# Does Virtual Reality Enhance the Psychological Benefits of Exercise?

Thomas G. Plante [1,2], Sharon Frazier [1], Anna Tittle [1], Mark Babula [1], Elizabeth Ferlic [1], and Esther Riggs [1]

Santa Clara University

[1] Department of Psychology, 500 El Camino Real, Santa Clara University, Santa Clara, California 95053-0333. Telephone (408) 554-4471, Fax (408) 554-5241. E-mail: TPLANTE@SCU.EDU.

[2] Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine

## Abstract

The purpose of the present study was to investigate if virtual reality technology might enhance the psychological benefits of aerobic exercise in a laboratory setting. In this study, 121 college students (72 females, 49 males) were randomly assigned to one of four 30-minute bicycle experimental or control conditions (i.e., exercise alone, exercise with virtual reality technology, virtual reality without exercise, and a control videotape condition watching someone bicycle). The Activation-Deactivation Adjective Check List (AD-ACL) measuring energy, tiredness, tension, and calmness was administered immediately before and after each experimental or control condition as well as administered prior to bedtime. Our results suggest that virtual reality may enhance the energy and tiredness levels of females hours after the completion of the exercise and virtual reality experience but not for males. To our knowledge, this represents the first empirical study to investigate virtual reality and the psychological benefits of exercise.


KEYWORDS: Exercise, virtual reality, psychological benefits, coping

## Introduction

Exercise enhances physical health including lowering risks of developing cancer, cardiovascular disease, and other illnesses (Blair, Kohl, Paffenbarger, Clark, Cooper, & Gibbons, 1989; Brill, Kohl, & Blair, 1992; Kampert, Blair, Barlow, & Kohl, 1996; Gauvin & Spence, 1995; Plante, 1996). Research consistently demonstrates that physical exercise is associated with a number of psychological benefits as well, including improvement in mood and the ability to cope with stress (Byrne & Byrne, 1993; Gauvin & Spence, 1995; Plante & Rodin, 1990; Thirlaway & Benton, 1992). A growing body of evidence advocates the use of physical exercise to improve both physical and psychological well being (Blair & Connely, 1996; Winett & Carpinelli, 2000).

While the benefits of exercise are numerous, questions remain regarding how and why exercise enhances psychological health. No one clear answer has emerged, but theories abound. Biological explanations posit that exercise increases body temperature, adrenal and steroid activity, and stimulates the release of specific neurotransmitters such as endorphins (Hughs, 1984; Michael, 1957; Von Euler & Soderberg, 1956, 1957; Ransford, 1982). Psychological approaches suggest that exercise serves as a distraction (Long, 1983), meditation (Buffone, 1980), biofeedback (Schwartz, Davidson & Coleman, 1978), or psychological buffer (Kobasa, Maddi, & Puccetti, 1982), and can result in an increased sense of self-efficacy, mastery, and control (Bandura, 1977; Marcus, Selby, Niaura, & Rossi, 1992). Another theory suggests that our perception of fitness plays a larger role in producing the psychological benefits of exercise than is generally assumed. Because we perceive fitness or exercise as beneficial, the psychological outcome of our exercise experience is enhanced (Folkins & Sime, 1981; Plante, 1999; Plante, Coscarelli, Caputo, & Oppezzo, 2000).

Just as relief is often experienced within moments of taking an aspirin, when in reality, the medication has yet to impact the body, it is the anticipation and expectation of pain relief that promotes an almost immediate positive effect. Therefore, it is reasonable to predict that possessing positive beliefs and expectations about exercise might result in a better psychological outcome associated with exercise behavior. In a recent study by Plante et al (2000), perceived physical fitness was a better predicator of psychological wellness than either actual fitness (measured by $VO_{2max}$) or physical activity as measured by ambulatory activity monitors among 130 university staff, faculty, and students. Another study by Plante and colleagues found that those with a high perception of physical fitness and low actual aerobic fitness were least affected by stressful laboratory tasks as determined by systolic blood pressure among 90 college students (Plante, Chizmar, & Owen 1999). Thus, beliefs and expectations about the benefits of exercise many account for many of the exercise benefits regardless of actual physical fitness obtained or exercise behavior engaged in.

