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Exercise Video Games are Associated with More Positive Affective Response, which Predicts Physical Activity Adherence.

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Abstract

Background: A more positive affective valence during exercise is predictive of adherence to physical activity programs. This study examines the relationship between affective response during exercise and longer-term maintenance of physical activity among individuals using exercise video games (EVGs) and standard modalities of physical activity (i.e., walking, cycling).

Methods: Healthy adults (mean age 45.4, SD=14.5) were randomly assigned to a 12-week supervised, thrice weekly program of EVGs (n=93) or Standard exercise (n=96), and were assessed for affect immediately before, at the mid-point, and immediately after one exercise session per week. Participation in moderate-to-vigorous physical activity (MVPA) was conducted at end of treatment (EOT) and 6-month follow up.

Results: EVG participants reported more positive affective valence during exercise compared to Standard participants (b=.63, SE=.08, p<.001), and perceived less exertion (b=.52, SE=.36, p=.04) compared to Standard participants. For both groups, a more positive affective valence during exercise was significantly predictive of continued physical activity at 6-months (b=6.64, SE=2.50,

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Declaration of interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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p=.01). EVG participants also showed a significant chronic effect such that week-to-week there were improvements in affect prior to exercise and this effect was significantly associated with greater MPVA at EOT and follow-up (b=21.96, SE=10.10, p=.03 at EOT). Among Standard participants no significant chronic effect was seen over time.

Conclusions: EVGs may provide an effective means of promoting more positive shifts in affective valence both during, and in anticipation of, physical activity that encourages longer-term participation.

Introduction

Despite the numerous health benefits associated with physical activity (PA; Eliassen, Hankinson, Rosner, Holmes, & Willett, 2010; Jakicic, 2009; Jefferis, Whincup, Lennon, & Wannamethee, 2012; Moore et al., 2016; Nocon et al., 2008; Samitz, Egger, & Zwahlen, 2011; Sattelmair et al., 2011; Woodcock, Franco, Orsini, & Roberts, 2011), less than half of American adults report being sufficiently active to meet national guidelines for moderate-to-vigorous physical activity (MVPA; Katzmarzyk, Lee, Martin, & Blair, 2017; National Center for Health Statistics, 2017; Tucker, Welk, & Beyler, 2011). While initiating a program of physical activity is difficult, maintaining long-term adherence is an even greater challenge with less than half of those who start exercising regularly continuing for more than 6 months (Dishman, Ickes, & Morgan, 1980; Fjeldsoe, Neuhaus, Winkler, & Eakin, 2011; Morgan, 2005; Spark, Reeves, Fjeldsoe, & Eakin, 2013; Williams, Hendry, France, Lewis, & Wilkinson, 2007).

One way to improve adherence to PA programs is to make the exercise experience more pleasurable or at a minimum, less aversive. Although most people tend to feel good immediately following a session of exercise (Ekkekakis, Parfitt, & Petruzzello, 2011), and regular exercise can enhance overall mood and well-being if performed consistently over time (Emerson & Williams, 2015), many people feel bad *during* exercise (Ekkekakis & Dafermos, 2012; Ekkekakis, Hall, & Petruzzello, 2005; Ekkekakis & Lind, 2006). Consistent with the principle of psychological hedonism (Cabanac, 1992b; Kahneman, Wakker, & Sarin, 1997; Williams, 2018; Williams & Connell Bohlen, 2019), previous research has shown that affective response while exercising—i.e., feeling good versus bad during exercise, is predictive of adherence to PA programs (Kwan & Bryan, 2010; Schneider, Dunn, & Cooper, 2009; Williams et al., 2008; Williams, Dunsiger, Jennings, & Marcus, 2012), as well as latency and duration of the next exercise session (Williams et al., 2016). Thus, interventions that successfully enhance a positive affective response to exercise sessions are likely to result in improvements in longer-term PA adherence.

