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The Dia*beat*es Project: Perceptual, Affective and Psychophysiological Effects of Music and Music-Video in a Clinical Exercise Setting

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Abstract

Aims: The purpose of this study was to examine the effects of music and music-video on perceptual (attentional focus, RPE), affective (affective valence and enjoyment), and psychophysiological (blood glucose, heart rate) variables among outpatients attending a diabetes exercise clinic. **Method:** Participants were 24 females (age = 66.0 ± 8.5 years) enrolled in a supervised exercise program for people with diabetes. They engaged in mixed-modality exercise sessions that included a standardized combination of flexibility, aerobic, and resistance activities under conditions of music, music-video and control. **Results:** Analyses revealed a main effect of condition on attentional focus and affect during aerobic exercise only. The music-video condition elicited the highest level of attentional dissociation, while affective valence was more positive in the 2 experimental conditions when compared to control. Rated perceived exertion and heart rate did not differ across conditions. Measures of exercise enjoyment indicated a main effect of condition wherein scores were higher with the music-video condition when compared to control. There was an acute glucose-lowering effect of exercise in all conditions. **Conclusions:** Results lend support to the notion that auditory and visual stimuli can enhance affective responses to exercise in a clinical setting. This may have meaningful implications for adherence, given the link between affective judgements and future behaviour in an exercise context.

Keywords: affect; attention; exercise enjoyment; type 2 diabetes

Introduction

Exercise is an integral component of diabetes management. It provides a range of health and psychosocial benefits that can reduce morbidity and mortality as well as improve quality of life [1]. Nonetheless, exercise adherence problems are common among individuals with diabetes [2]. Findings from the landmark Cross-National Diabetes Attitudes, Wishes, and Needs study showed that exercise adherence rates for type 2 diabetic patients were only 35% [3]. It is clear that more effective strategies are needed in order to promote the adoption and maintenance of physical activity among individuals with type 2 diabetes.

Behavioral interventions predicated upon the principles of cognitivism (i.e. modification of cognitive appraisals) have shown only limited efficacy [4]. An alternative approach suggests that the decision to engage in exercise depends not only on the rational cognitive appraisal of information but also, to a greater degree, on affective experiences (i.e. pleasure vs. displeasure) derived from prior engagement in physical activity [5]. Consequently, practitioners have been encouraged to enhance an individual's enjoyment of exercise with a view to enabling them to meet guidelines for physical activity [1]. The use of music and video are 2 clear targets for research, given their high level of popularity and ubiquity in exercise settings.

There is strong evidence to suggest that listening to music during exercise can significantly enhance many aspects of the exercise experience, engendering a range of positive perceptual and affective outcomes in an exercise context [6]. The phenomenon of attentional dissociation is often cited as a cognitive mechanism that underlies the psychological effects of auditory and visual stimuli [6]. This mechanism entails the propensity of stimuli such as music and video, to draw attention toward external cues and away from internal, fatigue-related cues, thus assuaging effort-related sensation and corollary declines in affect [6]. An important question that has yet to be addressed among clinical populations engaged in exercise is whether there is an additional attentional/processing demand when comparing a single stimulus with multiple external stimuli.

A perceptual load that engages close to full processing capacity leaves little spare capacity for the perception of competing stimuli such as those carried by the afferent nervous system during exercise [7]. Using this axiom, it is logical to predict that a plurality of external stimuli (e.g. music-video) should supersede a singular stimulus (e.g. music) in terms of a range of outcomes that are relevant to the exercise experience (i.e. lower RPE, more positive affective valence, and enhanced enjoyment). This has meaningful implications for exercise adherence, given the link between affective judgements and future behaviour [8, 9].