Related research also suggests that perception of health may be more predictive of positive health outcomes than actual health. Kaplan and Camacho (1983) examined a nine-year follow up of 6,982 adults in Alameda County, California. Perceived health was found to be an independent predictor of mortality during multiple logistic analyses while controlling for sex, age, physical health status, health practices, income, education, social network participation, health relative to age-peers, morale, happiness and depression. In studies conducted by Idler and colleagues results showed that regardless of actual health, elderly persons who perceived their health as good lived longer than those who perceived their health as poor (Idler & Angel, 1990; Idler & Kasl, 1991). Because it has been demonstrated that perceived health may be a better predictor of longevity than actual health, it is reasonable to suggest that perceived fitness may be a better predictor of psychological health than actual physical fitness or activity (Plante, 1999).

Human perceptions have proven to be powerful in affecting both physical and psychological health and well being. While past research clearly demonstrates that physical and psychological health is improved through health enhancing behaviors such as exercise (Blair et al. 1989; Brill et al. 1992; Plante & Rodin, 1990, Plante, 1999), more recent investigations demonstrate that health is also enhanced through positive perceptions of health and benefits about fitness (Idler & Ange 1990; Idler & Kasl 1991; Shephard & Bouchard 1994). The results of these and other investigations have proven so compelling that perception and beliefs, for example, must be assessed and controlled for by including placebo conditions in medical and psychiatric research protocols. With the knowledge that perception can positively affect health and well being, additional means of altering perception are being investigated. Technology currently offers one of the most promising avenues of exploration in this area.

Virtual reality, technology's answer to an alternate state of consciousness, has proven useful in enhancing psychological health by altering perception and their resulting behaviors. Specifically, virtual reality exposure therapy has been effective in treating individuals with various types of phobias, including acrophobia, agoraphobia, acrophobia, and social phobia (e.g., North, North & Coble, 1998; Rothbaum, Hodges, Kooper, Opdyke, Williford & North, 1995; Wiederhold, 1999). Rauthbaum and colleagues showed promising support for virtual reality exposure therapy (VRET) as a treatment of acrophobia. Before and after the three-week treatment session, the participant's acrophobia was evaluated on levels of anxiety, avoidance, and distress. At the end of the treatment period, VRET was found to reduce the patient's acrophobia by almost half compared to the control condition. In another study of the treatment of acrophobia, Wiederhold compared virtual reality exposure therapy with imaginal exposure therapy (IET). As indicated by self-report questionnaires, both therapies proved affective in decreasing anxiety after exposure in all of the following areas: attitude towards flying, level of fear of flying, physiological responses to stress, situational and general anxiety, as well as a checklist of different fear scenarios, such as "sitting on a plane, engines off; sitting on a plane engines on," as developed by Rothbaum & Hodges (1997). However, VRET exposure proved much more effective in enabling participants to fly without medication at three-month post treatment follow-up as compared to IET. Ninety percent of the participants who received VRET reported an ability to fly without medication or alcohol, while only 20 percent of the IET group reported this improvement. Virtual reality finds strong support here as a new medium for exposure therapy. The rapidly expanding field of virtual reality treatment present alternative means of achieving improved psychological well being.

Because perception plays such an important role in affecting our physical and mental health, and virtual reality appears to be a successful means of manipulating these perceptions, it is reasonable to assume that virtual reality might have an important influence on the psychological effects of health behaviors such as exercise. Just as virtual exposure therapy aid in the treatment of phobias, perhaps virtual exercise might produce benefits similar to actual exercise regarding psychological health outcomes such as mood.

The purpose of the present study was to investigate the effect of virtual reality exercise on psychological aspects of mood such as tension, calmness, energy, and tiredness. We predicted that the virtual exercise experience would enhance the psychological effects of physical exercise.

## Method

### Participants

A sample of 121 undergraduate university students (72 females and 49 males), ranging in age from 17 to 27 years (M=18.58, SD= 1.12), were recruited from introductory psychology classes. Participants reported no injuries, illnesses, or physical disabilities and were provided course credit for their participation. Since 80% of psychology students are female we had fewer men than women participate in this experiment.

All participants were asked to abstain from exercise on the day of their participation in the study to assure that the results obtained were due to laboratory based rather than field based exercise.

Measures

Marlowe Crowne Social Desirability Scale (MC- SDS; Crowne & Marlowe, 1960). This scale is designed to measure social desirability or defensiveness and consists of 33 true-false statements (Crowne & Marlowe, 1960). The Marlowe Crowne SDS has been found to maintain adequate internal consistency (KR-21=.75) and construct validity (Crowne & Marlowe, 1960; Strahan & Gerbasi, 1972).