Exercise video games (EVGs), also called “active video games” and “exergames,” require substantial body movement for continued play, and include platforms such as the Nintendo Wii, Xbox 360 Kinect, specially equipped stationary cycles (e.g., GameBike^{tm}) and dance simulations. Playing EVGs elicits greater energy expenditure compared to rest and sedentary videogames (Fitzgerald et al., 2004; Graves et al., 2010; Howe, Barr, Winner, Kimble, & White, 2015; Lanningham-Foster et al., 2009), and some EVGs result in energy expenditure commensurate with MVPA - similar to brisk walking and cycling (Bosch, Poloni, Thornton,

& Lynskey, 2012; Miyachi, Yamamoto, Ohkawara, & Tanaka, 2010; Sween et al., 2014). Evidence suggests that EVGs may also result in an enjoyable exercise experience, even when working at higher intensities (Barry, van Schaik, MacSween, Dixon, & Martin, 2016; Glen, Eston, Loetscher, & Parfitt, 2017; Moholdt, Weie, Chorianopoulos, Wang, & Hagen, 2017). Thus, EVGs may offer a viable, practical, and attractive alternative to traditional modes of exercise. They may promote a more positive affective response (e.g., "have more fun") during exercise and therefore may improve long-term adherence to PA.

We recently conducted a randomized clinical trial examining the efficacy of EVGs for promoting and maintaining MVPA among generally healthy adults. Details of that study protocol, methods and primary outcomes are published elsewhere (Bock et al., 2019; Bock et al., 2015). Guided by the reasoning that positive affect would contribute to greater sustained MVPA, this study reports follow-up analyses examining the relationship between affective response during exercise and adherence to MVPA through the six-month follow up among participants, within EVG and Standard exercise conditions.

Methods

Healthy, sedentary men and women (n=283) were consented and randomized to a program of either EVGs or Standard exercise (i.e., treadmill walking, stationary cycling), or a control condition. Both EVG and Standard participants attended exercise sessions in our lab (50 minutes, 3 × weekly for 12 weeks) supervised by trained staff. Heart rate was continuously monitored throughout each exercise session using a HR monitor (Polar RS400) to ensure that participants' activity was in their age-adjusted moderate-to-vigorous range (Karvonen, 1957). Participants reported their current affect immediately before, at the mid-point, and immediately after one exercise session each week (details below).

Results showed that the median time spent in MVPA at end of treatment (EOT=week 12) was significantly greater in both the EVG and Standard exercise groups compared to controls (all ps <0.01). Participants in EVG (n = 93) and Standard (n= 96) conditions did not differ with respect to mean number of sessions attended over 12 weeks or length of exercise sessions (p's>.05). EVG participants attended a mean of 27.11 (SD=9.81) sessions and Standard participants attended a mean of 27.45 (SD=7.85) sessions during the 12-week intervention. Participant retention through follow up was 88%, with no difference between groups. However, at EOT scores on the interview administered 7-day physical activity recall (Blair et al., 1985; Sallis et al., 1985) showed that EVG participants engaged in significantly more MVPA (+30 min/week) compared to Standard exercise (b=30.00, 95% CI: 4.46–64.46), indicating that *EVG participants were engaging in more MVPA outside of the lab sessions compared to Standard participants*. In addition, among EVG (but not Standard) participants, *weekly minutes of MVPA remained significantly higher than controls though the six-month follow up* (b = 16.00, 95% CI: 0.91–75.91) (Bock et al., 2019).

This paper examines the relationship between affective response during exercise and adherence to MVPA through the 6-month follow up among participants in the EVG and Standard conditions, to determine its contribution to greater and sustained MVPA. Given the greater amount of weekly MVPA obtained outside of exercise sessions in the original trial, we anticipated that participants in the EVG condition would continue to have greater MVPA at 6 months compared to Standard participants. Hedonic and behavioral learning models (Cabanac, 1992a; Hall, 1976) suggest that reported positive affect during exercise would be positively associated with the amount of MVPA at 6 months. And that continued positive affective response to exercise would produce an increase in positive pre-exercise affect, possibly in anticipation of a positive intra-exercise experience.

Measures

Physical Activity Assessments

MVPA.: MVPA (minutes/week) was the primary outcome in the parent study and was measured at baseline, EOT, and at 6-month follow up, using the interviewer-administered 7-day Physical Activity Recall interview (PAR) by study staff blind to participant randomization assignment (Blair et al., 1985; Sallis et al., 1985). The PAR is a reliable, validated instrument sensitive to change in physical activity. The PAR classifies all physical activity occurring in the past 7 days as light, moderate, or vigorous, and also records daily sleep and sedentary time (Conway, Seale, Jacobs, Irwin, & Ainsworth, 2002; Dubbert, Vander Weg, Kirchner, & Shaw, 2004; Hayden-Wade, Coleman, Sallis, & Armstrong, 2003; Washburn, Jacobsen, Sonko, Hill, & Donnelly, 2003). In addition, all participants wore an Actigraph Motion Monitor (model GTX3: Actigraph, LLC) for a 7-day period prior to each of the three assessment points to corroborate the self-reported data from the PAR.