Empirical research into music-video

There has been a flurry of research activity in recent years that has addressed the combined influence of music and video in nonclinical exercise settings. Bigliassi et al. [10] and Lin and Lu [11] both reported positive effects of music-video on performance and RPE when compared to control conditions. Jones et al. [12] adopted a novel approach insofar as they combined music with parkland video footage that was congruent with the pedal rate of a stationary cycling task. The researchers showed that at work intensities both above and below ventilatory threshold, music-only and music-video led to higher affective valence and enjoyment scores during and after exercise. Hutchinson et al. [13] conducted a follow-up study using music-videos and treadmill running intensities above and below ventilatory threshold. The music-video condition elicited the highest levels of dissociation, lowest RPE, and most positive affective responses regardless of exercise intensity, when compared to music-only and control. Among their recommendations, both of the aforementioned studies [12, 13] emphasized the applicability of music and video-related interventions among non-traditional exercise or at-risk populations.

Clinical applications

A qualitative review that examined the addition of music to exercise programs in clinical and elderly populations [14] concluded that music provides a number of benefits (i.e. enhanced exercise performance, adherence, and motivation to participate) but highlighted a number of methodological limitations and research concerns. In particular, the musical accompaniment was selected arbitrarily by the researchers in most of the studies reviewed, and several lacked a control groups or included a control group that did not isolate music as the variable influencing the differences among groups. To date, the effect of music-video has not been tested empirically in a clinical exercise setting.

Purpose and hypotheses

The present study was predicated on the notion that a dissociative manipulation of attentional focus through the application of music and music-video during exercise would be reflected in subjective indexes, such as RPE, affective valence, and post-exercise enjoyment. Thus, the primary objective was to evaluate the effectiveness of a music and music-video intervention in improving perceptual (attentional focus, RPE) and affective (affective valence, enjoyment) responses to exercise among people with type 2 diabetes. A secondary objective was to explore psychophysiological responses (i.e. heart rate, blood glucose) to exercise under conditions of music and music-video.

It was hypothesized that a significant Condition x Exercise Mode interaction would emerge, wherein the music-video condition would lead to more dissociative thoughts and lower RPE than music-only and control during aerobic exercise (H_1). During resistance exercise, where less attention is directed toward visual stimuli, the 2 experimental conditions were expected to lead to more dissociative thoughts and lower RPE than control. It was also hypothesized that the experimental conditions would yield more positive in-task affective valence and greater exercise enjoyment when compared to control, regardless of exercise mode (H_2). In terms of a return to pre-exercise levels of affective valance—the so-called affective rebound—it was hypothesized this would be less pronounced in the 2 experimental conditions when compared to control (H_3). Heart rate and blood glucose measures were taken to explore psychophysiological responses to the experimental conditions, so the null hypothesis was tested in this instance (H_4). If either of the experimental conditions elicited changes in work output, the psychophysiological measures would have been particularly sensitive to them.

Methods

Ethical clearance was obtained from the Institutional Review Board of the first author’s institution (Springfield College, Springfield, Massachusetts, United States) and from the hospital at which the research was conducted. A power analysis was undertaken based on a medium-effect size (Cohen’s $d = 0.46$) derived from variables that were common to the present study and assessed in a recent nonclinical study [12], an alpha level of .05, and power at .8. The analysis indicated that 20 participants would be required; an additional 4 participants were recruited to facilitate full counterbalancing and to protect against attrition and deletions due to outliers.

Participants

A purposive sample of 24 volunteer female participants (means ± SD; Age = 66.0 ± 8.5 years; BMI = 34.8 ± 6.2 kg/m^2; HbA1C 7.6 ± 2.6%) was recruited and all provided informed consent. Participants were physician-referred outpatients with type 2 diabetes who were recruited from a supervised exercise program at a nonprofit hospital in the USA.

