

Brief Reports

Psychological Benefits of Exercise Paired With Virtual Reality: Outdoor Exercise Energizes Whereas Indoor Virtual Exercise Relaxes

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In the present study the authors sought to evaluate the psychological effects of exercise when paired with virtual reality. One-hundred and twelve introductory psychology students (47 male and 65 female) were randomly assigned to one of three 20-min experimental conditions including (a) taking a brisk outdoor walk around a college campus, (b) walking on a laboratory treadmill combined with a virtual reality video presentation of the same college campus walk, or (c) viewing the virtual reality walk without participating in any actual exercise. Several standardized mood and enjoyment measures were administered immediately before and after the experimental conditions. Results suggest that greater energy was experienced while walking outside whereas less energy was reported when viewing the virtual reality walk with no actual exercise. These findings were most pronounced for female participants. Both female and male participants walking in the laboratory with the virtual reality were more relaxed and experienced the least tension of the three conditions.

Keywords: exercise, virtual reality, stress reduction, mood, physical activity

Research has consistently demonstrated the many physical and psychological benefits of physical exercise (e.g., Centers for Disease Control and Prevention, 2003). Prior research has demonstrated that individuals who exercise in an enriched environment, such as exercising with others, involving virtual reality stimulation, or getting feedback aimed at improving self-efficacy and enjoyment,

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report greater increases in stress reduction, mood, and well-being (e.g., McAuley, Blissmer, Katula, & Duncan, 2000; Plante, Coscarelli, & Ford, 2001). These findings suggest that exercise-related well-being could be manipulated by making effective environmental and social changes to the exercise experience. Therefore, adapting the exercise environment to promote greater comfort and enjoyment may encourage greater psychological benefits.

In a recent study (Plante, Aldridge, Bogden, & Hanelin, 2003), a virtual scene viewed through a virtual reality helmet depicted a walk around a college campus. Results from participants who used the virtual headset showed various psychological benefits when paired with actual exercise. Specifically, participants from both the exercise alone and exercise with virtual reality groups experienced more energy immediately after exercise than participants who viewed the virtual reality video without exercise. The participants in the exercise and virtual reality condition experienced the lowest levels of tiredness in comparison to the other groups. Overall, the study suggests that the combination of virtual reality and exercise might improve some of the positive psychological effects of exercise compared with simply virtual reality or exercise alone.

Tension experienced by some subjects in this and several other studies may be due to an uncomfortable feeling caused by the novel virtual helmet. Individuals who have a high susceptibility to motion sickness may experience more discomfort than others when in a virtual environment. Although the possibility exists for motion sickness and discomfort due to some virtual reality equipment, the potential benefits from virtual reality preserves the importance of continued research in this area. The following study used a flat-screen virtual reality system without a headset to decrease the possible occurrence of motion sickness or discomfort. Other advantages of using a flat screen virtual environment compared with a virtual reality helmet include much lower costs and freedom of motion for exercisers. Because past research has demonstrated the beneficial effects of exercise, we hypothesize similar results with use of virtual reality paired with exercise compared with exercise or virtual reality alone. We further suggest that exercise outdoors may provide a different psychological benefit than exercise indoors further demonstrating the environmental influences associated with any psychological and stress-reducing benefits of exercise.

METHOD

Participants

A sample of 112 introductory psychology students (47 male and 65 female) participated in this study.

Measures

Activation–Deactivation Adjective Check List

The Activation–Deactivation Adjective Check List (AD–ACL) (Thayer, 1986) is a brief and frequently used self-report checklist designed to measure momentary mood states including, energy, calmness, tension, and tiredness. Each adjective is scored on a 4-point Likert scale reflecting the degree to which the respondent agrees that the adjective reflects his or her current mood state. Thayer (1986) reported that the AD–ACL has adequate reliability and validity and has been validated and used in a number of psychophysiological and biopsychological investigations involving exercise.

Paces Activity Enjoyment Scale

The Paces Activity Enjoyment Scale (PACES; Kendzierski, Furr, & Schiavoni, 1998) includes 18 bipolar items on which individuals rate themselves on a 7-point Likert scale. The scale measures the amount of enjoyment individuals perceive themselves to have experienced during an exercise activity. Motl et al. (2001) found PACES to be a reliable measure of physical activity enjoyment and concluded that the scale had both factorial and construct validity.

Marlowe Crowne Social Desirability Scale

The Marlowe Crowne Social Desirability Scale (MC–SDS) is designed to measure social desirability or defensiveness and consists of 33 true–false statements (Crowne & Marlowe, 1960). Items are scored using 1 point for each true or false item endorsed in the direction of social desirability or defensiveness. The MC–SDS has been found to maintain adequate internal consistency ($K-R\ 21 = 0.75$) and construct validity (Strahan & Gerbasi, 1972).