Heart Rate and Perceived Exertion.: Heart rate (HR) was recorded using a HR monitor (Polar RS400) worn by each participant at each of 36 sessions. The target HR range was calculated by using the Karvonen Formula (Karvonen, 1957). Participants were also instructed to exercise in a perceived exertion range of “fairly light” to “somewhat hard” (11–13 on the Borg perceived exertion scale) (Borg, 1982), and to report their ratings of perceived exertion (RPE) at the end of each session. HR was continuously monitored and if HR fell below the moderate-intensity range study staff encouraged the participant to increase their speed and/or intensity.

Affective Valence.: Valence was assessed using the Feeling Scale, which is a single-item measure of the valence dimension of affect (Hardy & Rejeski, 1989), using an 11-point scale from −5 = “very bad” to 0=”neutral” to +5=”very good.” Using the Feeling Scale, participants completed a rating of how they were “feeling right now” immediately before, at the mid-point, and at the end of one exercise session per week for each of the 12 weeks. The Feeling Scale has been used as a measure of affective valence in a number of physical activity studies (for a review see Ekkekakis, 2003) and has been shown to be related to other measures of affect (Hall, Ekkekakis, & Petruzzello, 2002), and to both past and present physical activity participation (Hardy & Rejeski, 1989).

Analyses

A detailed description of the study sample has been presented elsewhere (Bock et al., 2019; Bock et al., 2015). Between-group differences (EVG vs. Standard) in baseline socio-demographics, physical activity and physiological measures were tested using t-tests for continuous variables, chi-squared tests for categorical variables and non-parametrics as appropriate.

First, using a longitudinal mixed effects model with a subject-specific intercept, we examined between group differences (EVG vs Standard) in during-session affective response to exercise over time. Models controlled for pre-session affect and time (study week). Standard errors were adjusted accordingly to account for repeated measures within-participant over time. As a subsequent step, we controlled for RPE (indexed by session). Our goal was to understand the effects of intervention group separate from perceived exertion.

Next, using a longitudinal quantile regression model, we examined the effects of within-session affective response to exercise on self-reported MVPA over time. The Feeling Scale during exercise was a time-varying indicator of affective response. Models controlled for pre-session affect, as well as time (week), baseline physical activity, treatment (EVG vs. Standard Exercise), treatment*during exercise affect, and treatment*affect*time. Bootstrapped standard errors (corresponding to 1000 reps) were estimated. Models allow for the estimation of the impact of a one-unit shift in pre-exercise affective valence from week-to-week (i.e., chronic effects on affect) and acute affective response during each exercise session on min/week of MVPA at EOT and 6-month follow-up, controlling for baseline MVPA. Interactions with treatment assigned and time (week) allow for testing whether there were differences between conditions on chronic and acute effects. A second model was run controlling for RPE (a time-varying variable). This process was repeated using the objectively measured MVPA data as the outcome. Finally, we ran a parallel model to examine within-session difference in RPE (time-varying outcome) as a function of treatment assigned.

Estimation was based on likelihood (for mixed effects models) and quasi-likelihood (for quantile regression models) approaches and all participants for whom affective response was collected were included in the sample. Models provide consistent estimates of the regression parameters without directly imputing missing outcomes. All analyses were run in SAS 9.3 and significance level was set at alpha=.05 a priori.

Results

A full description of the full study sample is presented in Table 1 and has been described in detail elsewhere (41, 42). There were no significant differences between EVG and Standard groups with respect to baseline demographics, participation in MVPA, or physiological variables. As noted above, time spent in MVPA during exercise sessions did not differ between conditions. Figure 1 shows the average affective response to exercise by group on a session-to-session basis.

Treatment Effect on Affective Response and RPE

Overall model results indicate that on average EVG participants reported more positively valenced affect during exercise compared to Standard participants ($b=.63$, $SE=.08$, $p<.001$) controlling for pre-exercise affective valence. Average rating on the feeling scale during exercise for EVG participants was 3.47 (SD=1.50), compared to Standard exercise 2.84(SD=1.57).

