

Exercising with others exacerbates the negative effects of mirrored environments on sedentary women's feeling states

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Abstract

The unique and interactive effects of mirrored exercise environments and the presence of co-exercisers on sedentary women's exercise-induced feeling states (FS) were examined. Participants ($n = 92$; mean age = 20.2) performed 20 min of moderate intensity exercise in one of four environments: (a) alone/mirrored, (b) not alone/mirrored, (c) alone/unmirrored, or (d) not alone/unmirrored. FS were measured pre-, mid-, and 5 min post-exercise. Self-consciousness, perceived social evaluation and social comparisons were also assessed post-exercise. Multilevel modeling procedures indicated that women in the not alone/mirrored environment experienced smaller increases in post-exercise revitalization than the other conditions ($p < 0.05$), and were the only condition to experience increased physical exhaustion ($p < 0.05$). Women in the not alone/mirrored condition also reported greater self-consciousness and more social comparisons than those in alone/mirrored condition ($ps < 0.01$). Findings are consistent with Objective Self-Awareness Theory, and suggest that mirrored, group exercise environments are not conducive to psychological well-being among women unaccustomed to exercise.

Keywords: *Physical activity, affect, objective self-awareness, environment, mirrors*

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It is well-documented that a regular regime of physical activity imparts significant psychological health benefits, such as a decreased risk for anxiety and depression, and increased self-esteem and body image (for an overview, see Lox, Martin Ginis, & Petruzzello, 2006). In addition, considerable research has shown that single bouts of exercise can have positive acute effects on psychological outcomes such as mood, self-perceptions, stress and anxiety (Biddle, Fox, & Boutcher, 2000; Lox et al., 2006). However, emerging data suggest that people's acute responses to exercise may be influenced by characteristics of the exercise environment, such as the temperature of the exercise facility (Hansen, Stevens, & Coast, 2001), the type of music played (Brownley, McMurray, & Hackney, 1995), and the presence of odors (Raudenbush, Meyer, & Eppich, 2002).

One environmental characteristic that has received increasing attention with regards to its effects on acute responses to exercise, is the presence of mirrors (Focht & Hausenblas, 2004; Katula & McAuley, 2001; Katula, McAuley, Mihalko, & Bane, 1998; Martin Ginis, Jung, & Gauvin, 2003; Radell, Adame, & Cole, 2002). Studies have shown that when habitually inactive women exercise in front of a mirror, they may not experience the affective benefits that are typically associated with exercise – that is, an increase in positive mood and a decrease in negative mood (Focht & Hausenblas, 2004; Martin Ginis et al., 2003). For example, sedentary women who performed a 20 min bout of exercise in front of a mirrored wall felt worse post-exercise than women who performed the same bout in front of an unmirrored wall. Furthermore, women in the mirrored condition experienced decrements in some positive feeling states (FS) from pre- to post-exercise, indicating that exercise actually made them feel worse, not better (Martin Ginis et al., 2003). As negative affective responses to exercise could compromise subsequent exercise motivation and adherence (Gauvin & Spence, 1996; Gauvin, Rejeski, Norris, & Lutes, 1997), further study of the effects of mirrored exercise environments on FS changes is warranted.

The detrimental effects of exercising in front of a mirror are consistent with the tenets of Objective Self-Awareness Theory (Duval & Wicklund, 1972) which posit that any stimulus that causes focus on the self, such as the presence of an audience or looking into a mirror (Carver & Scheier, 1978), can lead to a state of increased self-awareness. This state is characterized by a greater awareness of internal sensations and the elicitation of a self-evaluation process, whereby people compare themselves with standards or ideals that are salient in the situation. When the self-evaluation process results in a perceived discrepancy between the actual and the ideal self, negative self-evaluations and negative affect will occur. Consistent with the theory, numerous laboratory studies have shown that gazing at oneself in a mirror increases self-focus and can lead to increased negative mood, particularly among women (for a meta-analytic review, see Fejfar & Hoyle, 2000).

The extant exercise data suggest that mirrors do not just affect FS while one is at rest, but also the FS that are induced by a bout of exercise (Focht & Hausenblas, 2004; Martin Ginis et al., 2003). However, it is not known if the presence of co-exercisers moderates these effects. In Martin Ginis et al.'s study, women exercised alone, in front of a mirror. But in actual mirrored gym

environments, other exercisers are usually present. In their study of the effects of mirrored exercise environments on state anxiety, Focht and Hausenblas approximated the real-life gym environment by having women exercise in a public, mirrored setting. While exercising, these women reported an increase in anxiety. In contrast, when they exercised in a private, unmirrored setting, they did not experience changes in anxiety. Unfortunately, given the study's design, it was impossible to determine if the negative FS changes were due to the effects of the mirrors, the presence of others in the public gym setting, or a combination of these factors. Knowledge of the individual and interactive effects of mirrors and the presence of others in an exercise environment would be useful for identifying and creating exercise environments, where sedentary women are most likely to feel good after exercise. After all, if an exercise bout leaves a sedentary woman feeling worse than before she worked out, it will be difficult to convince her to establish a regular exercise program.