Procedure

Participants volunteered for this experiment to fulfill a research participation requirement for their general psychology undergraduate classes. Each participant attended a 30-min orientation meeting during which they were informed about the details of the study and then completed a consent form

and several questionnaires. At the end of the orientation session, participants were scheduled to attend a laboratory session on a different day. The research assistants informed the participants of the meeting place and proper exercise attire to wear and asked them to refrain from exercise on the day of their laboratory session. Participants who reported to have engaged in any form of exercise, other than walking, on the day of their laboratory session were excluded from data analyses.

Once in the laboratory, participants were asked to complete the AD-ACL Short Form questionnaire, which measured state energy, tiredness, calmness, and tension. Participants were then randomly assigned to one of three conditions. The first condition included a 20-min brisk outdoor walk. The experiment was conducted in northern California during the fall. Thus, weather conditions were fairly constant, and no participant was asked to walk in cold or rainy weather or at night. In this condition, participants were given a map of the predetermined route around campus and asked to complete the walk in approximately 20 min. To achieve this goal, participants needed to walk about 4.8 kph. After the walking session concluded, the participant again completed the AD-ACL Short Form and PACES.

Condition 2 combined virtual reality with walking on a laboratory treadmill (Quniton Q50 series 90). The video, recorded by a professional cameraman on a sunny day, was designed to follow the same route around campus that walkers in Condition 1 completed. The video was projected onto a 1.8 m $\times$ 1.8 m flat-screen placed 2.2 m directly in front of the treadmill. Two office partitions were placed on either side of the treadmill to prevent the participant's eyes from wandering to other areas of the laboratory area.

The researcher instructed the participants to stand on the treadmill and hold onto the treadmill safety bar. Then the research assistant started the treadmill, and the participants commenced walking. The virtual reality video was then turned on, and the participants went on a virtual walk around campus. The participants walked in this condition for 20 min at a brisk walking pace adjusted for height differences. The speeds ranged between 4.3–5.6 kph, 4.3 kph for the shorter participants, and up to 5.6 kph for the taller participants, enabling each participant to experience similar physical exertion. After the condition was completed, the participants completed the AD-ACL Short Form and PACES.

The third condition was a virtual reality without exercise condition. The same video and 1.8 m $\times$ 1.8 m screen that were used in Condition 2 was used for this condition. As in the previous two conditions, the participants completed the AD-ACL Short Form. The participants then sat in a soft chair in the laboratory placed directly in front of the treadmill used in Condition 2. All participants sat in the same chair in the same place in the laboratory. The experimenter then started the virtual reality video, and participants experi-

enced a virtual walk for 20 min. After the session ended, participants completed the AD-ACL Short Form and PACES.

RESULTS

Data from 112 (47 male and 65 female) participants were included in the analyses. However, three participants were not included in several analyses because of missing data on relevant variables. Means and standard deviations for enjoyment of the experiment experience, and social desirability are provided in Table 1 by gender and experimental condition. Means and standard deviations for energy, tension, calmness, and tiredness (pre- and postexperimental conditions) are provided in Table 2.

Baseline Differences

To examine potential preexperimental condition baseline differences in mood and social desirability, a series of 2 (Gender) $\times$ 3 (Experimental Condition) between-subjects analyses of variance were conducted. This method was used to examine potential significant differences between groups before the implementation of the experimental conditions. No baseline differences in tension, energy, or tiredness were found between groups (all $ps > .05$). However, a significant gender difference was found on calmness such that male participants reported being more calm than female participants, $F(1, 109) = 4.22, p < .05$. No significant group differences existed for social desirability.

Table 1. Means and Standard Deviations for Body Mass Index (BMI), Baseline Heart Rate, Experiment Enjoyment, and Social Desirability by Experimental Condition and Gender

Condition	Female		Male	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Exercise outside				
Experiment Enjoyment	93.88	14.37	78.70	22.83
Social Desirability	13.81	5.17	15.63	5.62
Exercise with virtual reality				
Experiment Enjoyment	63.55	14.12	78.60	21.75
Social Desirability	14.37	5.96	13.85	4.47
Virtual reality only				
Experiment Enjoyment	55.25	21.20	61.38	11.31
Social Desirability	12.67	5.63	13.93	4.38

Table 2. Means and Standard Deviations for Energy, Tension, Calmness, and Tiredness by Experimental Condition and Gender