Models of RPE showed significant differences between conditions with respect to perceived exertion within session with EVG participants perceiving less exertion (b=.52, SE=.36, p=.04).

Affective Response and Post-Intervention Maintenance of Physical Activity

Results indicate that for both groups, more positively valenced affect during exercise was significantly predictive of continued self-reported physical activity at the 6-month follow-up (b=6.64, SE=2.50, p=.01). Although not significant, effect estimates were in the same direction for objectively measured MVPA at 6-month follow-up (b=5.57, SE=5.23,p=.29). Analyses of RPE showed that perceived exertion did not predict self-reported or objectively measured MVPA at EOT or follow-up (p's>.05).

Treatment*Affective Response and Physical Activity

Results suggest that among EVG participants, there were significant acute effects of affective response on self-reported min/week of MVPA at EOT and at the 6-month follow-up such that at every session higher affective response during exercise was associated with greater MVPA at EOT and follow-up (b=13.84, SE=8.73, p=.04 at EOT; b=6.02, SE=2.87, p=.02 at follow-up). Furthermore, there were significant chronic effects of condition on pre-exercise affective valence such that among EVG participants week-to-week affective valence was more positive prior to exercise and this effect was significantly associated with greater physical activity at EOT and follow-up (b=21.96, SE=10.10, p=.03 at EOT; b=23.43, SE=11.71, p=.02 at follow-up). Among Standard participants, results suggest a significant (although smaller) acute effect of affective response to exercise (b=3.33, SE=1.68, p=.05 at EOT; b=7.81, SE=4.88, p=.04 at follow-up) but no significant chronic effect on pre-exercise affect over time (p's>.05). All models controlled for pre-exercise affective valence. A similar pattern of findings was shown in models that controlled for the time-varying indicator of RPE. Furthermore, effect estimates were in the same direction for objectively measured MVPA, although only trending. Specifically, among EVG participants, effect of affective response during exercise on objectively measured MVPA at EOT was b=4.08, SE=4,42, p=.36 and at follow-up was b=10.74, SE=9.64, p=.27. Among Standard participants, results did not suggest a significant acute effect of affective response to exercise at EOT(b=7.98, SE=6.28, p=.20) with a trend at follow-up (b=8.03, SE=4.68, p=.07). There were no significant chronic effects on pre-exercise affect over time (p's>.05).

Discussion

A persistent challenge for PA interventions is to establish durable lifestyle changes among sedentary individuals. This study examined the degree to which positive affect may contribute to PA outside of the structured (in-session) MVPA during the trial and continued practice of MVPA after the active intervention had ended.

Consistent with expectations, exercise video games appear to produce greater positive shifts in affective valence in response to exercise, compared to standard modalities of physical activity. This is consistent with primary outcomes of the main trial, which showed greater enjoyment of physical activity among EVG participants (Bock et al., 2019).

Notably, EVG was also associated with chronic positive shifts in affective valence as indicated by more positive feeling scale scores taken prior to each exercise session throughout the treatment period. Three possible explanations for this phenomenon come to mind: **First**, because chronic shifts in affective valence were derived from FS scores taken immediately prior to the exercise sessions, one interpretation of this finding is that participants in the EVG condition experienced more positively valenced affect in anticipation of exercise (i.e., anticipatory affect) than participants in the standard condition. This would be consistent with Hedonic and Learning theories (Cabanac, 1992a; Hall, 1976), in that continued exposure to a behavior that produces positive affect may result in anticipation of positive affect when approaching the next occurrence (anticipation of a positive experience may heighten immediate affect resulting in higher pre-session affect ratings); **Second**, that EVGs were associated with greater MVPA during the treatment program and regular participation in MVPA has been shown to enhance overall mood (Chan et al., 2019); and **Third**, that EVGs (specifically, separate from their effect on MVPA participation) may be superior to standard exercise for improving incidental affect (i.e., how people feel throughout the course of the day unrelated to the target behavior) as well as integral affect (i.e., how people feel in direct response to the target behavior). Sorting out the difference between these possible explanations will require a different study design. Regardless of which explanation is ultimately supported, it is noteworthy that EVG led to more positive shifts in affective valence both prior to and in response to exercise than the standard exercise program.

