDSR food recall interview is structured using a multiple-pass approach, providing several opportunities to recall EI for the previous 24-hour period. Women were provided a booklet of standard portion sizes and measurements, allowing for a more accurate estimation of food and beverage amounts consumed. EI data was gathered via telephone and entered directly into the NDSR program by the experimenter. Using the NDSR program, EI in kcals and macronutrient intake in grams were determined from the foods and beverages consumed through 11:59 p.m. on each experimental day.

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covariate effects ($B = 742.37$; $SE = 347.85$; $p = 0.04$), which held after accounting for the energy expended during each experimental condition ($p = 0.04$). Although the interaction between binge eating and experimental day did not significantly predict changes in EI or EE, the impact of this interactive effect on changes in macronutrient consumption and time spent being physically active or sedentary was explored. The interaction between binge eating and experimental day was not shown to predict macronutrient intake ($ps > 0.10$) but was a significant predictor of the number of minutes women spent being physically active ($B = -42.48$; $SE = 20.95$; $p = 0.05$) and sedentary ($B = 59.22$; $SE = 28.80$; $p = 0.05$) above and beyond covariate effects, which held after accounting for the period women were physically active or sedentary during the exercise and rest conditions, respectively ($ps < 0.05$).

5.0 Discussion

The present experimental study evaluated the impact of compensatory changes in EI and EE on overall EB following an acute bout of exercise among a sample of overweight and obese, physically inactive women and examined hypothesized predictors of compensatory changes in EB. On average, women decreased EI and increased EE in response to exercise, resulting in a negative EB. Importantly, this average response to exercise obscured considerable individual variability, and 63% of the sample behaviorally compensated for the energy expended during exercise. Of these women, 73% reported compensatory increases in EI following exercise relative to rest whereas 43% demonstrated compensatory reductions in EE. Although the majority of these women showed compensatory changes in either EI or EE following exercise, 17% both increased EI and decreased EE. The magnitude of behavioral compensation was sufficient to produce a notable impact on EB, such that 53% of women who behaviorally compensated had a more positive EB following exercise than rest and this effect largely was promoted through increased EI.

Results showed that nearly half of women increased EI following exercise by an average of 796 kcals, and approximately one-third of women reduced EE following exercise by an average of 271 kcals. However, these marked compensatory responses to exercise were masked by an overall reduction in EI and increase in EE, thereby highlighting the importance of scrutinizing individual variability in behavioral compensation. The majority of studies have based their conclusions on average effects and have failed to demonstrate compensatory responses in either EI (Donnelly et al., 2003; Donnelly, Jacobsen, Heelan, Seip, & Smith, 2000; Lluch, King, & Blundell, 2000; Martins, Morgan, Bloom, & Robertson, 2007) or EE (Alahmadi, Hills, King, & Byrne, 2011; Hollowell et al., 2009; Manthou, Gill, Wright, & Malkova, 2010; McLaughlin, Malkova, & Nimmo, 2006; Ross et al., 2004) following exercise. Given the present findings and those of others (Donnelly et al., 2013; Pomerleau, Imbeault, Parker, & Doucet, 2004), previous research may have underestimated compensatory responses to exercise by focusing on the group rather than the individual level.

Previous research largely has focused on compensatory changes in either EI or EE following exercise, which has limited the ability to characterize the effect of behavioral compensation on overall EB. The present study further extends prior research through the prolonged naturalistic assessment of both EI and EE and is the first to document that compensatory

responses to an acute bout of exercise can promote a positive EB, which could attenuate weight loss or promote weight gain if sustained over time. Indeed, over half of women who engaged in behavioral compensation had an energy imbalance 812 kcals higher in response to exercise compared to rest. Taken together, these findings demonstrate the importance of looking at both sides of the EB equation to adequately assess the potential impact of behavioral compensation on weight change.

Partially consistent with our hypothesis, binge eating but not disinhibition predicted compensatory changes in EB. Among women who reported binge eating, there was a significant difference between the negative EB observed in response to rest and the positive EB observed in response to exercise. This effect was driven by a tendency to spend less time being physically active and more time being sedentary following exercise. Thus, women who binge eat may be likely to compensate for exercise by reducing lifestyle activity rather than increasing dietary consumption. Although binge eating did not interact with disinhibition to predict a heightened compensatory response to exercise, women who reported binge eating did have higher levels of disinhibition. Given the high association between disinhibition and binge eating, the previous link between disinhibition and behavioral compensation (Keim et al., 1996; Visona & George, 2002) may be representative of more pathological eating disturbances. Moreover, the poor weight loss treatment outcomes commonly observed among women who binge eat (Wilson, Wilfley, Agras, & Bryson, 2010) may partly be explained by a greater tendency to engage in behavioral compensation. Accordingly, women who binge eat may require more tailored intervention strategies to reduce the likelihood of behaviorally compensating for exercise.