With these issues in mind, the present experiment manipulated the presence of others and the presence of a mirror in a full factorial design. Sedentary women were randomly assigned to exercise in one of four conditions: alone in front of a mirror, alone without a mirror, not alone in front of a mirror, or not alone without a mirror. It was hypothesized that women who exercised in front of a mirror with others would report significantly worse FS during and post-exercise than women in the other three conditions. This prediction was based on the proclivity for increased self-awareness and social evaluative concerns in the presence of an audience (Carver & Scheier, 1978), and reports that female exercisers tend to engage in social comparisons and become more aware of the discrepancy between their existing form and an ideal appearance when they see the reflections of other exercisers in a mirror (Maguire & Mansfield, 1998). Increased self-awareness, social evaluation concerns, and social comparisons have all been theoretically (Objective Self-Awareness Theory; Duval & Wicklund, 1972) and empirically (Fejfar & Hoyle, 2000) linked with mood decrements.

An important methodological feature of the present study was that participants' body mass index (BMI) was statistically controlled. A recent study reported that in comparison to women of normal weight, overweight women reported more negative FS when they exercised at an imposed intensity (Ekkekakis & Lind, 2006). The study authors proposed that overweight women may have a less pleasant affective experience during exercise than normal weight women because of compromised thermoregulatory abilities, a greater likelihood of experiencing aches and pains during exercise, and a greater propensity for perceiving evaluative threat during exercise. Thus, if BMI is not controlled, then any observed between-condition differences in affect could be confounded or masked by a sample composed of women with very different BMIs. Previous studies of mirrored exercise environments have not controlled for this possibility.¹

A second, exploratory objective was to examine differences in perceived social evaluation, self-consciousness, and the use of social comparison processes across the four experimental conditions. Assessment of these variables could provide insight into the mechanisms by which mirrors and the presence of others

influence exercise-induced affect. It was expected that women who exercised in the not alone/mirror condition would perceive more social evaluation, feel more self-conscious, and engage in more social comparison than women in the other three experimental conditions.

Method

Participants

Participants were 92 sedentary undergraduate female students with a mean age of 20.2 years (SD = 1.6, range = 18–26). Sedentary was defined as participation in ≤ 1 mild, moderate, or strenuous 15-min bout of leisure time physical activity in a typical 1-week period over the previous year. Participants were recruited from a university campus by means of word-of-mouth, posters, in-class announcements, and advertisements on the university’s web-page. Because the stigma associated with being sedentary (Martin, Sinden, & Fleming, 2000) could have dissuaded women from volunteering for the study, recruitment advertisements were phrased to target women who “exercised 0 or 1 time per week” as opposed to women who were “sedentary”. In addition, because we expected that inactive women would be reluctant to participate in a study that required performance of an exercise bout, as a participation incentive, the names of women who completed the experiment were entered into a draw for a watch valued at CAD \$150.00. Recruitment took place over a period of approximately 12 months. Of the 105 women who were recruited, 92 attended the experimental session (the remainder did not show up for the session and could not be contacted to reschedule). Further characteristics of the women who completed the study are presented in Table I.

Study design

The study utilized a 2 (physical environment: mirror/no mirror) $\times$ 2 (social environment: exercise alone/not alone) $\times$ 3 (time: pre-exercise *vs.* during exercise *vs.* post-exercise) mixed factorial design.

Table I. Descriptive characteristics of the study sample.

	Mean	SD
Age	20.22	1.64
Height (cm)	164.61	8.10
Weight (kg)	61.29	11.12
BMI	22.65	4.08
Bouts of strenuous exercise/week	0.12	0.32
Bouts of moderate exercise/week	0.37	0.47
Bouts of mild exercise/week	0.22	0.43

Measures

Screening questionnaires. Participants were identified as sedentary on the basis of their scores on the Leisure-Time Exercise Questionnaire (LTEQ; Godin & Shephard, 1985). This instrument assessed the number of strenuous, moderate, and mild leisure-time exercise bouts performed over a typical 1-week period in the past year. An in-house health questionnaire was used to screen participants for any health problems that may have precluded them from exercising.

Feeling states. FS were assessed using the Exercise-Induced Feeling Inventory (EFI; Gauvin & Rejeski, 1993). The 12-item EFI assessed the degree to which respondents experienced four distinct FS related to exercise: revitalization, tranquility, positive engagement, and physical exhaustion. Participants indicated the extent to which each EFI item (e.g., “calm,” “worn out”) described their current FS (0 = *do not feel*; 4 = *feel very strongly*). Internal consistency reliability for all of the EFI subscales was >0.80 at all three measurement points.

The EFI operationalizes a *categorical approach* to affect measurement, whereby four distinctive feeling states are assessed [i.e., as opposed to the *dimensional approach* advocated by Ekkekakis & Petruzzello, 2002, whereby only the underlying dimensions of affective states are assessed in terms of two basic dimensions (e.g., affective valence and perceived activation)]. Considerable research indicates that those FS that are particularly sensitive to the stimulus properties of physical activity are best represented categorically (for a review, see Gauvin & Rejeski, 2001). Also, exercise in mirrored environments may have differential effects on different affective states (Focht & Hausenblas, 2001; Martin Ginis et al., 2003), so it is appropriate and desirable, to utilize a categorical measurement approach to facilitate analysis of change in these distinct states. Another reason for using a categorical measurement approach is that conventional statistical methods cannot be easily applied to the analysis of dimensional affect data, making categorical measures the preferred method for testing hypotheses in experimental designs (Ekkekakis & Petruzzello, 2002). For these reasons, the EFI was our measure of choice in the present experiment.