Apparatus and measures

Heart rate (HR) was measured using a HR monitor (E600, Polar Electro, Lake Success, New York, United States). Blood glucose (mmol/L) was measured via capillary blood taken from the finger using a portable blood glucose meter (Accu-Chek Aviva, Roche Diagnostics, Risch-Rotkreuz, Switzerland). For aerobic exercise, participants used either a motorized treadmill (7.85T, Paramount Fitness, Los Angeles, California, United States) or a recumbent exercise cycle (RBK 835, Precor, Woodinville, Washington, United States). The reason for the use of 2 items of cardiovascular equipment was that some participants had limitations in mobility that precluded their use of either one or other of these exercise machines. For resistance exercise training, common items of circuit-type equipment such as mats, dumbbells, resistance bands, and medicine/Swiss balls were used. A decibel meter (407730, Extech Instruments, Waltham, Massachusetts, United States) was used to standardize the sound intensity of music and music-video at 75 dBA.

Self-reported attentional focus, ratings of perceived exertion (RPE), and affective valence (i.e. pleasure-displeasure) were measured using a state attentional focus scale [15], RPE scale [16], and the Feeling Scale [17], respectively. The Physical Activity Enjoyment Scale-8 (PACES-8) [18] was administered immediately after each condition to assess overall exercise enjoyment.

Procedure

Participants had been enrolled on the diabetes exercise program for at least 2 weeks prior to the commencement of experimental trials. Accordingly, they were familiar with the aerobic and resistance exercise modalities that formed the mainstay of the exercise program. The 55-min exercise session comprised a 10-min dynamic warm-up, followed by 20 min of aerobic exercise either on a treadmill or recumbent cycle and then a 20-min resistance-training circuit. The session concluded with a 5-min series of gentle static stretches. Exercise intensity for aerobic exercise was set at 40% to 60% max HR reserve (i.e. moderate intensity [19]) for each participant, and each participant used the same apparatus for each trial. Treadmill and cycle speeds were adjusted by the supervising clinical exercise physiologist to ensure that participants remained in the prescribed HR target zone. For those who were taking beta-blocking medication (*n* = 3), the formula was suitably adjusted (resting HR +30 bpm) to account for its heart rate-lowering effect [20]. The 20-min resistance training circuit comprised exercises such as lateral arm raise, hamstring curl, chest press, and standing squat.

Two experimental conditions (music and music-video) and a control condition (no external stimuli) were administered using a fully counterbalanced repeated-measures design, wherein all possible combinations of condition order were accounted for by use of a Williams design [21]. The music playlist was developed with reference to scientific guidelines [22] and detail regarding music preferences that were gleaned from a representative focus group of outpatients. In the music-only condition, participants were exposed to a 60-min playlist that was played from the time that they entered the clinic. The music-videos consisted of tracks that appeared in the music-only playlist, but the order of their appearance was changed so as to reduce any potential threat to internal validity with track order that might influence participants’ responses, perhaps through the psychomusicological phenomenon of anticipation [see 23].

On arrival, each participant was fitted with a heart rate monitor and had baseline blood glucose measured. Immediately thereafter, pre-exercise affective valence was measured using the Feeling Scale. In-task measures of state attention, RPE, and affective valence were taken at the mid-point (i.e. Minute 10) of both the aerobic exercise bout and resistance training circuit. Upon completion of the exercise session, measures of blood glucose and post-task affective valence were taken, and the Physical Activity Enjoyment Scale (PACES-8) was administered immediately thereafter to assess overall exercise enjoyment.

Data analysis

Following diagnostic tests for parametric analysis, a multivariate analysis of variance (MANOVA) and a series of analyses of variance (ANOVA) were computed. Where variables were theoretically linked, we applied MANOVA in order to reduce experimentwise error [see 24]. To investigate the effects of auditory-visual condition and exercise mode (aerobic v resistance) a 3 (Condition) x 2 (Mode) MANOVA (attentional focus and RPE), and ANOVA (affective valence) was used. A oneway repeated-measures ANOVA was used to ascertain the effect of condition on exercise enjoyment, and a 3 (Condition) x 3 (Time: baseline, during, post-task) ANOVA was applied to assess whether there was a more pronounced affective rebound in the experimental conditions. To facilitate this analysis, the in-task valence scores were averaged and compared against baseline and post-task valence scores. Where the *F* ratio was significant, we used Bonferroni-adjusted pairwise comparisons (main effects) or checks of standard errors (interaction effects) to identify where differences lay. Effect sizes for main effects were calculated using Cohen’s *d*.