This study has several limitations. First, indirect calorimetry was not used to assess EE during the supervised exercise condition. Thus, women varied in the amount of energy they expended during exercise, which may have impacted the extent to which they engaged in behavioral compensation. Second, EI was measured through self-report, which is subject to demand characteristics that may have caused women to misreport dietary consumption (Scagliusi et al., 2009). Third, EI only was assessed following experimental visits. Thus, we are unable to determine whether the EI observed in response to each experimental condition differed from what women typically would have consumed under normal circumstances. Fourth, binge eating was self-reported, which may have caused our rates of binge eating to differ from those measured by clinical interview. Moreover, because we did not collect detailed information on when binge eating occurred, we are unable to determine whether the magnitude of behavioral compensation was influenced by how recently women engaged in binge eating prior to exercising. Nonetheless, self-reported binge eating was predictive of compensatory responses to exercise and may have utility as an easily assessed marker of problematic responses to exercise. Finally, the present study provides a laboratory demonstration of behavioral compensation following a single bout of exercise among a sample of young women. Given that compensatory responses to exercise vary across time (Unick et al., 2015), we are unable to assess whether the effects of chronic exercise training would differ compared to what is observed in response to acute exercise and these findings may not be generalizable to other populations.

Despite these limitations, these findings document wide individual variability in compensatory responses to acute exercise that is not captured at the group level. Although dietary intake was the largest source for behavioral compensation, compensatory reductions in EE also were notable. Not all women who engaged in behavioral compensation had a positive EB following exercise, however, suggesting that assessing the impact of behavioral compensation on EB may be critical in predicting individual responses to weight loss in the context of exercise. Moreover, women who reported a recent history of binge eating were at elevated risk of having a more positive energy imbalance following exercise than rest. Given that over half of the present sample compensated for the energy expended during exercise, these findings substantiate the need for a better understanding of psychosocial predictors and common mechanisms through which behavioral compensation is promoted and whether these factors remain consistent following recurrent bouts of exercise to better inform intervention efforts.

Acknowledgments

The authors acknowledge the skilled research assistance of Anna Bartko, Hillary Doucette, Margaret Fromuth, and Zachary Westerfer and thank them for their hard work on and dedication to this project.

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Highlights

- We assessed predictors of compensatory changes in energy balance after exercise.
- The majority of the sample behaviorally compensated for exercise.
- Disinhibition was not predictive of behavioral compensation.
- Binge eating predicted compensatory increases in energy balance.

Figure 1.

Individual energy balance difference between the exercise (EB_{ex}) and rest (EB_{rest}) experimental days. *Note:* Energy balance difference calculated as $EB_{ex} - EB_{rest}$. Positive values indicate “compensation” and negative values indicate “non-compensation.” The dashed line reflects the net energy expenditure ($EE_{ex} - EE_{rest}$) of the exercise session. Women above this line fully compensated for the energy expended during exercise by increasing energy intake or decreasing energy expenditure, resulting in a more positive energy imbalance.

Descriptive Characteristics (N = 48)

Characteristic	Mean $\pm$ SD
Age (years)	21.33 $\pm$ 2.09
Weight (kg)	85.38 $\pm$ 15.81
Height (cm)	166.54 $\pm$ 7.15
BMI (kg/m ²)	30.69 $\pm$ 5.07
Disinhibition (0–16)	6.56 $\pm$ 2.2
	% (n)
% White	63 (30)
% Employed	73 (35)
% Income < \$30,000	29 (14)

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Table 2

Differences in Energy Intake, Energy Expenditure, and Energy Balance across Experimental Days

	Rest Day	Exercise Day	Difference*	p
	Mean ± SD	Mean ± SD	Mean ± SD	
Energy Balance (kcal)	110.50 ± 949.04	-215.17 ± 1010.11	-325.57 ± 1089.66	0.04
Energy Intake (kcal)	1850.98 ± 901.97	1794.27 ± 660.02	-56.70 ± 1043.87	0.71
Energy Expenditure (kcal)	1740.48 ± 487.73	2009.44 ± 739.81	268.96 ± 506.84	0.001

* Difference scores were calculated by subtracting the values for each variable obtained on the exercise day from those obtained on the rest day, such that positive scores indicate a higher value on the exercise day relative to the rest day.

Table 3

Differences in Energy Intake, Energy Expenditure, and Energy Balance between Non- compensators and Compensators

	Experimental Condition	Non-compensators (n = 18)	Compensators (n = 30)	p
		Mean ± SD	Mean ± SD	
Energy Balance (kcal)	Rest	574.88 ± 958.91	-168.13 ± 840.55	0.007
	Exercise	-641.65 ± 921.17	40.73 ± 987.7	0.02
Energy Intake (kcal)	Rest	2281.51 ± 946.37	1592.66 ± 780.65	0.009
	Exercise	1458.69 ± 514.89	1995.62 ± 664.47	0.005
Energy Expenditure (kcal)	Rest	1706.63 ± 477.84	1760.79 ± 500.55	0.71
	Exercise	2100.34 ± 863.7	1954.89 ± 664.47	0.52

Note: Women were considered to be “compensators” if they increased energy intake or decreased energy expenditure following the exercise condition relative to the rest condition.

Women were considered to be “non-compensators” if they decreased energy intake or increased energy expenditure following the exercise condition relative to the rest condition.