Social comparison, self-consciousness, and social evaluative concerns. Six items were written to assess the extent to which the various experimental conditions elicited social comparisons, self-consciousness, and self-presentation concerns. *Social comparisons* were measured with the items “While I was exercising, I was comparing my level of physical fitness to the physical fitness of other people in the room” and “While I was exercising, I was comparing my physical appearance to the appearance of other people in the room.” Responses were made on a scale ranging from 1 (*not at all*) to 5 (*extremely*). *Self-consciousness* was assessed with two semantic-differential items querying how participants felt while exercising: *self-conscious of my appearance/unconcerned with my appearance* and *self-conscious of my fitness level/unconcerned with my fitness level*. These items were rated on 7-point scales ranging from -3 to +3. Similarly, *perceived social evaluation* experienced

during exercise was assessed by a semantic-differential item rated on a 7-point scale: *other people were judging me/nobody was judging me*. Participants also responded to a second social evaluation item – “While I was exercising, I was worried that other people were judging me” – using a scale ranging from 1 (*not at all*) to 5 (*extremely*). Responses to each item were analyzed separately.

Body mass index. BMI was calculated as the ratio of actual weight (kg) to height (m^2) as assessed, using a standardized, mechanical scale (Healthometer, Boca Raton, FL).

Procedure

Volunteers were screened for eligibility via telephone. Screening consisted of administering the LTEQ and health-screening questionnaire. Potential participants were told that this was a study examining women’s thoughts and feelings during exercise, and that they would be required to perform 20 min of moderate intensity exercise, and fill out a series of questionnaires. Interested, eligible women were then asked to choose an experimental session from a list of session dates and times provided by the experimenter. Unknown to participants, the sessions had already been randomly assigned to one of the four experimental conditions. It was necessary to randomly assign sessions, rather than participants to experimental conditions, because the not alone conditions were to be comprised of four women. Thus, recruiters had to be aware of how many women (one or four) to book for each experimental session, and also ensure that these women did not know one another. Participants were instructed to arrive at the lab at their scheduled time, dressed in baggy shorts, a T-shirt, and running shoes. This dress code was designed to standardize exercise attire and remove any effects it may have on women’s responses.

All experimental sessions were conducted by one of the researchers (S.M.B.), or a female assistant who was trained to carry out the experimental protocol. Participants in the alone conditions were tested individually. Participants in the not alone conditions were to be tested in groups of four. However, in many cases, one, two, or three women failed to show up for a scheduled not alone testing session. Rather than turn away the women (or woman) who *did* come to the testing session (which would likely result in their withdrawal from the study), the session was conducted as a not alone condition if ≥ 2 women attended, and an alone condition if only one woman attended. On average, three women were present for each of the not alone conditions. The unequal sample sizes across conditions (Table II) are the result of participants failing to show up for their experimental sessions.

In the alone conditions, a single Monark 817 Exercise bicycle (Monark Exercise AB, Vansbro, Sweden) was positioned in the center of the lab (the lab dimensions were $3.7\text{ m} \times 4.6\text{ m}$). In the not alone conditions, four bikes were positioned side-by-side in the lab. In the mirror conditions, bikes were positioned in front of mirrors that covered the entire front wall of the laboratory, from floor

Table II. Self-consciousness, perceived social evaluation and social comparisons experienced during the exercise bout.

	Alone/Mirror <i>n</i> = 27		Alone/No mirror <i>n</i> = 27		Not alone/Mirror <i>n</i> = 19		Not alone/ No mirror <i>n</i> = 19	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. Fitness self-consciousness	-0.37	1.76	0.07	1.90	-0.32	1.59	-0.74	1.86
2. Appearance self-consciousness	0.63 _{ab}	1.96	1.70 _a	1.64	0.00 _b	1.73	0.47 _{ab}	1.81
3. Perceived social evaluation	1.15	1.70	1.30	1.86	0.74	1.73	0.89	1.88
4. Worry about social evaluation	1.56	0.64	1.46	0.71	1.47	0.84	1.79	0.98
5. Fitness social comparisons	1.30 _a	0.72	1.27 _a	0.72	2.53 _b	0.96	2.74 _b	1.20
6. Appearance social comparisons	1.41 _a	0.69	1.23 _a	0.71	2.37 _b	1.07	2.37 _b	1.12

Notes: Values in the same row with different subscripts are significantly different ($p < 0.01$).

Items 1–3 were scored on -3 to +3 scale, with lower scores denoting greater self-consciousness and perceived social evaluation. Items 4–6 were scored on 5-point scales with higher scores denoting more worry about social evaluation and greater social comparisons.

to ceiling (2.5 m high $\times$ 3 m wide). In these mirrors, participants had a full view of themselves and, in the not alone conditions, they also had a full view of the other exercisers present. In the no mirror conditions, a set of floor-length, dark blue curtains was drawn across the mirrored wall such that the mirrors were completely hidden from view. Participants exercised facing these blue curtains.

The protocol for the alone and not alone conditions was virtually identical except where noted. Upon arrival at the laboratory, the curtains were closed across the mirrors and participants were seated in a chair, positioned in one of the four corners of the room, and facing the wall. They were given a clipboard that had been fitted with cardboard sides/blinders to ensure privacy while completing the study measures. Participants were first required to read and sign a consent form, and were verbally reminded that all information provided was confidential. Next, they were asked to review the LTEQ and the health-screening questionnaire that had been completed over the telephone in order to verify their responses. To control for verbal distractions during the exercise bout, all participants were asked to refrain from speaking to the researcher for the remainder of the study session (unless, of course, they were uncomfortable, in pain, etc.). Participants in the not alone conditions were also asked to refrain from speaking to each other. Participants then completed the EFI.

