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Internalized weight bias is associated with perceived exertion and affect during exercise in a sample with higher body weight

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Abstract

Objective: For individuals with overweight/obesity, internalized weight bias (IWB) is linked to low physical activity (PA). This study used a laboratory-based paradigm to test the hypothesis that IWB moderates the association between heart rate (HR) and perceived exertion and affect during PA.

Methods: Participants with overweight/obesity completed 30-min of supervised moderate-intensity treadmill walking (65%–75% of age-predicted maximal HR). Body Mass Index (BMI) and Weight Bias Internalization Scale were assessed at baseline. HR was monitored every minute; perceived exertion and affect were assessed every 5 min. Linear mixed models were employed with random effects of time and participant.

Results: The sample (n = 59; 79.7% female, 91.5% white) had an average BMI = 32.1 kg/m^2 (SD: 3.3), and age = 47.1 (SD: 10.3) years. There was a main effect of IWB on perceived exertion (greater IWB was associated with greater perceived exertion during exercise; $p < 0.001$). There was an interaction of IWB and HR on affect ($B = -0.01$, $p < 0.01$). For individuals with high IWB, HR elevations were associated with a negative affective response during exercise. For individuals with low IWB, HR elevations were associated with increased positive affect during PA.

Conclusions: Findings indicate that among individuals of higher body weight, IWB is associated with reporting higher perceived exertion during 30 min of moderate intensity PA. IWB moderated the relationship between increasing HR during exercise and affect. Among individuals with overweight/obesity who report IWB, the initial experience of PA may be harder and more unpleasant, with lasting implications for the adoption of PA.

KEYWORDS

affect, exercise, internalized weight bias, obesity, perceived exertion, physical activity

David M. Williams, Kathryn E. Demos, and Jessica L. Unick share senior author/multi-PI status.

1 | INTRODUCTION

Physical activity (PA) is a key element of a healthy lifestyle as it is associated with numerous physical, emotional, and cognitive benefits.[1,2] The most recent guidelines for Americans state that individuals should aim to achieve at least 150 min (and up to 300 min) of moderate intensity activity each week to achieve health benefits of aerobic PA.[3,4] Yet estimates indicate that 35%–50% of American adults are insufficiently active based on self-reported data.[5,6] Studies using objective accelerometer data reflect even lower rates of adherence.[7] This is especially troublesome for individuals of higher body weight, where PA can mitigate risk for adiposity-related morbidity and contribute to long-term weight control.[8–10] As a result, identifying modifiable factors that influence adoption and maintenance of PA remains a significant public health priority, especially among individuals with overweight or obesity.[11]

Weight-related stigma and internalized weight bias have been identified as psychosocial factors that may interfere with PA among individuals with obesity.[12] Weight or obesity stigma is common in the United States, whereby individuals of higher weight are socially devalued due to body size, often accompanied by negative stereotyping (i.e., lazy, lacking self-control, unintelligent[13]). These attitudes are pervasive and perpetuate widespread prejudice and discrimination of individuals of higher body weight.[14] In some circumstances individuals internalize these beliefs, meaning that they believe weight stigmatizing attitudes are accurate or true for themselves.[15,16] The study of internalized weight bias is in relative infancy compared to the study of experienced weight stigma, yet growing evidence suggests internalized weight bias is associated with various measures of PA and may mediate the relationship between experiencing weight stigma and reduced PA.[17] Specifically, internalized weight bias is associated with lower engagement in leisure time PA,[18] lower self-reported motivation to exercise,[19,20] and self-reported avoidance of exercise.[21–23] Furthermore, individuals who report internalized weight bias may be less responsive to interventions to increase PA.[24]

While these findings indicate internalized weight bias is a factor that may undermine engagement in PA, more research is needed to understand how internalized weight bias is associated with reduced activity. Observational research suggests that weight-related stigmatization and internalized weight bias are associated with self-reported bodily pain and pain-related interference among individuals with higher body weight.[25,26] These findings stem from research based in social neuropsychology suggesting that there is an overlap in the neurophysiological pathways for processing of physical and social pain.[27,28] A potential implication of this overlap is that perceiving and internalizing social rejection in the form of weight-related stigmatization may contribute to or exacerbate uncomfortable physical experiences. Therefore, exercise may be perceived as more uncomfortable or unpleasant among individuals who internalize weight bias, perhaps undermining motivation, promoting avoidance, and ultimately interfering with uptake and maintenance of regular PA.