Activation-Deactivation Adjective Check List (AD-ACL; Thayer, 1967, 1978, 1986). The AD-ACL is a brief and frequently used self-report checklist designed to measure momentary mood states. Thayer (1978, 1986) reports 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.

Perceived Exertion Scale (PES; Borg, 1982). The PES Scale was used to evaluate the participant's perceived level of exertion where 6=very light exertion and 20=very hard exertion. The PES is frequently used in exercise research and has adequate reliability and validity (Borg, 1982).

Procedure

In order to inform participants about the procedures of the study and obtain informed consent, students were invited to an orientation session prior to their laboratory participation. All participants were told about the study, had their questions answered, signed a consent form, and were asked to complete several questionnaires. Following the orientation meeting, participants then signed up for a laboratory session with a female research assistant. The day prior to their scheduled laboratory session, the research assistant called the participants to confirm their appointment, remind them about proper exercise attire, and asked that they abstain from exercise prior to the laboratory session. All contact with the participants by telephone was scripted to minimize potential experimenter influence.

Participants were randomly assigned to one of the four 30 minute experimental conditions. The first included a control condition that did not involve either exercise or virtual reality. This condition involved watching a video simulating a biking experience (condition #1). The second condition involved engaging in a mountain biking virtual reality video game (Trek Extreme Mountain Biking, Head Games Publishing Company, 1999) on a computer (condition #2). The third condition involved riding a stationary exercise bike alone without any virtual reality involvement (condition #3). The fourth condition involved riding a stationary exercise bike while engaged in an interactive virtual reality (Cycle Fx, Model ITS-1, 2000 Cycle Fx) biking experience (condition #4). Prior to the presentation of one of the four laboratory experiences, participants completed a questionnaire assessing their levels of calmness, tension, tiredness and energy using the AD-ACL.

Participants in condition 1 were seated in a chair and were instructed to watch a video for 30 minutes while a heart rate monitor was clipped to their ear. Participants in condition 2 were briefly oriented (shown how to use the computer mouse) to a mountain biking virtual reality video game by the research assistant. The participants completed 5 different downhill courses and then proceeded to the single-track courses for the remainder of the time. Prior to operating the virtual reality video game, participants were seated in front of a computer and a heart rate monitor was attached to their earlobe. The participants' heart rate was measured every five minutes. Participants in conditions 3 and 4 were instructed to get on an exercise bike and were then attached to a heart rate monitor that clipped to their earlobe. Participants in condition 4 were told that they had the option of racing or simply joining the other bikers within their interactive virtual experience presented on a 17 inch computer screen in front of them. The heart rate monitor continually assessed participants' heart rates and those in the 2 exercise conditions were instructed to stay within a heart beat range of 120 to150 bpm to maintain a moderate level of exercise intensity (i.e., 60-70% maximum heart rate). They were also asked to evaluate their level of exertion on a scale of 6-20 after every 5-minute interval during the 30-minute exercise period. Partitions were placed on each side of the stationary bike in order to enhance the participants' focus.

Participants were then instructed to ride the exercise bike for the duration of 30 minutes, with the first five minutes being a warm up and the last five minutes a cool down period. After 30 minutes within either randomly assigned condition participants completed the AD-ACL again that measured tension, calmness, energy, and tiredness. They were given the same questionnaire to take home and complete later that day before bed. Participants were instructed to return the completed questionnaire to a drop box in the psychology department the following day.

## Results

One hundred and twenty one participants were included in the data analysis (72 females, 49 males). Means and standard deviations for age, experimental condition heart rate, and social desirability by experimental condition and gender are shown in Table 1. AD-ACL mood scores (i.e., energy, tired, tension, calmness) assessed before and after exercise participation by experimental condition are presented in Table 2. Pearson product-moment correlation coefficients were calculated among salient variables and are reported in Table 3. Significant correlations are noted in the table.

As a manipulation check, a series of within subject repeated measure analysis of variance (ANCOVA) procedures were conducted to ensure that participants generally felt better after exercise or virtual reality experiences than before the experimental conditions relative to the control condition. Social desirability was used in the analyses as a covariate since the mood measures were based on self report. Participants generally experienced more self reported energy and calmness and less tiredness and tension as reported by AD-ACL mood scores following the experimental conditions than before the experimental experience relative to the control condition (all $p$'s $< .05$). Thus, both exercise and virtual exercise appeared to have an immediate positive impact on energy, calmness, tired, and tension scores.