Condition	Female		Male	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Exercise outside				
Energy 1	11.08	2.90	11.59	2.96
Energy 2	13.68	3.62	12.35	4.29
Tension 1	8.79	2.92	8.88	2.47
Tension 2	8.59	2.38	8.24	2.75
Calmness 1	11.58	2.43	12.12	2.42
Calmness 2	10.64	2.42	10.88	2.50
Tiredness 1	7.00	2.36	8.35	2.34
Tiredness 2	5.55	2.56	6.41	1.84
Exercise with virtual reality				
Energy 1	9.65	3.05	11.33	3.15
Energy 2	9.90	3.11	12.07	2.37
Tension 1	8.05	2.93	7.60	1.84
Tension 2	6.00	1.45	6.53	1.51
Calmness 1	10.90	2.51	12.13	2.26
Calmness 2	12.90	2.69	11.20	2.98
Tiredness 1	8.25	2.45	7.80	1.93
Tiredness 2	8.30	2.72	5.53	2.64
Virtual reality only				
Energy 1	10.30	3.15	11.07	3.63
Energy 2	6.85	2.06	9.87	3.29
Tension 1	8.15	2.46	7.60	2.44
Tension 2	7.55	2.42	8.73	3.83
Calmness 1	10.65	1.35	11.47	1.77
Calmness 2	12.70	2.36	11.93	1.98
Tiredness 1	7.45	2.84	7.07	2.84
Tiredness 2	9.95	2.44	7.80	2.31

Experimental Condition Differences

Within-Subjects Analyses

A series of paired sample *t* tests (baseline mood – mood following experimental condition) were used to measure changes in mood following the experimental condition for both genders within each experimental condition. Among all participants, from baseline to posttest, there was no significant difference in energy, calmness, or tiredness. However, there was a significant difference for tension such that participants as a whole were less tense following the experimental conditions, $t(110) = 2.48, p < .05$.

Between-Subjects Analyses

A series of 2 (Gender) $\times$ 3 (Experimental Condition) analyses of covariance were performed on self-reported experiment enjoyment following

the experimental conditions. Whenever significant differences were found they were followed by Tukey post hoc analyses to detect where the significant differences occurred.

PACES. Results from the PACES questionnaire demonstrated a significant condition effect, $F(2, 110) = 21.65, p < .001$, and Gender $\times$ Condition interaction effect, $F(2, 110) = 6.60, p < .001$. Post hoc tests indicate that Condition 1 (exercise outside) was reported to be the most enjoyable of the three experimental experiences and Condition 3 (virtual reality only) was reported to be the least enjoyable, especially for female participants ($ps < .05$). However, effect size analyses conducted on PACES scores revealed rather small effects ($ds < 2.22$).

A series of 2 (Gender) $\times$ 3 (Experimental Condition) analyses of covariance were performed on mood levels directly following the experimental conditions. Baseline mood scores and social desirability were used as covariates in all analyses. The analyses were conducted a second time using enjoyment as a covariate. Whenever significant effects were found, they were followed by Tukey post hoc analyses to detect where the significant differences occurred.

Energy. A significant condition main effect for energy occurred, $F(2, 112) = 21.99, p < .001$. Furthermore, a significant Gender $\times$ Condition interaction effect for energy was found as well, $F(2, 112) = 6.13, p < .01$. Post hoc analyses indicated that more energy was experienced while the participants exercised outside and the least energy was reported when they watched the video only ($p < .05$). These findings were especially true for female participants. When self-reported experimental enjoyment was used as a covariate, the significant condition main effect, $F(2, 111) = 18.45, p < .001$, and Gender $\times$ Condition interaction effect were maintained, $F(2, 111) = 4.75, p < .05$. However, effect size analyses conducted on energy scores revealed rather small effects ($ds < 2.50$).

Tension. A significant condition main effect was found where Condition 2 (exercise with virtual reality video) resulted in the most relaxed scores, $F(2, 111) = 7.62, p < .001$. Furthermore, no significant gender main effects or condition interaction surfaced. When self-reported experimental enjoyment was used as a covariate, the significant condition main effect remained, $F(2, 110) = 8.71, p < .001$. However, effect size analyses conducted on tension scores revealed minimal effects ($ds < 1.20$).

Calmness. A significant gender main effect, $F(1, 110) = 4.27, p < .05$, and condition main effect, $F(2, 110) = 5.16, p < .01$, emerged for calmness. No significant results for calmness were found for Gender $\times$ Condition interaction. Post hoc tests suggest that female participants were calmer than male participants in general. However, those participants in Condition 1 (exercise outside) were the least calm ($p < .05$). After using experimental enjoyment as a covariate, the significant gender main effect, $F(1, 109) =$

3.89, $p = .05$, and condition main effect, $F(2, 109) = 3.34$, $p < .05$, remained. Again, no significant results for calmness were found for Gender $\times$ Condition interaction. Effect size analyses conducted on calmness scores revealed minimal effects ($ds < 1.12$).