Next, the researcher showed participants the exercise bicycle that they would be using. To reduce the chance of injury, the bicycle seat heights were adjusted so that while pedaling, there was always a slight bend in participants' knees. Participants were informed that they would be performing a 5-min warm-up of light intensity pedaling and then 20 min of pedaling at a moderate intensity. They were given instructions on how to use the 11-point Rating of Perceived Exertion Scale (RPE; Borg, 1982) to rate how hard they were exercising (i.e., exercise intensity). The RPE scale ranges from 0 (*nothing at all*) to 10

(*very, very heavy*). Participants were advised to stop exercising if they experienced any pain or dizziness, and to raise their hand at any time while cycling if they were thirsty, and the experimenter would give them a drink of water.

Throughout the experimental session, except when she was administering questionnaires, the researcher organized paperwork at the back of the lab. She deliberately avoided watching the exercisers so as to minimize any effect that her presence might have on them. To minimize the effects that her physique could have on participants, the researcher wore a baggy white lab coat.

The exercise protocol was identical to that employed in the Martin Ginis et al. (2003) study of exercise in mirrored and non-mirrored environments and consisted of a 5-min warm-up followed by 20 min of moderate intensity exercise and then a 3 min cool down. Specifically, participants began with a 5-min warm-up, pedaling at an easy cadence with the bicycle wheel-tension set at 0. After the warm-up, participants were shown how to increase their workout intensity by turning a dial on the bike in order to increase the tension on the bicycle wheel. They were instructed to adjust the dial until they felt they were working at a “moderate” intensity, or at an RPE between 4 (*somewhat hard*) and 5 (*heavy/strong*). They were asked to maintain this level of intensity (RPE = 4–5) for the remainder of the exercise session. In order to ensure that participants were exercising at the appropriate intensity, at 5, 10, and 15 min into the exercise bout, the researcher asked them to refer to a RPE chart posted on the lab wall, and to adjust their bike tension accordingly.

Ten minutes into the exercise bout, participants were given the EFI, a clipboard and pencil. They were instructed to respond to the EFI items while continuing to pedal at a moderate intensity. They then returned their clipboards to the researcher and continued exercising. After 20 min of exercise, they were instructed to reduce their wheel-tension back to 0 and to perform a 3-minute cool down by pedaling at a light intensity.

Next, participants took a seat in the corner of the room, for 5 min of quiet rest. In the mirror conditions, the researcher closed the curtain over the mirror to control for any effects of mirror exposure independent of exercise. Five minutes later, the EFI, social comparison, self-consciousness and social evaluation measures were administered. Participants were taken to a private room where their height and weight were measured. They were then thanked for their time, and given a ballot for entry into the draw.

Data analysis strategy

Several challenges arose when crafting a data analysis strategy to analyze changes in FS. First, we were confronted with the problem of how to deal with between-subject, baseline differences in these measures. In our previous study (Martin Ginis et al., 2003), baseline FS varied tremendously across individuals, and were best conceptualized as random rather than fixed parameters. Furthermore, several studies (Blanchard, Rodgers, Courneya, & Spence, 2002; Gauvin, Rejeski, & Reboussin, 2000) have shown that baseline FS moderate the change

in exercise-induced FS, such that people who have the worst baseline profiles experience the greatest improvements post-exercise.

A second challenge emerged from our interest in simultaneously examining the impact of the physical and social environment, while taking into account randomly varying baseline FS and individual-level BMI. Although analysis of covariance strategies offers a potential tool for addressing these issues, heterogeneity of slopes precludes their use. As such, we used multilevel modeling (Bryk & Raudenbush, 1992) for our data analysis. We applied the multivariate normal models approach (Bryk, Raudenbush, & Congdon, 2000), which allowed us to relax the assumption of fixed effects at baseline by using a random parameter at baseline, and to test the significance of fixed effects using models with unrestricted variance–covariance structure, homogenous level-1 variance, and heterogeneous level-1 variance. In order to interpret findings, we used the model with the fewest parameters but that also did not differ significantly from the unrestricted model.

The model included an intercept to model baseline FS, and two dummy variables to model changes in FS occurring in-task and post-task, respectively. In addition, we added three dummy variables to model the moderating effects of group assignment on intercept, in-task changes, and post-task changes. We chose the alone/no mirror condition as the control condition, and created three orthogonal dummy variables to represent the alone/mirror, not alone/no mirror, and not alone/mirror conditions, respectively. As indicated above, we also included BMI as a covariate to control for the influence of body size on the outcome variables.²

We also conducted between-groups comparisons of scores on the measures of social comparison, self-consciousness and social-evaluation concern during exercise. Responses were analyzed using separate 2 (mirror/no mirror) $\times$ 2 (alone/not alone) ANCOVAs that controlled for differences in BMI.

Results

Feeling state change analyses

Using the multilevel modeling procedure previously described, we observed that fixed effects were similar across differing variance–covariance structures. We therefore chose to report the results for the most parsimonious model (fewest number of parameters), the homogenous level-1 variance. All results appear in Tables II and III. Illustrations of the significant effects are presented in Figure 1. Given the complexity of multilevel modeling and the absence of a generalized consensus on how to compute effect-sizes in multilevel modeling, we chose to illustrate predicted scores for the four experimental conditions. It is important to underscore that Figure 1 is included for illustrative purposes only. All inferences are based on modeling results appearing in Tables II and III.

For the EFI measure of *positive engagement*, there was a tendency ($p = 0.08$) for women assigned to the not alone/mirror condition to experience decreases in this

Table III. Fixed effects revealed by multilevel modeling procedures for the feeling states.