A second manipulation check was performed on the heart rate measures to insure that heart rates were higher in the two exercise conditions relative to the no exercise conditions. The manipulation check was also performed to be sure that heart rates for males and females did not differ in any of the experimental conditions. An ANOVA procedure was conducted using a 4 (exercise and/or virtual reality condition) X 2 (gender) research design. A significant between subject condition main effect surfaced ($F$ (3, 125) = 317.99, $p < .001$) such that those in the two exercise conditions experienced significantly higher heart rate scores (means = 141.41for the exercise alone group and 149.06 for the exercise with virtual reality group) than the control video condition (mean heart rate = 74.86) or virtual reality without exercise group (mean heart rate = 78.29). No significant gender main effects or gender by condition interaction effects emerged ($p$'s > .05).

A series of 4 (exercise and/or virtual reality condition) by 2 (gender) ANCOVAs with repeated measures were conducted on the AD-ACL mood measures. Scores obtained immediately before and after the experimental or control procedure, as well as before bed were used in the repeated measures procedure.

While examining the AD-ACL energy scores, the ANCOVA procedure with repeated measures revealed significant between subject main effects and interactions. Thus, energy scores differed based on exercise/virtual reality group assignment and gender. A significant exercise group/virtual reality main effect surfaced [$F(3,112) = 4.29$, $p < .05$] as well as a significant gender by exercise/virtual reality group interaction effect [$F(3,112) = 2.88$, $p < .05$]. Paired comparison post hoc analysis revealed that those who experienced any of the three experimental conditions reported more energy after the laboratory experience relative to the control condition. Females experienced more energy after the two exercise conditions (with or without virtual reality) and experienced greater energy at bedtime in the exercise with virtual reality condition relative to the other three conditions. Males experienced more energy equally in the three exercise or virtual reality conditions relative to the control condition.

While examining the AD-ACL tired scores, the ANCOVA procedure with repeated measures revealed significant between subject interaction effect differences. Thus, a significant exercise/virtual reality group by gender interaction effect surfaced [$F$ (3,112) = 3.32, $p < .05$].

Paired comparison post hoc analyses revealed that females experienced less tiredness after the two exercise conditions (with or without virtual reality) and experienced less tiredness at bedtime in the exercise with virtual reality condition. Males experienced less tiredness in both of the exercise conditions (with or without virtual reality) relative to the virtual reality without exercise and control conditions immediately after exercise and experienced equal degrees of tiredness at bedtime regardless of group assignment. An exercise/virtual reality main effect trend ($p = .10$) surfaced such that participants in either exercise condition (with or without virtual reality) experienced less tiredness than those in either the control or virtual reality without exercise condition.

Gender main effects were found while examining both the tension [$F(1,112) = 4.48$, $p < .05$] and calmness [$F(1,112) = 6.67$, $p < .05$] dependent measures such that males reported less tension and more calmness throughout the laboratory sessions than females. No exercise/virtual reality condition main effects or interactions surfaced while examining either the tension or calmness scores (all $p$'s > .05).

## Discussion

The purpose of the present study was to investigate the effect of virtual reality exercise on psychological aspects of mood such as tension, calmness, energy, and tiredness. We predicted that the virtual exercise experience would enhance the psychological effects of physical exercise. Our results suggest some support for our hypothesis.

Females experienced more energy and less tiredness after the two exercise conditions (with or without virtual reality) and experienced greater energy and less tiredness at bedtime in the exercise with virtual reality condition relative to the other three conditions. Males experienced more energy equally in the three exercise or virtual reality conditions relative to the control condition. Thus, our results suggest that virtual reality may enhance the energy and tiredness levels of females hours after the completion of the exercise and virtual reality experience but not for males. Relative to exercise alone, adding virtual reality to the exercise experience results in more energy and less tiredness for females at bedtime. Males experienced less tiredness in both of the exercise conditions (with or without virtual reality) relative to the virtual reality without exercise and control conditions immediately after exercise and experienced equal degrees of tiredness at bedtime regardless of group assignment. Thus, virtual reality did not appear to enhance the psychological benefits for males. Males also reported less tension and more calmness throughout the laboratory sessions than females.