Results

Inferential statistics for all dependent variables are presented in Table 1. Means and standard deviations for in-task and post-task measures are presented in Supplementary Table S1. The MANOVA revealed a significant Condition x Mode interaction that applied only to attentional focus. The music-video condition yielded the highest level of dissociation, followed by the music-only condition, and then control during aerobic exercise, while no differences emerged during resistance exercise. Thus (H_1) was partially accepted. The significant main effect of state attention was rendered moot by the interaction effect, so it is not presented here [see 24]. The significant main effect of exercise mode indicated that RPE was higher during resistance exercise than aerobic exercise (d = 1.22).

There was no Condition x Mode interaction effect for affective valance, although there were significant main effects of condition and mode. Valance was more positive in the music and music-video conditions when compared to control (d =.57; p = 0.02 and d = .56; p = 0.01, respectively), and overall in-task affective valence was more positive during resistance exercise than aerobic exercise (d

= .47; *p* = 0.01). Participants reported greater enjoyment of exercise in the music-video condition when compared to music-only (*d* = .42; *p* = 0.02) and control (*d* = .50; *p* = 0.01). Thus, the hypothesis that the 2 experimental conditions would yield more positive in-task affective valence and greater exercise enjoyment when compared to control (H_2) was only partially supported, given that, although in-task affect was more positive in the 2 experimental conditions for exercise enjoyment, differences emerged between the experimental conditions and between music-video and control.

The examination of pre-, during- and post-session affect indicated a significant Condition x Time interaction wherein affective valance scores were more positive during exercise in the music and music-video conditions (*M* = 2.96, *SD* = 1.02 and *M* = 3.18, *SD* = 1.01, respectively) when compared to control (*M* = 1.98, *SD* = 1.36). However, as predicted (H_3), there was greater affective rebound in the control condition, resulting in comparable post-exercise affective valance scores across the three conditions (see Fig. 1).

There were no significant differences across conditions or between exercise modes for HR, therefore H_4, which entailed a test of the null hypothesis, was accepted in the case of HR. There was no significant Condition x Time interaction for blood glucose. There was, however, a main effect of Condition with pairwise comparisons showing that blood glucose was lower in the music-video condition (*M* = 145.81, *SD* = 51.34) when compared to control (*M* = 162.14, *SD* = 49.04; *d* = .31 *p* = .015). There was also a main effect of time, with a large decline in blood glucose levels from pre- to post-task (*M* = 173.75, *SD* = 62.90 and *M* = 137.36, *SD* = 47.23, respectively; *d* = .58; *p* < .001). The null hypothesis (H_4) was therefore rejected in the case of blood glucose.

Discussion

The main purpose of this study was to examine the effects of music and music-video on perceptual and affective responses to exercise among people with type 2 diabetes in an ecologically-valid setting. A secondary objective was to explore psychophysiological responses to exercise under conditions of music and music-video.

Perceptual variables

As expected, the state attention data indicated that music-video elicited the highest number of dissociative thoughts during aerobic exercise, followed by music-only and then control. These results are consistent with those of previous research [12, 13] wherein the combined auditory and visual stimuli captured participants' attention to a greater degree than a single stimulus, yet this is the first experimental study to date that has tested this combination in a clinical exercise setting. Load theory [7] incorporates clear predictions regarding the relationship between selective attention and perceptual awareness; specifically, a high level of perceptual load exhausts attentional capacity, resulting in reduced perception of unattended information, while conditions of low perceptual load leave "spare" capacity, resulting in capacity allocation to the extraneous stimuli. In the exercise context, this may refer to internal sensations of fatigue that are associated with a decline in affective valence [5]. These sensations are amenable to modulation by perceptual load, with bimodal audiovisual cues (e.g. music-video) effecting a higher level of perceptual load than unimodal presentations (e.g. music).