Tiredness. No significant results appeared either as main effects or interactions on tiredness. However, after self-reported experimental enjoyment was used as a covariate, a significant gender main effect, $F(1, 111) = 7.94$, $p < .05$, emerged such that female participants were more tired than male participants following the experimental conditions. In addition, a significant condition main effect, $F(2, 111) = 15.19$, $p < .001$, surfaced such that participants in Condition 3 (virtual reality only) were the most tired and those in Condition 1 (exercise outside) were the least tired. Finally, a Gender $\times$ Condition interaction, $F(2, 111) = 3.24$, $p < .05$, was found such that female participants were especially tired after watching the virtual reality video. Effect size analyses conducted on tiredness revealed very small effects ($ds < 1.76$).

DISCUSSION

The purpose of this experiment was to investigate the role of virtual reality on the psychological benefits of aerobic exercise. It was predicted that when virtual reality was paired with actual exercise, it would positively influence the mood benefits of exercise. Virtual reality alone was used to determine whether it could produce mood-enhancing changes similar to those with exercise. Our results suggest some support for our hypotheses as virtual reality did boost positive mood benefits when paired with actual exercise in certain conditions. In addition, our results suggest that exercising indoors and outdoors produces different psychological benefits.

Our results among both genders suggest that increased energy levels are more likely to occur with actual exercise than with virtual reality alone. These findings were especially true for female participants such that they reported feeling more energy than male participants following exercise outside. Our results did not indicate that virtual reality alone increases energy; however when exercise was combined with virtual reality, energy levels increased. This finding may suggest that the mood benefits of virtual reality are enhanced by exercise. Overall, the results provide some evidence for virtual reality benefits that can be applied to the exercise experience. These results support previous findings by Plante et al. (2003) using a virtual reality headset.

Our findings also suggest that exercising outside was the most enjoyable experimental condition and watching the virtual reality video alone was the

least enjoyable. These findings were especially true for female participants. It is interesting that enjoyment of the experimental condition did not affect any of the mood scores except tiredness. When enjoyment was used as a covariate, our findings suggest that exercise outside resulted in less tiredness.

As mentioned earlier, the exercise environment contributes to psychological benefits of exercise by affecting well-being, confidence, enjoyment, mood, and self-efficacy (e.g., McAuley et al., 2000; Plante et al., 2001). Our findings demonstrate that an outdoor exercise environment might be more enjoyable and energizing but not necessarily relaxing. This effect was especially true for female participants and may suggest that the surrounding environment may impact the mood and energy level of individuals and that females may be most susceptible to these environmental influences. Because being outdoors creates a more scenic experience and provides fresh air and the sights, sounds, and smells of the outdoors, exercise may be more revitalizing. Also, exercising outside may encourage an individual to be more cautious and alert to their surroundings for safety reasons, thus providing more stimulation. Our results also demonstrated that indoor exercise was likely to be more relaxing, again more so for female participants. An indoor environment may prove to be more calming because it is an enclosed and secure area, and there are minimal distractions. Furthermore, our findings suggest that an individual's decision to work out indoors or outdoors could be influenced by whether he or she is attempting to relax or energize. For example, one may choose to run outside in the morning to increase energy levels or choose to run indoors in the evening to wind down and decrease tension before bed.

Results must be viewed cautiously in light of several important factors. First, the small sample size, comprising more women than men, may have affected the outcome of this study. Second, participants were drawn from a homogenous population of healthy undergraduate students from northern California. Thus, many other segments of society as well as clinical populations should be investigated to determine possible benefits of virtual reality exercise. Finally, the use of a flat-screen virtual system placed in front of the treadmill may have resulted in a less realistic feel than may have been achieved using other technologies, such as three-dimensional virtual reality headgear. However, the lower costs, ease of motion, and lower risk of motion sickness using a flat-screen system might be more useful and practical than the use of virtual reality headgear. Finally, effect size analyses revealed rather small and sometimes minimal effects, and thus our findings, although significant, are not as large as hoped for.

Future researchers should incorporate better virtual reality technologies to enhance participants' experiences through a more realistic environment with increased ergonomic and tracking features. Additional means of measuring the effects of virtual reality exercise on mood would also be beneficial.

Finally, our study may have been limited by the use of only three experimental conditions. Future researchers should include additional conditions to determine more specifically which features of virtual reality exercise contribute to changes in mood, and how an indoor or an outdoor environment influences those features.

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