	Positive engagement coefficient (SE)	Revitalization coefficient (SE)	Tranquility coefficient (SE)	Physical exhaustion coefficient (SE)
Intercept β_{00}	5.10 (0.57)***	3.35(0.54)***	7.44(0.56)***	4.50(0.56)***
BMI β_{01}	-0.06(0.08)	-0.06(0.07)	-0.16(0.08)*	0.02(0.08)
Alone-Mirror β_{02}	0.99(0.80)	-0.001(0.77)	-0.46(0.80)	-0.28(0.79)
Not alone-Mirror β_{03}	0.65(0.89)	0.05(0.86)	-0.09(0.88)	-0.68(0.87)
Not alone-No mirror β_{04}	0.88(0.87)	0.05(0.84)	0.34(0.87)	-0.33(0.86)
Change in-task β_{10}	-0.35(0.45)	0.73(0.53)	-20.93(0.50)***	0.72(0.53)
BMI β_{11}	0.06(0.06)	0.15(0.07)*	0.24(0.07)***	-0.15(0.07)*
Alone-Mirror β_{12}	-0.93(0.63)	-0.48(0.75)	0.85(0.71)	-0.70(0.76)
Not alone-Mirror β_{13}	-1.25(0.70) [†]	-1.19(0.83)	0.07(0.78)	1.56(0.84) [†]
Not alone-No mirror β_{14}	-0.89(0.69)	-1.25(0.81)	-0.93(0.77)	-0.03(0.83)
Change post-task β_{20}	0.48(0.45)	2.71(0.53)***	-0.32(0.50)	-0.95(0.53) [†]
BMI β_{21}	0.16(0.06)**	0.25(0.07)***	0.22(0.07)***	-0.19(0.07)**
Alone-Mirror β_{22}	-0.76(0.63)	-0.35(0.75)	0.13(0.71)	0.42(0.76)
Not alone-Mirror β_{23}	-1.20(0.70)	-1.81(0.83)*	0.48(0.78)	1.64(0.84)*
Not alone-No mirror β_{24}	0.04(0.69)	0.48(0.81)	0.03(0.77)	-0.32(0.83)

Notes: [†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Level-1 Model:

$$Y_{ij} = \text{IND}_1^* Y_1^* + \text{IND}_2^* Y_2^* + \text{IND}_3^* Y_3^*$$

where IND₁ represents a dummy variable taking on a value of 1 if the recording in the concatenated database was taken at baseline and 0 otherwise; IND₂ represents a dummy variable taking on a value of 1 if the recording in the concatenated database was taken in-task and 0 otherwise; and IND₃ represents a dummy variable taking on a value of 1 if the recording in the concatenated database was taken post-task and 0 otherwise.

$$Y_{ij}^* = \pi_{0j} + \pi_{1j}^*(\text{D_INTSK}) + \pi_{2j}^*(\text{D_POST}) + \varepsilon_{ij}$$

where D_INTSK represents a dummy variable taking on a value of 1 if the recording in the concatenated database was taken in-task and 0 otherwise and D_POST₃ represents a dummy variable taking on a value of 1 if the recording in the concatenated database was taken post-task and 0 otherwise.

Level-2 Model:

$$\begin{aligned} \pi_{0j} &= \beta_{00} + \beta_{01}^*(\text{BMI}) + \beta_{02}^*(\text{D_AL_MIR}) + \beta_{03}^*(\text{D_NAL_MIR}) + \beta_{04}^*(\text{D_NAL_NO}) + v_{0j} \\ \pi_{1j} &= \beta_{10} + \beta_{11}^*(\text{BMI}) + \beta_{12}^*(\text{D_AL_MIR}) + \beta_{13}^*(\text{D_NAL_MIR}) + \beta_{14}^*(\text{D_NAL_NO}) \\ \pi_{2j} &= \beta_{20} + \beta_{21}^*(\text{BMI}) + \beta_{22}^*(\text{D_AL_MIR}) + \beta_{23}^*(\text{D_NAL_MIR}) + \beta_{24}^*(\text{D_NAL_NO}) \end{aligned}$$

where D_AL_MIR represents a dummy variable taking on a value of 1 if the person was assigned to the alone-mirror condition, D_NAL_MIR represents a dummy variable taking on a value of 1 if the person was assigned to the not alone-mirror condition, and D_NAL_NO represents a dummy variable taking on a value of 1 if the person was assigned to the not alone-no mirror condition

Intercept represents estimate of outcome value at baseline for person with average BMI and who was randomized to the alone-no mirror condition. Other coefficients therefore represent difference estimates due to BMI or to assignment to experimental conditions. Change in-task represents the change in the outcome value occurring between baseline and halfway through the exercise bout for a person with average BMI and who was randomized to the alone-no mirror condition. Change post-task represents the change in the outcome value occurring between baseline and the end of the exercise bout for a person with average BMI and who was randomized to the alone-no mirror condition.