Among EVG participants in this study, positive affective response to exercise was significantly predictive of longer-term maintenance of MVPA through 6 months. These results are consistent with previous research showing that affective response while exercising—i.e., feeling good versus bad during exercise—is predictive of PA adherence (Kwan & Bryan, 2010; Schneider et al., 2009; Williams et al., 2008; Williams et al., 2012). It is noteworthy that in this study EVGs produced significantly more positive affective response to PA, indicating that they may provide a sustainable venue for PA engagement and promote better longer-term adherence than other, less enjoyable PA interventions.

Our results also suggest an interesting discrepancy between subjective and objective indicators of exertion, with potential consequences for PA adherence. Although both groups spent an equal amount of time within their targeted range for HR during exercise sessions, HR, which is often used as a physiological index of exercise intensity (Reljic et al., 2019), was slightly higher among EVG participants compared with Standard condition participants. However, EVG participants reported significantly lower levels of perceived exertion. Higher-intensity PA such as vigorous exercise is associated with lower adherence, but it is unclear to what extent this is due to the effect of perceived exertion rather than objective differences in exertion (HR). If EVGs can contribute to lower perceived exertion even during higher-intensity PA, they may help circumvent subjective factors associated with higher-intensity PA as obstacles to MVPA adherence.

Limitations

This study had several limitations. First, the Standard condition group engaged in structured indoor MVPA activities such as running on a treadmill or using an exercise bicycle. Lifestyle physical activities, such as walking or cycling outdoors, may provide a more positive experience and produce a different affective response than we observed in our lab.

In addition, after EOT we no longer assessed the amounts of MVPA that were due to EVGs vs. other activities. It is possible that those in the EVG condition engaged in some Standard exercise modalities, and/or that those in the Standard condition may have started using EVGs at home. This means that for the 6-month follow-up, participants were no longer subject to the degree of experimental control that existed during the initial 12 weeks, and therefore there is some reduction in internal validity. This limits the degree to which it may be said that the patterns in affect and MVPA were specifically due to EVGs vs. Standard exercise, or about the degree to which people sustain specific modes of exercise based on this trial.

To minimize practice effects, we only assessed affect one day each week during the trial, rather than during all three sessions every week. This lower assessment frequency may have obscured findings that may have been enabled with the use of more fine-grained data collection on affect. Similarly, although the FS is a well-validated instrument for assessing affective response to exercise, single-item measures can lack the resolution of more comprehensive measures. Furthermore, the FS really only captured one dimension of affective experience (i.e., “good” and “bad”) but not the depth and range of possible emotional experience (e.g., angry, tired, happy, proud, calm) or change of experience from pre-, during, or post- PA. This approach was chosen to avoid substantial interruption of exercise sessions with longer assessments. Consequently, there may be other elements of affect beyond positivity and negativity involved in our outcomes, which we were not able to measure.

Conclusion

EVGs are an increasingly diverse and accessible means for MVPA. They may provide an effective method of promoting positive shifts in affective valence during physical activity, and consequently encourage longer-term participation in MVPA. Positive affect in response to EVG sessions may be an especially valuable element for increasing sustainable physical activity as part of a healthy lifestyle.

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Highlights

- In a trial comparing exercise modalities, sedentary adult endorsed more positive affect during exercise video games than during standard exercise.
- Greater positive affect during exercise predicted more physical activity six months after the end of the intervention.
- Both groups exercised at the same intensity as measured by heart rate monitors, however, participants randomized to exercise video games perceived lower exertion than those assigned to standard exercise.
- Exercise video games are a promising physical activity intervention for sedentary adults.