The environmental stimuli had no effect on state attention during the resistance component of the program, which was expected, given the higher anaerobic component associated with resistance exercise when compared to aerobic exercise. Moreover, maintaining visual fixation on a wall-mounted screen is biomechanically more challenging during resistance training than during aerobic exercise; accordingly, exposure to the visual stimuli was less regular during resistance exercise. A specific consideration that pertains to resistance exercise is the requirement to maintain good form and posture in order that the health of the participant is not compromised. To this end, fixation on a screen is perhaps ill advised in instances when there is likely to be some degradation in the required form.

Music and music-video did not influence RPE scores during aerobic exercise. This finding is inconsistent with recent findings [13] wherein RPE scores in a music-video condition were significantly lower than those in the control condition. However, the college-aged, highly-active participants who were tested in the Hutchinson et al. [13] study are not comparable to the current sample of older outpatients with type 2 diabetes. Thus, although external stimuli do appear to capture attention during exercise in a clinical setting, they do not appear to influence RPE in this particular population [e.g. 25].

Affective variables

The main effect of condition that emerged for in-task affect was as expected. In considering the findings of related studies [12, 13], the present findings were almost identical, with the exception that Hutchinson et al. reported differences between music-video and music-only at a low intensity of aerobic exercise. Nonetheless, the experimental set-up in the Hutchinson et al. study, which was laboratory based, was more immersive and individually-oriented than the set-up of the present field study. Seemingly, the presence of music and music-video are equally effective means by which to ameliorate affective declines experienced by individuals in a clinical exercise setting.

The main effect of exercise mode revealed that resistance exercise yielded superior affective valance scores when compared to aerobic exercise. Given that this was a field study, and the clinicians would not permit the research team to counterbalance the order in which the exercise modes were administered, it is only possible to speculate in regard to the efficacy of resistance exercise in terms of enhancing in-task affect. One plausible explanation is that the intermittent nature of the resistance circuit made it more pleasurable relative to the unabating nature of the aerobic exercise bout that preceded it [26]. An alternative explanation is that the cessation of aerobic exercise engendered a positive affective state via psychobiological mechanisms, such as endorphin release, serotonin release, and thermogenesis that pervaded the resistance exercise component of the session [27].

The Condition x Time interaction for affective valance revealed that the experimental conditions yielded superior affective valance scores during exercise when compared to control. The music-video condition exhibited a small but steady enhancement in affective valence over time, whereas a clear affective rebound evident in the music condition. An examination of standard errors indicates that the experimental conditions did not differ from each other in statistical terms; nonetheless, the difference in the pattern of response over time is notable and suggests that music-video was more effective in assuaging the affective decline that is normally evident during an exercise bout [c.f. 13]. In contrasting the 2 experimental conditions with control, it is evident that when environmental manipulations were not present, there was a sharper decline in affective valence during the exercise bout followed by a far more pronounced affective rebound than was evident in the music condition. This finding is consistent with the affective or “hedonic contrast” effect described by Solomon [28] and expounded by Ekkekakis [29]. Specifically, the effect entails the magnitude of the post-exercise affective rebound, which should be proportional to the extent of the negative affective shift experienced during exercise. Thus, post-exercise affective state is invariably more positive than pre-exercise affective state. Although often touted as evidence of the “feel better effect” of exercise, this has alternatively been interpreted as a consequence of the cessation of exercise, rather than being engendered by the exercise per se [30]. Notably, it is the in-task (rather than post-exercise) affective responses to exercise that are predictive of future exercise behaviour [9].

The exercise enjoyment scores showed that the dual environmental stimuli were superior to music-only and control. This is a surprising finding given the lack of difference between music and control, which counters previous recent findings [12]. The music seemed less relevant to post-task enjoyment and given that vision is a stronger sense that audition [31], the music-video may have had a stronger bearing on participants’ recall of their exercise enjoyment.