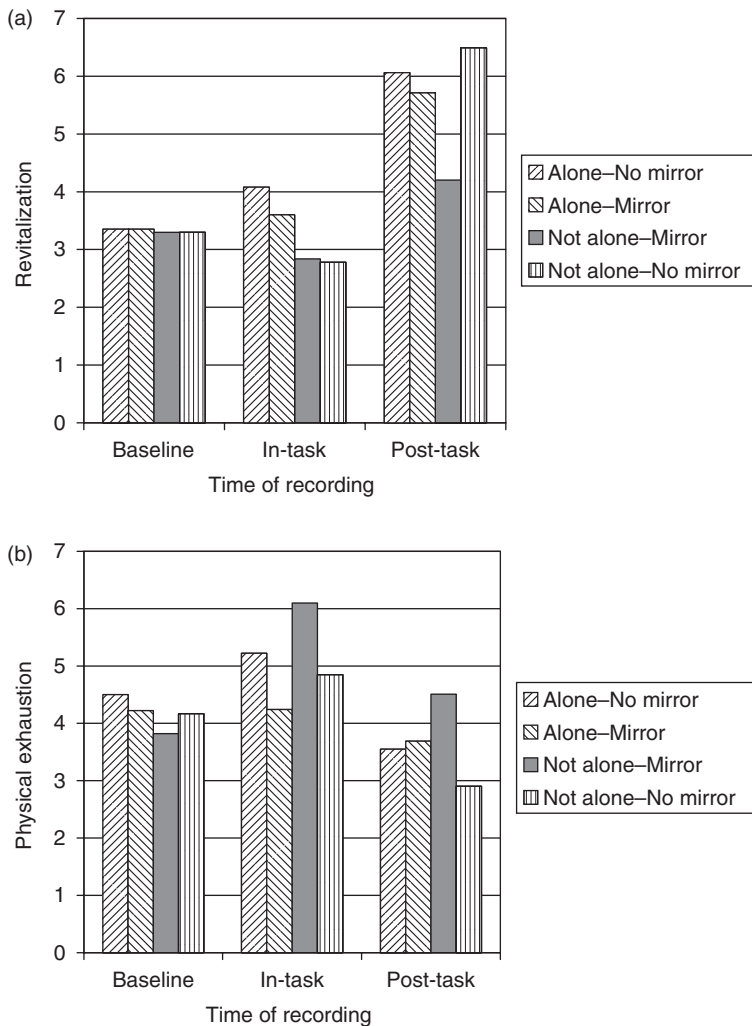


Figure 1. Predicted scores on revitalization (a) and physical exhaustion (b) as a function of time of recording and group assignment, as per the final multilevel model.

FS during exercise. However, there were no significant changes in positive engagement from pre- to post-exercise for any condition. Women with higher BMI experienced significant increases in positive engagement from pre- to post-exercise in comparison to women with lower BMI ($p < 0.01$).

For the *revitalization* subscale, participants showed no changes in this FS during exercise, but they did show significant increases following exercise ($p < 0.001$). Interestingly, women assigned to the not alone/mirror condition experienced significantly smaller increases in revitalization from pre- to post-exercise ($p < 0.05$) in comparison to women assigned to the other conditions. Women with a higher BMI reported greater improvements in revitalization both during exercise ($p < 0.05$) and after exercise ($p < 0.001$) compared to women with a lower BMI.

For the *tranquility* subscale, women experienced significant decreases in tranquility during exercise ($p < 0.001$), with a return to baseline levels post-exercise. There were no significant differences in tranquility or changes in tranquility across the four conditions. Women with a higher BMI had lower levels of tranquility at baseline than women with a lower BMI ($p < 0.05$), and greater increases in tranquility during exercise ($p < 0.001$) and post-exercise ($p < 0.001$).

Scores on the *physical exhaustion* subscale did not change from baseline to during exercise. Overall, there was a trend towards decreased exhaustion from pre- to post-exercise ($p < 0.10$). However, women assigned to the not alone/mirror condition tended towards increased exhaustion during exercise ($p < 0.10$) and reported a significant increase in physical exhaustion following exercise ($p < 0.05$). They also tended to report greater post-exercise physical exhaustion than women assigned to the other conditions ($p = 0.06$). Women with a higher BMI experienced greater decreases in physical exhaustion than women with a lower BMI both during ($p < 0.05$) and after exercise ($p < 0.01$).

Differences in social comparison, self-consciousness, perceived social evaluation

Significant between-groups differences emerged for physical appearance self-consciousness, $F(3, 87) = 3.84$, $p = 0.01$, physical fitness social comparisons $F(3, 87) = 17.06$, $p < 0.001$, and physical appearance social comparisons $F(3, 87) = 10.54$, $p < 0.001$. Bonferroni adjusted *post hoc* tests revealed that participants in the not alone/mirror condition felt more self-conscious about their physical appearance than participants in the alone/no mirror condition ($p = 0.01$). In addition, participants in the not alone/mirror and not alone/no mirror conditions engaged in more social comparison regarding their fitness and appearance than participants in the alone/no mirror and alone/mirror conditions ($ps < 0.001$). No other comparisons were significant. Means and standard deviations for each item are presented in Table II.

Discussion

The primary purpose of this experiment was to examine the unique and interactive effects of mirrored exercise environments and the presence of co-exercisers on sedentary women's exercise-induced FS. After controlling for differences in BMI, women who exercised with one or more people in front of a mirror experienced significantly smaller increases in revitalization and significantly greater increases in exhaustion than women in the other three conditions. These findings provide partial support for our hypotheses, and have implications for understanding environmental factors that might deter sedentary women from exercise.