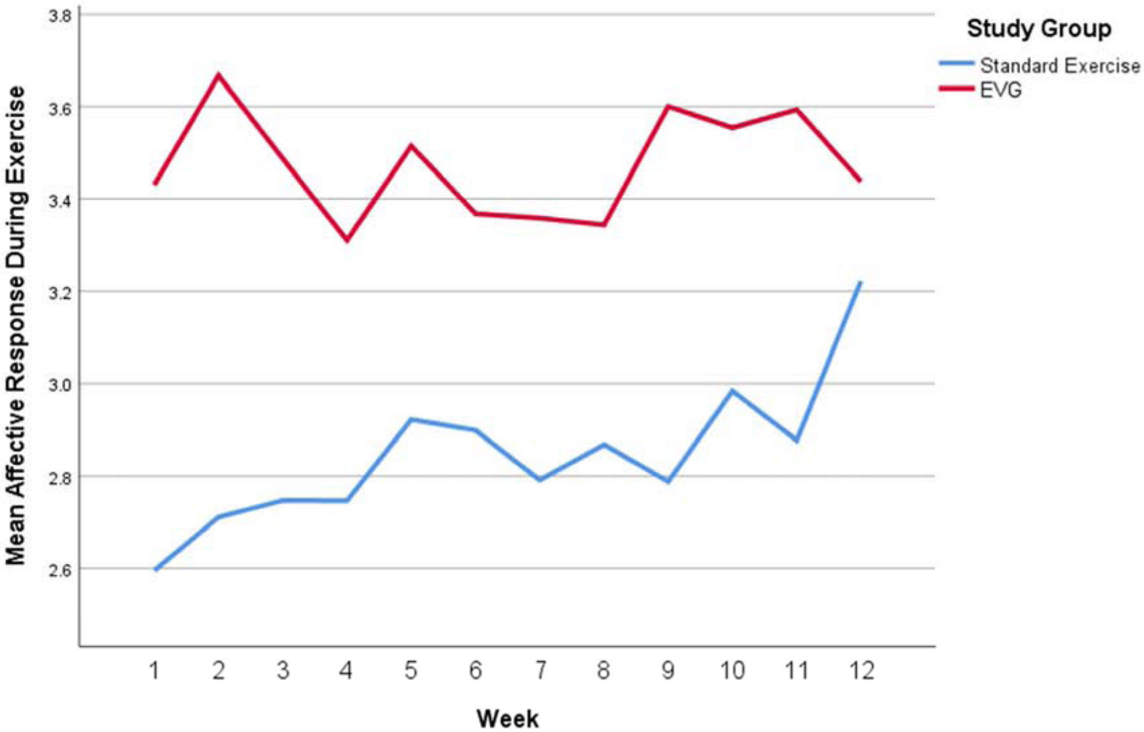

Figure 1.

Mean Affective Response During Exercise Over Time by Condition Unadjusted mean affective response during exercise over time by group.

Table 1.

Sample Descriptives at Baseline

Variable	Standard (n=96)	EVG (n=93)
Gender, % Female	74 (77.9%)	75 (80.6%)
Employed, % Yes	72 (77.4%)	70 (76.9%)
Marital Status		
Married/Partnered	54 (60.7%)	52 (56.5%)
Education:		
At least some college	79 (89.8%)	83 (91.2%)
Ethnicity, % Hispanic	7 (8.6%)	8 (10.5%)
Race, % White	77 (82.8%)	70 (76.1%)
Age	45.7 (SD=15.0)	45.1 (SD=14.0)
MVPA Avg min/week	54.9 (90.9)	63.8 (72.5)
(PAR)	Median=30	Median=40
MVPA Avg min/week	35.59(77.44)	31.59(44.69)
(Accelerometer)	Median=0	Median=10.83

Table 2.

Adjusted effects of Treatment Condition, Affective Response, Treatment*Affective Response and Physical Activity

Predictor	**b(SE)**	**p-value**
Self-Reported MVPA at EOT		
Treatment (EVG vs SE)		
Pre-Exercise $Affect_t$	2.12(4.62)	.48
During-Exercise Affectt	3.33(1.68)	.05
Treatment*Pre-Exercise $Affect_t$	19.84(8.23)	.04
Treatment*During-Exercise $Affect_t$	10.51(5.24)	.03
Self-Reported MVPA at 6-month Follow-up		
Treatment (EVG vs SE)	**b(SE)**	**p-value**
Pre-Exercise $Affect_t$	1.56(3.14)	.32
During-Exercise $Affect_t$	7.81(4.88)	.04
Treatment*Pre-Exercise $Affect_t$	20.87(7.23)	.04
Treatment*During-Exercise $Affect_t$	−1.79(0.92)	.03

Outcome was self-reported Min/Week of MVPA at EOT and 6-month follow-up. Models used a quantile-regression approach, modeling median outcome as a function of predictors. Estimates of standard errors (SE) are based on a bootstrapping approach. Models additionally controlled for pre-exercise affective response, self-reported MVPA at baseline. Note that affective response is indexed by *t* (where t=session number, t=1,2,…,12).