Virtual reality seemed to particularly enhance some of the more sustained psychological reducing benefits of exercise (i.e., energy and tiredness) for female participants. Perhaps females were inspired by the exercise with virtual reality condition to exercise harder or to feel more engaged in the experience. This heightened level of exertion, attention, or interest could explain the sustained psychological effects present for females at bedtime. This is speculative since exertion, interest, and enjoyment were not measured in this study. Heart rate scores, however, did not differ between males and females in the experimental conditions and thus whatever exertion differences may have existed they couldn’t have been too significant. The exercise conditions (with and without virtual reality) clearly had some effect on males in that they were more energized directly after the experimental procedures relative to the control condition. However, this represented merely a short-term elevation in energy; the exercise with virtual reality condition did not result in more energy at bedtime than did the exercise without virtual reality condition for males.

There are several possible explanations for the discrepancy in the results with respect to gender. Females may have experienced enhanced psychological benefits in the exercise with virtual reality condition based upon the subjective novelty of the virtual reality stimuli. Males, in general, tend to play more video games and to expose themselves to virtually enhanced computer games relative to females (McClure & Mears, 1984). Males may be more habituated to virtual reality and high-tech graphics stimulation (Cowan, Frederick, Rainey, Levin, Bang, Hennen, Lukas, & Renshaw, 2000). It just so happens that the habitual virtual equipment and video game users tend to be male, and the non-users female (McClure & Mears, 1984). The graphics and sophistication of the virtual reality software used in this study may not have been novel or advanced enough to fully capture the attention or interest of the males and thus impact the mood results. It is possible that the males may require more compelling stimuli to exhibit virtual reality's sustained enhancement of the psychological benefits of exercise. Females were perhaps more attentive to and affected by the virtual reality software because they may have had less exposure to similar software. Of course, this is also speculative since we did not assess interest and comfort with virtual reality or computer technology in this study.

In general, males reported less tension and more calmness throughout the laboratory sessions than did females. It is believed that females, overall, admit to vulnerability more than men do (Goldsmith & Flynn, 2000). This could explain why females reported higher levels of tension and lower levels of calmness in the laboratory setting than men. However, our results included statistically controlling for social desirability to adjust for the potential presentation bias phenomenon. Another possibility is that females experience more discomfort about exercise as related to higher body image anxiety than do males. Exercise forces one to become aware of the movements, shape, form, and workings of the body. More females than males have anxiety about their body shape and image and the prospect of exercise in a laboratory may bring to the surface and accentuate these concerns (Rodin, 1996).

Results suggest that augmenting an exercise experience with virtual reality may enhance the psychological benefits of exercise, but may do so differently for males and females. Females in particular obtained better psychological effects associated with exercise if virtual reality was added to the exercise experience. Females were less tired and more energetic immediately after the two exercise conditions, and had more energy and less tiredness at bedtime in the exercise with virtual reality condition. Males were more energized directly after engaging in the two exercise conditions (with or without virtual reality) but this effect did not carry over to bedtime. Thus, females experienced a more lasting enhancement of the psychological benefits of exercise when virtual reality was added to the exercise experience.

Our results must be viewed cautiously due to several reasons. First, we used college students as research participants who are generally homogeneous regarding age, health status, fitness levels, comfort with computers, and so forth. Second, encouraging results supporting our hypothesis were found on 2 of the 4 dependent measures (i.e., energy and tiredness). Results using the tension and calmness dependent measures did not support our hypothesis for either gender. Third, while the virtual reality experience was state-of-the-art, it may have not been compelling enough to fully engage the participants (especially males who might be sophisticated with computer game technology).

Future studies should incorporate a larger and more heterogeneous sample. It might be beneficial to include a survey that asks the participant to evaluate how many hours per week he/she spends playing with virtually enhanced software or video games. From this information, participants could be rated as either “habitual virtual equipment users” or “infrequent virtual equipment users." More technologically advanced virtual reality equipment could be utilized in future studies, once the technologies are developed, to assure that even "habitual virtual equipment users" are captivated by the experience.

Human perceptions can strongly influence physical and psychological health and well being. Health may be enhanced through positive perceptions of health and benefits of exercise (Idler & Ange, 1990; Idler & Kasl, 1991; Shephard & Bouchard, 1994). Virtual reality, one of technology's contributions to altering human perceptions, has proven useful in enhancing psychological health through altering one's perceptions and resulting behaviors (North et al., 1998; Rothbaum et al., 1995). Because perception can significantly alter our physical and mental health, and virtual reality appears to successfully manipulate these perceptions, it is possible to suggest that virtual reality might have an important effect on the benefits of exercise. Furthermore, if virtual reality enhances the exercise experience it might help those who are unable to exercise due to injury, disability, or inclement weather. It may be possible to obtain psychological benefits from virtual exercise with or even without actual exercise. To our knowledge, this study represents the first virtual reality exercise and psychological benefit investigation conducted. Further research will hopefully better address these compelling issues.