Psychophysiological variables

The main effect of time for blood glucose emerged in accord with expectations. There was a decline in blood glucose following exercise, which was in line with that typically observed in individuals with type 2 diabetes following an acute bout of combined aerobic and resistance exercise [2]. One of the major goals associated with prescribing exercise for individuals with type 2 diabetes is to reduce hyperglycemia, a risk factor for long-term complications [1]. The main effect of condition revealed lower blood glucose overall in the music-video condition when compared to control. This indicates that the participants may have worked harder in the music-video condition; nonetheless, the HR data did not support this notion given that there were no significant differences for HR across conditions. This anomalous finding could possibly be explained by the intermittent measurement of HR, particularly during the resistance circuit, where there was ostensibly greater scope for participants to increase their exercise intensity (when compared to the aerobic component where the treadmill velocity and/or pedal resistance was set by the presiding exercise physiologist). Thus, we are not able to state conclusively that the presence of music-video would maximize the benefits of exercise for glycemic control, albeit that there is a trend to suggest this (Cohen’s $d = 0.31$).

Limitations and future directions

The present study was applied in nature and sought to maintain a high level of ecological validity, but it is not without limitations. In order not to interfere with the participants' exercise program, research assistants recorded HR intermittently between elements of the resistance circuit. It is acknowledged that this may not have been sufficient to capture the brief but intense efforts that are typical of resistance exercise. Continuous monitoring of HR is recommended to address this limitation. Related to this, given the applied nature of the present study, the experimenters were not able to control the precise intensity at which participants completed the resistance circuit. Furthermore, participants were given a free choice of aerobic exercise equipment, albeit that the initial choice was adopted across trials (21 chose the treadmill and three chose the recumbent exercise cycle). It is, thus, possible that choice of exercise modality may have influenced the findings.

The present study entailed an acute trial, a valuable addition to the current line of research would be to explore the prolonged effects of music and music-video on affective response to exercise in clinical settings. It is possible that there was a novelty factor associated with the intervention that may diminish over time and could be overcome with a long habituation period. Conversely, it is equally plausible that clinical benefits may become more marked with increased exposure to interventions of this nature. Such research efforts should be focussed on female and male samples given that the present study was delimited to female participants due to the demographic profile of outpatients entering the diabetes exercise clinic (female/male ratio of 8:1).

The influence of environmental manipulations using music and video on exercise-related affect is likely to be a particularly fruitful endeavour in terms of assessing patterns of long-term adherence and health-related outcomes. The benefits of exercise for type 2 diabetes management have been demonstrated consistently, yet participation rates are low. Therefore, the primary challenge at this time is to determine how increased physical activity levels can be sustained in patients' daily lives [32]. The relationship between acute affective responses to exercise and exercise adherence by previously sedentary individuals has received some recent empirical support [e.g. 9]. Extending these findings to clinical and/or other at-risk populations will yield insights that are of potential value to public health professionals.

Conclusions

Collectively, the present findings highlight the utility of music and music-video as a means by which to enhance the affective responses of older people with type 2 diabetes during exercise. From a theoretical standpoint, these results illustrate the efficacy of experimental manipulations pertaining to components of the information-processing system (i.e. attentional focus) in influencing affective responses during exercise and extend previous evidence concerning the efficacy of music and music-video interventions in the amelioration of negative affect during exercise [12, 13] to the clinical exercise domain. This finding is particularly salient given the fact that negative affective responses to exercise are recognized as one of the major barriers to exercise initiation and adherence among people with type 2 diabetes [33]. From a practical standpoint, the results present exercise professionals with evidence-based and cost-effective interventions that are relatively easy to implement in a hospital setting. Such interventions appear to embrace the implications of the most recent joint position statement from the American College of Sports Medicine and American Diabetes Association [1], which includes an extract indicating that “affective responses to exercise may be important predictors of adoption and maintenance” (p. e159). This statement resonates against a backdrop of burgeoning data in support of the role of during-exercise affect [9] and enjoyment [8] in the promotion of habitual exercise behaviours.