Extensive research has explored how individuals feel while they are engaging in PA, providing a strong empirical basis to begin exploring the relationship between internalized weight bias and how individuals of higher body weight experience exercise. For example, previous research has documented that as heart rate (HR) increases, individuals report increased perceived exertion.[29] In fact, HR and perceived exertion are so highly correlated during exercise that they are often considered interchangeable when the more direct physiological measurement of HR is not possible.[29] Furthermore, laboratory-based exercise protocols allow for repeated assessment of factors such as affective valence (e.g., how pleasant or unpleasant the exercise feels), which can be assessed throughout the protocol at any given time or intensity.[30] During moderate intensity (i.e., 64%–76% maximal HR—the minimum intensity of aerobic exercise consistent with national guidelines), there is significant individual variability in affective response.[31] This variability in affect has been shown to predict adherence to PA programs,[32–35] consistent with the principle of psychological hedonism.[36,37] Understanding factors that account for variability in affective response to exercise, such as internalized weight bias, is of considerable interest as this may contribute to motivation, or lack thereof, to exercise in the future.

Given the robust literature documenting consistent relationships between physiological indicators of exercise intensity (HR) and subjective responses to exercise (both perceived effort and affective response to exercise), the goal of the current study was to evaluate internalized weight bias as a moderator of these highly studied relationships among a sample of individuals with overweight or obesity during a 30-min bout of laboratory-based, supervised, moderate intensity treadmill walking. The current study is a secondary analysis of a larger trial designed to study the impact of affective response to exercise among exercisers and nonexercisers. It was hypothesized that internalized weight bias would moderate the relationship between HR and perceived exertion as well as the relationship between HR and affective response. Specifically, it was anticipated that individuals with higher internalized weight bias would find exercising at moderate intensity more effortful and more unpleasant (reporting more negative affect) compared to individuals with lower levels of internalized weight bias.

2 | METHODS

2.1 | Participants and recruitment

Participants who were interested in weight loss treatment were recruited via the Internet. To be eligible, individuals had to be between 18 and 60 years of age, have a Body Mass Index (BMI) of 25–40 kg/m^2, and not have any condition that would limit their ability to exercise (e.g., orthopedic limitations or serious medical conditions). Participants were recruited to be either "nonexercisers" (average self-reported moderate-to-vigorous intensity physical activity (MVPA) ≤30 min/week) or regular "exercisers" (≥150 min/

week). Given that PA may differ as a function of BMI, exercisers and nonexercisers were matched on this variable. Additional exclusionary criteria include: a history of coronary artery disease (i.e., myocardial infarction), stroke, diabetes, pulmonary disease (e.g., COPD), use of any medication that would affect HR (e.g., beta blocker), or women who are nursing or pregnant, current weight loss treatment including history or plan for bariatric surgery.

2.2 | Procedures

Interested participants contacted study staff and underwent preliminary screening via telephone to determine initial eligibility. During this time, they were asked to report on their average MVPA over the previous 6 months and over a recent "typical" week. Individuals who self-reported >60 to <150 min/week of MVPA either over the past 6 months or during a recent "typical" week were deemed ineligible for this study. Participants deemed initially eligible based upon the phone screen were invited to an orientation session where the study was described in detail and informed consent was obtained. Height and weight were assessed in the laboratory to confirm BMI within eligible range and a measure of fitness was performed.

Approximately 1 week later, participants returned to the laboratory for a supervised exercise visit. Prior to beginning the exercise protocol, participants were equipped with a HR monitor. Immediately prior to the start of the exercise bout, participants reported their current (pre-exercise) affective valence using the Feeling Scale. The exercise session included a 2-min warm-up, followed by 30 min of moderate intensity walking (65%–75% of age-predicted maximal HR), and a 2-min cool-down. This exercise duration and intensity was chosen because it is consistent with the American College of Sports Medicine's exercise guidelines[38] and is feasible for individuals of higher body weight. In order to account for potential individual differences in fitness level, the starting exercise intensity was estimated using HR data from the baseline fitness test (described below). HR was monitored every minute and the treadmill grade or speed was adjusted appropriately if the subject's HR fell outside the target range for two consecutive minutes. Perceived exertion and affective valence were assessed every 5 min during exercise using the Ratings of Perceived Exertion Scale and Feeling Scale respectively (described in detail below). Participant study involvement included additional procedures after this exercise session, but the current analyses solely focus on this exercise session. Study procedures were approved by the Miriam Hospital (Lifespan) Institutional Review Board.