References

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84, 191-215.

Blair, S. N., & Connelly, J. C. (1996). How much physical activity should we do? The case for moderate amounts and intensities of physical activity. Research Quarterly for Exercise and Sport, 67, 193-205.

Blair, S. N., Kohl, H. W., Paffenbarger, R. S., Clark, D. G., Cooper, K. H., & Gibbons, L. W. (1989). Physical fitness and all-cause mortality. A prospective study of healthy men and women. Journal of the American Medical Association, 262, 2394-2401.

Borg, G. V. (1982). Psychophysiological bases of perceived exertion. Medical Science in Sports and Exercise, 14, 377-81.

Brill, P. A., Kohl, H. W., & Blair, S. N. (1992). Anxiety, depression, physical fitness, and all-cause mortality in men. Journal of Psychosomatic Research, 36, 267-273.

Buffone, G. W. (1980). Exercise as therapy: A closer look. Journal of Counseling and Psychotherapy, 3, 101-115.

Byrne, A., & Byrne, D. G. (1993). The effect of exercise on depression, anxiety, and other mood states: A review. Journal of Psychosomatic Research, 37, 565-574.

Cowan, R. L., Frederick, B., Rainey, M., Levin, J. M., Bang, J., Hennen, J., Lukas, S. E., & Renshaw, P. F. (2000). Sex differences in response to red and blue light in human primary visual cortex: A bold fMRI study. Psychiatry Research: Neuroimaging, 100, 129-138.

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. Journal of Counseling Psychology, 24, 349-354.

Folkins, C. H., & Sime, W. E. (1981). Physical fitness and mental health. American Psychologist, 36, 373-389.

Gauvin, L., & Spence, J. C. (1995). Psychological research on exercise and fitness: Current research trends and future challenges. The Sport Psychologist, 9, 434-448.

Goldsmith, R., & Flynn, L. (2000). Gender differences in self-image described by Malhotra's Self-Concept Scale. Psychological Reports, 86, 1213-1217.

Hughes, J. R. (1984). Psychological effects of habitual aerobic exercise: A critical review. Preventative Medicine, 13, 66-78.

Idler, E. L., & Angel, R. J. (1990). Self-rated health and mortality in the NHANES-I epidemiologic follow-up study. American Journal of Public Health, 80, 446-452.

Idler, E. L., & Kasl, S. (1991). Health perceptions and survival: Do global evaluations of health status really predict mortality? Journal of Gerontology, 46, S55-S65.

Kampert, J. B., Blair, S. N., Barlow, C. E., & Kohl, H. W. (1996). Physical activity, physical fitness, and all-cause and cancer mortality: a prospective study of men and women. Annual Epidemiology 6, 452-457.

Kaplan, G. A., & Camacho, T. (1983). Perceived health and mortality: A nine-year follow-up of the human population laboratory cohort. American Journal of Epidemiology, 117, 292-304.

Kobasa, S. C., Maddi, S. R., & Puccetti, M. C. (1982). Personality and exercise as buffers in the stress-illness relationship. Journal of Behavioral Medicine, 5, 391-404.

Long, B. C. (1983). Aerobic conditioning and stress reduction: Participation or conditioning? Human Movement Science, 2, 171-186.

Marcus, B. H., Selby, V. C., Niaura, R. S., & Rossi, J. S. (1992). Self-efficacy and the stages of exercise behavior change. Research Quarterly for Exercise and Sport, 63, 60-66.

McClure, R., & Mears, G. (1984). Video game players: Personality characteristics and demographic variables. Psychological Reports, 55, 271-276.

Michael, E. D. (1957). Stress adaptation through exercise. Research Quarterly, 28, 50-54.

North, M. M., North, S. M., & Coble, J. R. (1998). Virtual reality therapy: An effective treatment for phobias. In G. Riva and B.K. Wiederhold (Eds.) Virtual Environments in clinical psychology and neuroscience: Methods and techniques in advanced patient-therapist interaction. Studies in Health Technology and Informatics, 58, pp. 112-119. Amsterdam, Netherlands: Antilles IOS Press.

Plante, T. G. (1999). Could the perception of fitness account for many of the mental and physical health benefits of exercise? Advances in Mind-Body Medicine, 15, 291-295.

Plante, T. G. (1996). Does the use of physical exercise in treating psychiatric disorders help? Journal of Psychosocial Nursing and Mental Health Services, 34, 38-43.