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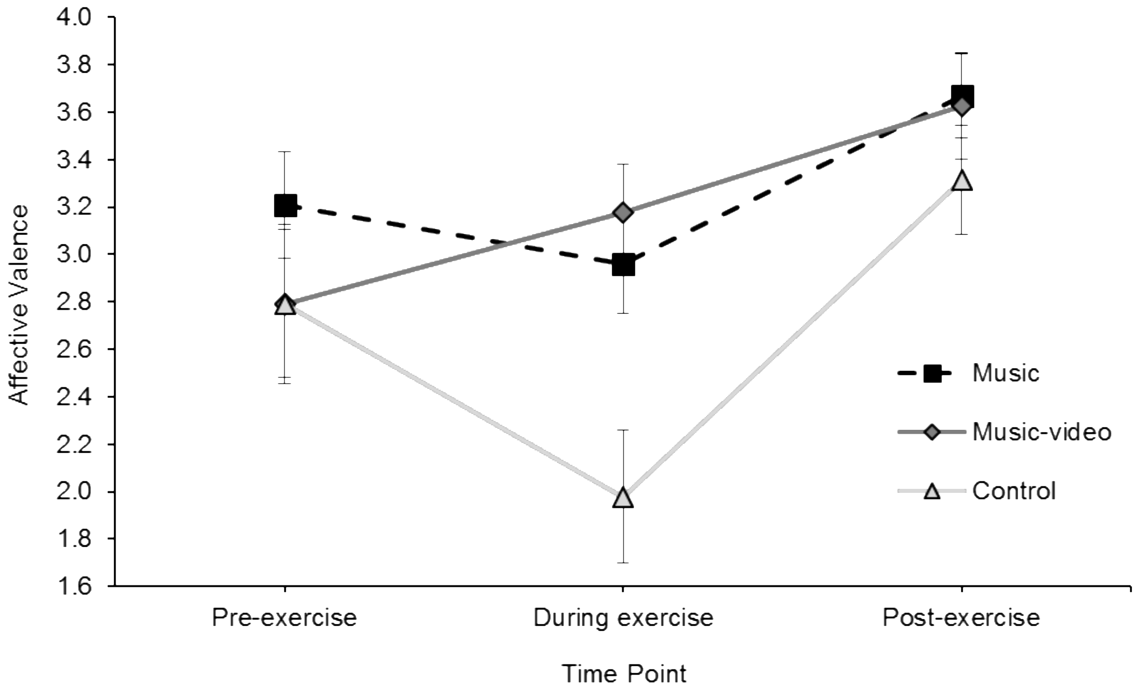

Fig. 1. Condition x Time interaction for affective valance (*P* = .045). Error bars represent standard error of the mean

Table S1

Descriptive Statistics for In-Task and Post-Task Measures (N = 24)

	Condition					
	Music		Music-video		Control	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
State attentional focus						
Aerobic exercise	64.50	17.44	80.25	12.98	55.95	20.48
Resistance exercise	57.95	21.72	56.83	20.19	56.54	20.27
Rating of perceived exertion						
Aerobic exercise	3.75	1.50	3.75	1.24	3.43	1.10
Resistance exercise	5.04	1.82	5.41	1.91	4.86	1.60
Affective valance (in-task)						
Aerobic exercise	3.00	0.93	3.05	1.04	2.31	1.37
Resistance exercise	3.21	0.87	3.29	1.22	2.74	1.14
Enjoyment (post-task)	47.85	5.15	50.12	5.61	46.89	7.50
Heart rate						
Aerobic exercise	106.75	25.36	110.61	21.41	111.79	18.23
Resistance exercise	104.20	17.11	107.19	19.09	104.32	21.65