2.3 | Measures

2.3.1 | Weight, height, and BMI

Weight was measured to the nearest 0.1 kg using a calibrated digital scale. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. BMI was calculated (kg/m^2) to confirm eligibility.

2.3.2 | Baseline fitness test

Fitness was measured via a submaximal graded exercise test (GXT). Participants walked on the treadmill at 3.0 mph, and the speed and incline were increased every three minutes until 75% of age-predicted maximal HR (calculated as 220-age) was achieved.[38] The purpose of this GXT was to allow participants to gain familiarity with walking on a treadmill, to compare fitness between "exercise" and "nonexercise" groups, and to assist in determining the starting treadmill speed and grade for the exercise visit. The decision to perform the GXT to 75% of age-predicted maximal HR was chosen because this is the upper range of what is still considered to be moderate-intensity and thus would not require medical supervision, as is the case with a maximal exercise test.

2.3.3 | Perceived exertion

Participant perceptions of how hard they were working were assessed using the Borg Ratings of Perceived Exertion.[39] Every 5 min during the protocol (beginning after the warm-up and first 5 min of exercise were completed), participants were prompted verbally (i.e., "how hard do you feel that you are working right now?") to rate their exertion on a scale ranging from 6 (no exertion at all) to 20 (maximum exertion).

2.3.4 | Affective valence

Participants were asked to report their current affect before, during, and following exercise using the Feeling Scale (FS).[40] This single-item measure asks participants to rate how they feel "at the present moment" on an 11-point scale ranging from −5 (very bad) to +5 (very good). The FS has been shown to be related to other measures of affective valence[41] and has been shown to be predictive of future PA behavior.[33–35] Furthermore, it is ideal for assessing affective valence during exercise given that it is a single item measure, and it has been used as a measure of affective valence in numerous PA studies.[42,43]

2.3.5 | Weight Bias Internalization Scale (15)

The Weight Bias Internalization Scale (WBIS) is an 11-item scale designed to measure the degree to which an individual believes that negative weight-related attitudes are relevant and accurate for him- or herself. Items are answered on a 7-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree and higher scores reflect greater internalized weight bias. Consistent with work that has documented low internal reliability of the first item of this scale ("As an overweight person, I feel that I am just as competent as anyone"), this item was removed for all analyses.[44] The WBIS demonstrated adequate internal consistency in this study (Cronbach's $\alpha = 0.83$).

2.4 | Statistical analysis

Data were analyzed with R studio version 3.5.1.[45] Descriptive statistics included means and standard deviations of continuous variables and percentages of categorical variables. The associations between internalized weight bias and baseline variables were evaluated with simple linear regression and independent samples *t*-tests for continuous (i.e., BMI, age) and categorical (i.e., sex, exercise status) predictors, respectively.

Given the nested structure of observations within individuals during the exercise task, multilevel modeling was employed to acknowledge that both individual-level and time-level effects might contribute to variation in our dependent variables of interest: perceived exertion and affect. Linear mixed models with random effects of time (minutes in the task) and participant were employed using the "nlme" package.[46] Models were run using an AR(1) correlation structure to account for greater correlations between adjacent time points (e.g., minute 17 being highly correlated with minute 12 and minute 22) as this is the recommended strategy for time series analysis.[47] Given that the exercise task was one lab-based session, there were no missing observations in this sample. Therefore, no procedures were employed for handling missing data and results reflect complete data from all 59 study participants. Independent variables of interest were internalized weight bias and HR. Group mean centering was used to create between-subject fixed effects for both weight bias internalization and HR. Within-subject effects for the primary nested independent variable of interest, HR, were centered within persons. The within-subjects centered value for HR was used when testing model interactions. Models evaluating HR as a fixed effect included between- and within-subjects centered variables as a method for partitioning the variance of HR on perceived exertion and affect. While model estimates are based on continuous values of independent variables, interaction terms were trichotomized for graphing purposes into high (2+ standard deviation above the mean), medium (within ±2 standard deviation of the mean), and low (2+ standard deviation below the mean) values for ease of interpretation.