Exercise and affect

None of the four experimental conditions showed post-exercise improvements in positive engagement or tranquility. Although studies of *active* women typically

show exercise-related increases in these two FS, our results are consistent with findings from studies of *sedentary* women showing that inactive women do not derive all of the mood-enhancing benefits of an exercise bout that are typically experienced by regularly active women (Gauvin et al., 1997; Martin Ginis et al., 2003). Women in the present study did, however, experience mildly positive changes in two other FS. Specifically, women in the alone/mirror, alone/no mirror, and not alone/no mirror conditions showed a significant increase in revitalization and a trend towards decreased exhaustion. As these two FS are at least partly reflective of changes in energy levels (Gauvin & Rejeski, 1993), it seems that although sedentary women may not experience all of the psychological benefits that typically accompany acute exercise among active persons, they do experience increased energy, even in environments that could potentially undermine the psychological beneficence of physical activity (i.e., group, mirrored settings). This noteworthy finding indicates that selected FS, namely revitalization and exhaustion, may be most sensitive to exercise stimuli in comparison to other FS (cf Gauvin & Rejeski, 1993). The results also speak to the independence of exercise-induced FS as measured by the EFI.

Compared to women in the other three conditions, women in the not alone/mirror condition experienced a significantly smaller increase in revitalization and they also reported a significant increase in physical exhaustion. Consistent with our hypotheses, this pattern of findings speaks to the negative impact of mirrored, co-exercising environments on exercise-induced FS. The findings are also consistent with previous exercise and non-exercise studies that have tested Objective Self-Awareness Theory (Duval & Wicklund, 1972) and found that women report feeling worse after exposure to manipulations that increase self-awareness (e.g., Fejfar & Hoyle, 2000; Focht & Hausenblas, 2004; Martin Ginis et al., 2003; Scheier & Carver, 1977). It is noteworthy that revitalization and exhaustion were the two FS most responsive to the not alone/mirror manipulation. Based on this finding, it seems that the self-awareness manipulation affected women's energy levels, rather than the affective dimensions captured by the tranquility and positive engagement subscales. This finding evidently requires replication and further scrutiny. However, as reviewed by others (Baumeister, Heatherton, & Tice, 1994) it may be that the process of self-awareness, in and of itself, requires the mobilization and expenditure of "mental energy". This energy expenditure could explain the lower levels of revitalization and higher levels of physical exhaustion observed in the not alone/mirror manipulation.

Interestingly, there were no differences in revitalization and exhaustion between women exposed to only *one* type of self-awareness manipulation [i.e., exposure to just the mirror (alone/mirror condition) or just other exercisers (not alone/no mirror condition)] and women exposed to *no* self-awareness manipulation (alone/no mirror). These results are in opposition to those from our earlier study (Martin Ginis et al., 2003) in which women in an alone/mirror condition experienced significant mood decrements relative to women in an alone/no mirror condition. It is possible that by controlling for BMI in the present study, the previously observed between-group effects were attenuated.

Another possibility is that with greater statistical power, significant differences would have emerged between the alone/mirror and alone/no mirror conditions. Indeed, the parameter estimates in Table III indicate that the effects for the alone/mirror condition were in the expected direction, with participants reporting smaller changes in positive engagement, revitalization and exhaustion than participants in the alone/no mirror condition.

In contrast, the parameter estimates for the not alone/no mirror condition indicated improvements in all four FS that were similar in magnitude, or even slightly better, than those reported for the alone/no mirror condition. Thus, in an unmirrored exercise environment, the presence of other exercisers does not have a detrimental effect on women's FS. Rather, the presence of other exercisers *combined* with a mirrored environment is detrimental. We suspect that in mirrored group exercise situations, co-exercisers are more likely to be perceived as an audience, and not simply co-participants in the exercise experience. The mirror also facilitates social comparisons such that exercisers are essentially 'on display' for one another to see. Consistent with the tenets of objective self-awareness theory, these types of conditions have been associated with increased self-awareness and concomitant decrements in mood (e.g., Carver & Scheier, 1978; Fejfar & Hoyle, 2000).

Self-consciousness, social comparisons, and perceived social evaluation

In order to gain insight into the mechanisms by which mirrors and the presence of others influence exercise-induced affect, we looked for differences in self-consciousness, social comparisons, and perceived social evaluation across the experimental conditions. Focht and Hausenblas (2004) argued that their female participants experienced increased anxiety in a public, mirrored exercise setting but not a private, unmirrored exercise setting because of differences in the perceived evaluative threat of the environments. We did not find any differences in perceived social evaluation between the not alone/mirror and the alone/no mirror conditions. However, women in the not alone/mirror condition were more self-conscious about their appearance and engaged in more social comparisons than women in the alone/no mirror condition. Consistent with Objective Self-Awareness Theory, these results provide support for increased self-awareness, rather than perceived evaluative threat, as the mechanism underlying the observed effects of the exercise environment on women's FS.

We recognize, however, that our findings cannot explain why the not alone/mirror condition was more detrimental than the not alone/no mirror condition. There were no significant differences between these two conditions for self-consciousness, social comparison or perceived evaluation. It is possible that our single-item measures of these constructs were not sufficiently sensitive to detect subtle between-groups differences.

The failure to replicate Focht and Hausenblas' (2004) findings may reflect differences in study methodologies. Specifically, Focht and Hausenblas sampled women who scored high on a measure of social physique anxiety. These women

may have been more attuned to other people's evaluations of them than the women in our study, and thus, more likely to report real or imagined social evaluation during exercise in the public, mirrored setting. In addition, there were an average of 14 men and 22 women present when each participant exercised in Focht and Hausenblas' public, mirrored condition, compared with just 2–4 other female exercisers in our study. With more people present in a mixed-sex environment, it is understandable that participants would experience greater evaluative threat in Focht and Hausenblas' study than in the current study.