Plante, T. G., Chizmar, L., & Owen, D. (1999). The contribution of perceived fitness to physiological and self-reported responses to laboratory stress. International Journal of Stress Management, 6, 5-19.

Plante, T. G., Coscarelli, L., Caputo, D., & Oppezzo, M. (2000). Perceived fitness predicts daily coping better than physical activity or aerobic fitness. International Journal of Stress Management, 7, 181-192.

Plante, T. G., & Rodin, J. (1990). Physical fitness and enhanced psychological health. Current Psychology: Research and Reviews, 9, 3-24.

Ransford, C. P. (1982). A role for amines in the antidepressant effect of exercise: A review.

Medicine and Science in Sports and Exercise, 14, 1-10.

Rodin, J., & Larson, L. (1992). Social factors and the ideal body shape. In K.D. Brownell and J. Rodin (Eds). Eating, bodyweight, and performance in athletes: Disorders of modern society. Pp. 146-158. Philadelphia, PA: Lea and Febiger.

Rothbaum, B. O., Hodges, L. F., & Kooper, R. (1997). Virtual Reality Exposure Therapy. Journal of Psychotherapy Practice and Research, 6, 219-226.

Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., & North, M. (1995). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. American Journal of Psychiatry,152, 626-628.

Schwartz, G. E., Davidson, R. J., & Coleman, D. J. (1978). Patterning of cognitive and somatic processes in the self-regulation of anxiety: Effects of meditation versus exercise. Psychosomatic Medicine, 40, 321-328.

Shepard, R. J., & Bouchard, C. (1994). Population evaluations of health related fitness from perceptions of physical activity and fitness. Canadian Journal of Applied Physiology, 19, 151-173.

Strahan, R., & Gerbasi, K. (1972). Short, homogeneous versions of the Marlowe-Crowne Social Desirability Scale. Journal of Clinical Psychology, 28, 191-193.

Thayer, R.E. (1967). Measurement of activation through self-report. Psychological Reports, 20, 663-678.

Thayer. R.E. (1978). Factor analytic and reliability studies on the Activation-Deactivation Adjective Check List. Psychological Reports, 42, 747-756.

Thayer, R.E. (1986). Activation-Deactivation Adjective Check List: Current overview and structural analysis. Psychological Reports, 58, 607-614.

Thirlaway, K., & Benton, D. (1992). Participation in physical activity and cardiovascular fitness have different effects on mental health and mood. Journal of Psychosomatic Research, 36, 657-665.

Von Euler, C., & Soderberg, U. (1956). The relation between gamma motor activity and electroencephalogram. Experimentia, 12, 278-279.

Von Euler, C., & Soderberg, U. (1957). The influence of hypothalamic thermoceptive structures on the electroencephalogram and gamma motor activity. EEG and Clinical Neurophysiology, 9, 391-408.

Wiederhold, B. K. (1999). A comparison of imaginal exposure and virtual reality exposure for the treatment of fear of flying. Dissertation Abstracts International: Section B: The Sciences and Engineering, 60 (4-B) 1837.

Winett, R. A., & Carpinelli, R. N. (2000). Examining the validity of exercise guidelines for the prevention of all-cause mortality. Annals of Behavioral Medicine, 22, 237-45.

Table 1

Means and Standard Deviations for Age, Social Desirability, and Heart Rates by Experimental Condition and Gender

| | | MALE* | | | | FEMALE | | | |
|---|---|---|---|---|---|---|---|---|---|
| Condition- > | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| N | | 12 | 13 | 14 | 10 | 18 | 18 | 18 | 18 |
| Age | M= | 19.23 | 18.86 | 18.40 | 18.80 | 18.37 | 18.41 | 18.10 | 18.80 |
| | SD= | 2.42 | 0.77 | 0.51 | 1.03 | 0.60 | 0.80 | 0.64 | 1.24 |
| Social Desirability | M= | 16.46 | 14.57 | 14.33 | 14.10 | 16.44 | 15.78 | 15.10 | 15.85 |
| | SD= | 4.74 | 5.71 | 3.99 | 3.41 | 4.63 | 4.73 | 5.97 | 4.37 |
| Heart Rate (bpm) | M= | 74.92 | 75.02 | 139.80 | 151.20 | 74.80 | 80.83 | 142.62 | 147.98 |
| | SD= | 13.15 | 10.09 | 9.98 | 15.43 | 11.01 | 14.47 | 12.45 | 11.28 |