For both dependent variables of interest (perceived exertion [Model set "a"] and affect ["Model set b"]), analyses proceeded via an iterative model building approach using a stepwise examination of a series of four nested models. First, a null model (Models 0a and 0b) was assessed to examine the variation in the dependent variables across participant ID (random effect) without any other predictors. Then, time in the task was added (Models 1a and 1b) to determine whether the dependent variables varied as a function of time. Within Model 1, time in the task was evaluated as both a fixed effect and as a random effect to determine whether individuals vary with regard to their rate of change over time. Both linear and quadratic effects of time in the task were also evaluated. Third, individual-level predictors (i.e., age, exercise status, sex, race/ethnicity, baseline BMI) were added as fixed effects to control for their effects on both of the dependent variables (Models 2a and 2b). In addition to these covariates, pre-exercise affect rating was also included to control for its effect on affect throughout the task (Model 2b). Fourth, to examine our primary hypothesis regarding the effects of internalized weight bias and HR on the dependent variables, both between- and within-subjects HR, centered weight bias internalization, and interaction term were added to the model as fixed effects (Models 3a and 3b). For significant interaction terms, regions of significance were evaluated.

3 | RESULTS

3.1 | Descriptive statistics

Participants (n = 59) were mostly female (79.7%) and middle-aged (M = 47.10, SD = 10.31). Participants' average BMI was 32.09 kg/m^2 (SD = 3.27), and 71.2% were classified as "obese" (BMI ≥ 30 kg/m^2). The majority of the sample identified as non-Hispanic (94.9%). The sample was 91.5% White, 3.4% Black, 1.7% Asian, 1.7% Pacific Islander/Native Hawaiian, and 1.7% Other. At baseline, participants reported moderate weight bias internalization (M = 3.84, SD = 1.11). Participants were roughly split between exercisers (49.2%, n = 29) and nonexercisers (50.8%, n = 30). Consistent with study procedures, average HR for participants during the exercise protocol was 69.9% (SD = 2.76) of maximal HR (see Figure 1 for individual trajectories of HR throughout the exercise session). See Table 1 for measures of affective valence (Feelings Scale), HR, and perceived exertion at each assessment point during the exercise session.

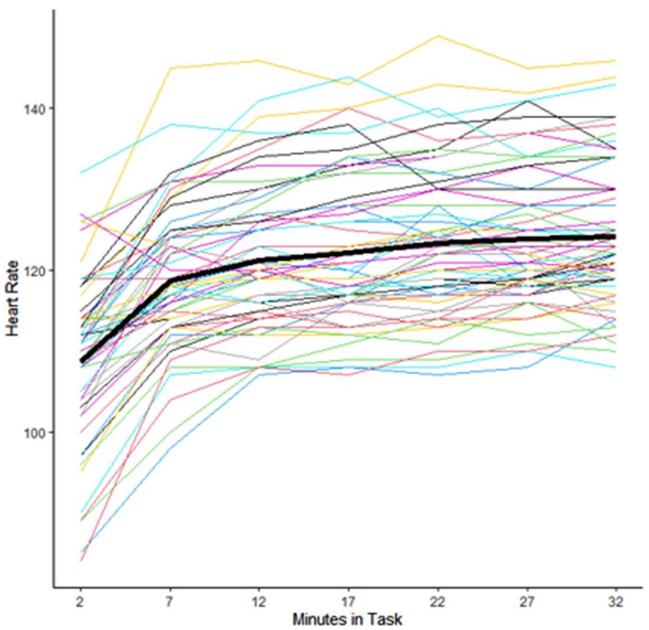


FIGURE 1 Average heart rate over time in the exercise task (black line) and Individual trajectories of heart rate over time in the exercise task (color lines)

TABLE 1 Means and standard deviations of affect, heart rate, and perceived exertion during exercise task

Time in the task (min)	Feelings scale rating *M* (SD)	Heart rate *M* (SD)	Rate of perceived exertion *M* (SD)
2	3.32 (1.84)	108.73 (10.37)	–
7	3.17 (1.65)	118.69 (8.73)	9.31 (2.04)
12	3.17 (1.63)	121.25 (8.97)	9.93 (2.27)
17	3.05 (1.64)	122.22 (9.33)	10.22 (2.36)
22	3.07 (1.67)	123.34 (9.20)	10.47 (2.40)
27	3.10 (1.75)	123.86 (8.85)	10.68 (2.37)
32	3.14 (1.82)	124.15 (8.99)	10.61 (2.55)