Body mass index

BMI was included in the analyses as a covariate, to control for the possibility that women with a higher BMI would report worse in-task (Ekkekakis & Lind, 2006) and post-exercise affect. Unexpectedly, changes in all four EFI subscale scores were *positively* related to BMI. Regardless of which environment they exercised in, women with a higher BMI experienced greater increases in positive engagement, revitalization and tranquility and larger decreases in physical exhaustion than women with a lower BMI. These unexpected positive relationships warrant some discussion.

Ekkekakis and Lind (2006) found that overweight women experienced a significant decline in affect and felt worse than normal-weight women during exercise performed at an imposed intensity. They found no within- or between-group differences in affect when exercise was performed at a lower, self-selected intensity. Given that the women in this study self-selected their exercise intensity (in the "somewhat hard" to "heavy" range), it is probably not surprising that heavier women did not experience affective declines. Yet, what could account for them experiencing greater improvements in affect than women with a lower BMI?

There are at least two plausible explanations for this finding. The first is that women with a higher BMI had poorer baseline FS and thus, greater room for improvement over the course of the exercise bout. Indeed, the people who derive the greatest mood-enhancing benefits of exercise are those who feel the worst prior to exercising (Gauvin et al., 2000). The generally negative association between baseline BMI and FS (Table III) supports this hypothesis. A second possibility is that heavier women experienced greater increases in self-efficacy during the exercise bout, which, in turn, elicited greater improvements in mood. Chronically inactive, heavier women may have less confidence in their exercise capabilities and thus, a greater propensity to increase their self-efficacy by completing an exercise bout. As previous research has shown that a single exercise bout can increase sedentary women's exercise self-efficacy in both mirrored and non-mirrored settings (Martin Ginis et al., 2003), and that changes in self-efficacy mediate the effects of acute exercise on FS (McAuley, Talbot, & Martinez, 1999), we suggest that the observed effects for BMI are driven more by differences in self-efficacy change than by differences in body mass.

Limitations and practical implications

Our findings are tempered by a few study limitations that should be addressed in future research. First, due to participants failing to show up at their appointed times, there were fluctuations in the number of co-exercisers present in the not alone conditions. Variation in the number of co-exercisers may have affected participants' psychological responses to the environment. Second, our sample was comprised of very sedentary women ($\leq$ one 15-min bout of activity/week). Readers are cautioned against generalizing the present findings to more active women. Third, we wish to emphasize that this was a controlled experiment designed to test a theoretical proposition (i.e., that increased self-awareness, social evaluation concerns and social comparisons associated with exercising with others, in front of a mirror, would lead to mood decrements; Objective Self-Awareness Theory) using a design that would yield high internal validity. In our desire for experimental rigor, we may have traded-off some external validity. Hence, it would be premature to extrapolate findings to real-world gym settings, without first replicating the study in an actual, mirrored gym environment.

Nevertheless, we suspect that the environmental stimuli simulated in our experiment would be more powerful in actual gym settings and thus, have an even greater negative impact on sedentary women. If this hypothesis holds true, then from a practical perspective, the typical fitness center layout – with a bank of cardio exercise equipment facing a mirrored wall – is not conducive to psychological well-being among women who are unaccustomed to exercise or those who may be just starting an exercise program. Exercise interventionists need to be aware of the potential negative impact of environmental characteristics on sedentary women's affective responses to exercise, and devote effort to identifying and creating exercise environments where sedentary women are most likely to feel good. Since women are unlikely to adhere to exercise programs that make them feel bad, beginner exercisers should be encouraged to sample a variety of exercise environments to determine where they feel best. For example, an exercise initiate may feel better working out in a private, unmirrored environment, or outdoors, instead of partaking in a group exercise class in a mirrored aerobics studio. Although our findings may not generalize to all exercisers, they do highlight the importance of the physical and social environments for eliciting psychological responses to exercise.

Notes

- [1] Intuitively, one might expect that body image, and not BMI, would influence women's affective responses to mirrored exercise environments, such that women with greater body image concerns would be more negatively affected by watching themselves exercise in a mirror. However, in our previous study (Martin Ginis et al., 2003), body image did not have any effect on women's affective responses to the mirrored exercise environment. Similarly, Focht and Hausenblas (2001) reported that affective responses to exercise performed in a mirrored, gym environment did not vary as a function of social physique anxiety (i.e., a measure of the affective dimension of body image). Thus, body image does not seem to play a role in women's responses to mirrored exercise settings.

- [2] As noted in our previous study (Martin Ginis et al., 2003), power and sample size calculations in multilevel modeling are complicated by the presence of an intraclass correlation and the inclusion of random effects. Indeed, it is generally agreed that more simulation studies are required before firm statements can be made regarding the manner in which to calculate power (Kreft & De Leeuw, 1998; Snijders & Bosker, 1999). However, Snijders and Bosker (1999) have noted that “sample size at the highest level is usually the most restrictive element in the design . . . Requirements on the sample size at the highest level, for a hierarchical linear model with q explanatory variables at this level, are at least as stringent as requirements on the sample size in a single level design with q explanatory variables” (p. 140). Had we analyzed the data with fixed effects models (i.e., single level design), sample size could have been determined a priori using Green’s (1991) estimation procedures for regression-type analyses. With four predictors in our model, Green’s conventions would indicate that a sample of 81 would be needed to detect medium-sized effects with $\alpha = 0.05$ and power = 0.80. Thus, our sample of 92 provides sufficient power to detect medium-sized effects.

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