*Key for experimental conditions:

1 = video control 3 = exercise without virtual reality

2 = virtual reality without exercise 4 = exercise with virtual reality

Table 2

AD-ACL Mood Scores Assessed Before the Experimental Condition (Time 1), Directly After The Experimental Condition (Time 2), and Before Bedtime (Time 3)

Time 1

| | | MALE | | | | FEMALE | | | |
|---|---|---|---|---|---|---|---|---|---|
| Scale | Condition- > | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| N | | 12 | 13 | 14 | 10 | 18 | 18 | 18 | 18 |
| Energy | M= | 12.08 | 10.23 | 13.43 | 10.40 | 11.28 | 9.83 | 10.50 | 13.00 |
| | SD= | 2.50 | 3.70 | 2.98 | 2.91 | 3.18 | 4.18 | 4.27 | 2.61 |
| Tiredness | M= | 10.33 | 13.46 | 10.71 | 12.60 | 12.17 | 13.50 | 13.78 | 11.00 |
| | SD= | 3.82 | 4.27 | 3.75 | 3.72 | 3.49 | 4.69 | 3.95 | 3.83 |
| Calmness | M= | 10.83 | 13.23 | 11.00 | 13.3 | 11.28 | 12.11 | 12.67 | 10.89 |
| | SD= | 2.79 | 2.59 | 3.51 | 2.58 | 3.29 | 2.47 | 3.33 | 3.50 |
| Tension | M= | 7.33 | 7.62 | 8.79 | 8.30 | 8.89 | 8.39 | 8.56 | 9.44 |
| | SD= | 1.23 | 1.45 | 2.26 | 2.54 | 3.32 | 3.73 | 3.85 | 3.97 |

Time 2

| | | MALE | | | | FEMALE | | | |
|---|---|---|---|---|---|---|---|---|---|
| Scale | Condition- > | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Energy | M= | 8.58 | 12.54 | 13.21 | 12.70 | 8.22 | 11.83 | 15.33 | 15.89 |
| | SD= | 2.54 | 3.73 | 3.14 | 4.27 | 4.15 | 2.71 | 3.16 | 3.45 |
| Tiredness | M= | 13.17 | 11.85 | 9.71 | 11.50 | 15.28 | 11.67 | 8.83 | 8.37 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SD= | 2.89 | 4.16 | 2.84 | 4.74 | 4.81 | 3.65 | 3.57 | 3.74 |
| Calmness | M= | 13.67 | 11.38 | 11.64 | 10.7 | 12.78 | 9.56 | 9.83 | 9.39 |
| | SD= | 4.01 | 3.62 | 2.84 | 3.68 | 3.61 | 2.62 | 2.09 | 2.64 |
| Tension | M= | 6.42 | 9.00 | 8.21 | 9.70 | 8.83 | 12.50 | 8.39 | 8.89 |
| | SD= | 1.62 | 2.65 | 2.72 | 3.34 | 3.47 | 4.00 | 2.89 | 2.37 |

Time 3

| | | MALE | | | | FEMALE | | | |
|---|---|---|---|---|---|---|---|---|---|
| Scale | Condition- > | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Energy | M= | 9.67 | 9.38 | 10.43 | 9.20 | 10.89 | 10.44 | 8.50 | 12.11 |
| | SD= | 3.03 | 3.07 | 3.65 | 3.22 | 4.11 | 3.97 | 3.75 | 4.64 |
| Tiredness | M= | 14.25 | 15.08 | 14.29 | 15.80 | 14.17 | 13.78 | 15.39 | 11.74 |
| | SD= | 3.96 | 3.52 | 4.65 | 5.18 | 4.71 | 4.68 | 4.45 | 4.90 |
| Calmness | M= | 11.75 | 13.23 | 13.07 | 14.90 | 10.94 | 11.28 | 13.78 | 11.44 |
| | SD= | 4.00 | 3.06 | 3.02 | 2.85 | 2.26 | 3.23 | 3.23 | 2.68 |
| Tension | M= | 6.67 | 7.46 | 7.43 | 8.60 | 8.06 | 8.67 | 7.72 | 8.22 |
| | SD= | 1.83 | 2.03 | 3.00 | 1.90 | 2.73 | 4.06 | 2.76 | 2.44 |

*Key for experimental conditions:

1 = video control

2 = virtual reality without exercise

3 = exercise without virtual reality

4 = exercise with virtual reality