3.2 | Internalized weight bias association with baseline characteristics

Analyses revealed statistically nonsignificant relationships between internalized weight bias and BMI (B = 0.04, SE = 0.04, t = 0.98, p = 0.33), age (B = −0.03, SE = 0.01, t = −1.87, p = 0.07), and exercise status (t(56.91) = 1.95, p = 0.06). A statistically significant relationship was observed between sex and internalized weight bias, such that women (n = 47, M = 4.01, SD = 1.06) reported higher internalized weight bias than men (n = 12, M = 3.18, SD = 1.07), t (16.91) = 2.43, p = 0.03.

3.3 | Heart rate and internalized weight bias association with perceived exertion and affect

3.3.1 | Perceived exertion (Models 0a-3a)

Results are presented in Table 2. Examination of results from the null model (Model 0a) with a random effect of participant ID revealed an intercept that is significantly greater than zero and positive, indicating that individuals had significant elevations in perceived exertion during the task. For Model 1a, fixed and random effects of time in the task were evaluated, which revealed a model with random effect of time has a significantly better fit (AIC = 1011.17 vs. 1008.47, BIC = 1030.52 vs. 1031.69, deviance = −500.58 vs. 498.23, p = 0.03). These models were compared to one accounting for the quadratic effect of time (as both fixed and random effect), which outperformed the previous models and therefore model building proceeded using quadratic model (AIC = 996.69, BIC = 1027.65, −490.35, p < 0.001).

Significant linear and quadratic terms for time in the exercise session indicate that perceived exertion increased as participants spent more time exercising and eventually leveled off. Model 2a, which controlled for several relevant covariates, revealed a significant negative effect of exercise status, indicating that relative to non-exercisers, exercisers reported lower perceived exertion. All other covariates were nonsignificant and therefore model building proceeded with only exercise status as a covariate.

In Model 3a, the effects of HR and internalized weight bias, and their interaction were evaluated. A significant positive effect of within-subjects HR was observed, such that increasing HR (relative to one's own average) was associated with greater perceived exertion. A significant positive effect of internalized weight bias was found, such that higher internalized weight bias at baseline was associated with greater perceived exertion during exercise. There was no significant interaction observed between internalized weight bias and HR, as such the final Model 3a was presented without the interaction term in Table 2.

3.3.2 | Affect (Models 0b-3b)

Results are presented in Table 3. Examination of results from the null model (Model 0b) with a random effect of participant ID revealed an intercept that is significantly greater than zero and positive, indicating that individuals had significant elevations in affect during the task. For Model 1b, fixed and random effects of time in the task were evaluated, which revealed that these models did not significantly differ from one another (AIC = 866.56 vs. 866.68, BIC = 866.68 vs. 890.17, deviance = −428.28 vs. 427.01, p = 0.11). These models were compared to one accounting for the quadratic effect of time (as both fixed and random effect), which outperformed the previous models and therefore model building proceeded using the quadratic model (AIC = 858.52, BIC = 890.71, −421.26 p < 0.01). There was not a significant linear or quadratic fixed effect of time on affect; however, these terms remained in the model due to their contribution to model fit and conceptual relationship to the primary outcome.

Model 2b, which controlled for several relevant covariates, revealed a significant positive effect of pre-exercise affect that indicating that more positive affect at rest is associated with more positive affect throughout the task. There was a significant positive effect of sex, such that relative to women, men reported higher (more positive) affect during the task. Finally, there was a significant positive effect of age, such that being older is associated with reporting more positive affect. All other covariates were non-significant, and therefore model building proceeded using pre-exercise affect, sex, and age as covariates.

TABLE 2 Model development to evaluate the effects of HR and WBIS on perceived exertion during exercise

	Model 0a B (SE)	Model 1a B (SE)	Model 2a B (SE)	Model 3a B (SE)	Final Model 3a B (SE)
Intercept	10.00 (0.28)***	10.20 (0.29)***	11.30 (3.17)***	10.64 (0.35)***	10.64 (0.35)***
Time in task (linear)		8.31 (1.38)***	8.31 (1.39)***	6.23 (1.48)***	6.41 (1.48)***
Time in task (quadratic)		−3.13 (0.81)***	−3.31 (0.82)***	−2.56 (0.82)**	−2.66 (0.82)**
Age			−0.03 (0.03)	–	–
Exercise status[a]			−1.24 (0.55)*	−1.13(0.52)*	−1.11 (0.52)*
Gender[b]			−1.11 (0.66)	–	–
Baseline BMI			0.04 (0.08)	–	–
Race/Ethnicity			0.61 (0.81)	–	–
Between-subjects HR				0.004 (0.03)	0.005 (0.03)
Within-subjects HR				0.06 (0.02)**	0.06 (0.02)**
WBIS				0.69 (0.23)**	0.73 (0.23)**
WBIS: HR (within) interaction				0.02 (0.02)	–

Fit statistics

Model	AIC	BIC	Deviance
Model 0a	1039.48	1054.95	−515.73
Model 1a	996.69	1027.65	−490.35
Model 2a	993.45	1043.76	−483.73
Model 3a	977.13	1027.44	−475.57
Final model 3a	976.88	1023.32	−476.44

Abbreviations: HR, heart rate; WBIS, internalized weight bias.
[a]Reference group is non-exercisers.
[b]Reference group is females.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

In Model 3b, the effects of HR and internalized weight bias, and their interaction were evaluated. A significant negative interaction effect was observed between internalized weight bias and HR on affect. As demonstrated by Figure 2, individuals who reported high levels of internalized weight bias at baseline demonstrated a negative association in which an increase in HR (relative to one's own average) was associated with a more negative affective response. Per Figure 3, the region of significance on weight bias internalization ranged from −3.02 to 0.28 (centered values), indicating that any given simple slope outside this range is statistically significant. Therefore, the observed centered values of weight bias internalization (the WBIS score) in this sample (range = −1.94–2.45) indicate that the effect of HR on affect during the exercise task was only significant for individuals with a high WBIS score (greater weight bias internalization). As such, individuals who reported low levels of internalized weight bias at baseline demonstrated an attenuated and nonsignificant association between HR and affect during the task.

To account for the possibility that this effect was driven by the fact that individuals higher in internalized weight bias were exercising at a higher percentage of maximum HR throughout the exercise session, a post hoc analysis was conducted to test the association between internalized weight bias and percent maximum HR. Results indicated that internalized weight bias and percent HR max were weakly and nonsignificantly correlated ($r = 0.08$), and that internalized weight bias was a non-significant linear predictor of percent HR max ($B = 0.002$, SE = 0.003, $t = 0.62$, $p = 0.54$).

4 | DISCUSSION

The findings of the current study indicate that among individuals with overweight or obesity, internalized weight bias is associated with greater perceived exertion during moderate intensity aerobic exercise when controlling for HR and exercise status. Furthermore, increasing HR relative to one's average during a single bout of moderate-intensity exercise was associated with more negative affect among those who endorsed higher internalized weight bias while those with lower internalized weight bias did not exhibit a relationship between HR and affect. The results partially support the specific hypotheses of this study (e.g., internalized weight bias had a main effect on the relationship of HR and perceived exertion as opposed to the hypothesized moderating effect). Yet, taken together

TABLE 3 Model development to evaluate the effects of HR and WBIS on affect during exercise

	Model 0b *B* (SE)	Model 1b *B* (SE)	Model 2b *B* (SE)	Model 3b *B* (SE)
Intercept	3.21 (22)***	3.15 (0.21)***	−1.40 (1.43)	−2.12 (1.06)*
Time in task (linear)		−1.21 (1.24)	−1.23 (1.29)	0.09 (1.43)
Time in task (quadratic)		1.17 (0.61)	1.17 (0.60)	0.42 (0.70)
Age			0.03 (0.01)*	0.07 (0.02)**
Exercise Status[a]			0.01 (0.26)	–
Gender[b]			0.67 (0.30)*	0.84 (0.32)*
Baseline BMI			0.03 (0.04)	–
Race/Ethnicity			0.02 (0.36)	–
Pre-exercise affect			0.644 (0.07)***	0.61 (0.06)***
Between-subjects HR				0.06 (0.03)*
Within-subjects HR			.	−0.01 (0.008)
WBIS				−0.11 (0.11)
WBIS: HR (within) interaction				−0.02 (0.005)**

Fit statistics

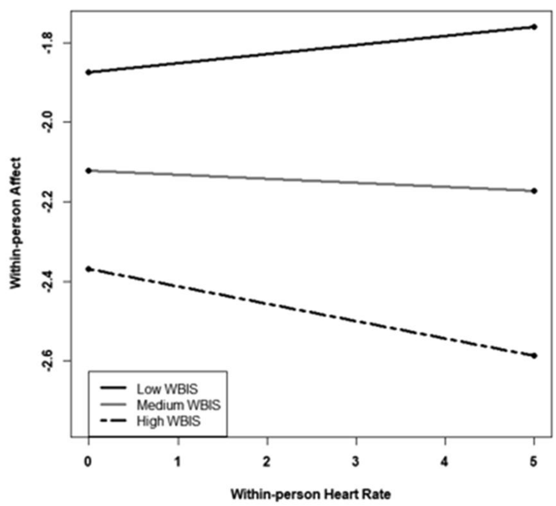
Model	AIC	BIC	Deviance
Model 0b	865.69	881.78	−428.84
Model 1b	858.53	890.71	−421.26
Model 2b	800.39	856.71	−386.19
Model 3b	785.35	845.70	−377.68

Abbreviations: HR, heart rate; WBIS, internalized weight bias.

[a]Reference group is non-exercisers.

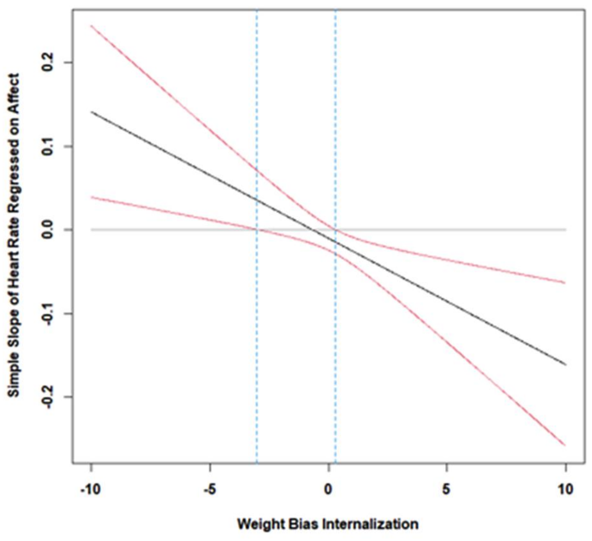
[b]Reference group is females.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.



Note: Associations depicted based on within-person centered independent variable (HR) and between-persons centered interaction term (WBIS); interaction terms have been trichotomized into high (2+ standard deviation above the mean), medium (within ±2 standard deviation of the mean), and low (2+ standard deviation below the mean) values for visualization.

FIGURE 2 Association between heart rate and affect in moderated by internalized weight bias (WBIS). Association depicted based on within person centered independent variable (HR) and between persons centered interaction term (WBIS); interaction terms have been trichotomized into high (2+ standard deviation above the mean), medium (within ±2 standard deviation of the mean), and low (2+ standard deviation below the mean) values for visualization



Note: Values based on within-subjects centered heart rate; blue dotted lines represent lower and upper bounds of significance region; simple slopes are significant outside of this region.

FIGURE 3 Plot illustrating confidence bands for observed sample values of weight bias internalization. Values based on within subjects centered heart rate; blue dotted lines represent lower and upper bounds of significance region; simple slopes are significant outside of this region

the findings do support the larger premise put forward that weight bias may be associated with how uncomfortable individuals with overweight or obesity perceive exercise to be.

These results provide important insight into the possible pathways linking internalized weight bias to reduced engagement with PA. There is substantial evidence that affective response during exercise is associated not only with motivation to exercise but also subsequent adherence to an exercise regimen.[32–35,37,48] Our results indicate that even when the intensity is restricted in range (in this case moderate intensity) internalized weight bias elucidates variability in individual responses to this type of aerobic activity. The clinical implication of these findings, if substantiated in additional research, is that individuals who internalize negative weight-related attitudes may be more likely to find exercise to be more effortful and unpleasant, leading to lower hedonic motivation and reduced engagement with PA.[36,37,49] These findings are especially pertinent as the exercise bout in the current study (a 30-min walk at moderate intensity) is consistent with national guidelines for regular exercise[4] as well as recommendations for exercise in the context of behavioral weight management.[8]

In addition to expanding the literature linking internalized weight bias to exercise, the results of this study are consistent with multiple, disparate lines of inquiry. The results align with findings from social neuropsychology indicating that social pain may be processed similarly to physical pain, providing a biologically plausible pathway for internalized weight bias (and weight-related stigmatization) to influence the perception of physical discomfort. The findings also are consistent with the Dual-Mode model of affective response to exercise,[50] which posits that cognitive factors (e.g., the way someone thinks about exercise and their ability to exercise) may influence affective responses to exercise. The assumption that someone of higher body weight does not engage in PA or is "out of shape" is a quintessential example of obesity stigma.[51] Individuals who internalize weight bias may hold these ideas about their own capacity for exercise to be true, providing a mindset that promotes negative affect during exercise. Importantly, although regular exercisers in the current study reported lower internalized weight bias on average compared to nonexercisers, the effects of internalized weight bias held even when adjusting for exercise status.

Within each of these literatures, the current findings generate ideas for future investigation. It is important to investigate and better understand how internalized weight bias "gets under the skin." As discussed, social neuropsychology offers insight into the ways that experiencing and internalizing social rejection may be processed in the brain, activating overlapping neurophysiological pathways with processing of physical pain. This perspective is consistent with other models such as the Dual-mode model of affective response to exercise and the Gate Control Theory of Pain[52] which all converge to suggest that cognitive, top-down processes can influence individual perception of a physical experience. These basic science investigations will be essential to fully understand the interplay between weight stigma in its various forms and various negative correlates. Furthermore, it will be important to determine if the impact of internalized weight bias on perceived exertion and affective response replicates in ecologically valid settings. Relatedly, an important next step will be to determine if the relationship between internalized weight bias and perceived exertion/affect predicts subsequent adherence to an exercise prescription. Replicating and translating these findings into real-world settings is key in order to lay the groundwork for intervening on internalized weight bias as a barrier to uptake and maintenance of PA among individuals of higher body weight. As interest grows in using affect to guide exercise prescriptions,[53] internalized weight bias may be an important factor to consider in advancing this personalized medicine objective.

There are a number of limitations that should be considered when interpreting the findings of this study. The Rating of Perceived Exertion values are lower than would be expected for moderate intensity activity. Although standardized methods were used for explaining the RPE, it is possible that participants misunderstood or felt social pressure to report lower values to staff. Additionally, this may be the result of methodological factors that have potential to introduce error such as using age-predicted maximal HR rather than using maximal exercise testing to determine participants' target heart range. For purposes of the current secondary analysis, the accuracy with which moderate intensity activity was determined and maintained is less integral than ensuring that all participants were subject to the same experimental paradigm so that error related to these methodological factors is consistent across participants. It is important to note that it is unclear if the results would be comparable outside of the laboratory setting, when individuals engage in free-living PA. Also, the current sample was primarily white and female, and was specifically selected to include two disparate groups in regard to exercise behavior (individuals who exercised regularly vs. those who do not), highlighting the importance of replicating the results in a more representative and diverse sample. Furthermore, the current study investigated moderate-intensity activity, but given the potential utility of high-intensity interval training, it is important to investigate the current relationships during varying levels of exercise intensity.

The current findings suggest that internalized weight bias is associated with how PA feels for individuals of higher body weight; specifically, that exercise is perceived as more effortful and unpleasant among those with higher internalized weight bias. This pattern of results is consistent with converging lines of research across various disciplines and perspectives. These results provide an important step forward as this is the first investigation (to our knowledge) of the influence of internalized weight bias on the experience of exercise in real-time during an episode of exercise among individuals with overweight or obesity. Additional research is needed to understand how internalized weight bias may be influencing perceived exertion and affect as well as to determine how to intervene on this factor as a potential barrier to exercise.

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AUTHOR CONTRIBUTIONS

KayLoni Olson formulated the study question and drafted the majority of the manuscript. Stephanie P. Goldstein ran all analyses and drafted the analysis and results section. Jessica L. Unick and Kathryn E. Demos were responsible for the original study and data collection that facilitated this secondary analysis. All authors reviewed and contributed feedback to the manuscript.

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