

ABSTRACT

ZEDAKER, J. M. Physiological and psychological responses to self-selected exercise using a virtual reality and nonvirtual reality stepper. MS in Adult Fitness/Cardiac Rehabilitation, December 1997, 64 pp. (J. Porcari).

Health benefits, both physical and mental, result from regular, moderate intensity exercise. The purpose of this investigation was to determine the effects of visual, audio, and interactive external stimuli, provided by a virtual reality (VR) stepper, on ratings of perceived exertion (RPE), self-selected exercise intensity, psychological parameters, and exercise enjoyment when compared to a similar nonvirtual reality (nonVR) stepper. Eight male (age = 25.6 ± 3.8 yr., ht = 174.6 ± 5.5 cm, wt = 76.9 ± 7.0 kg) and 10 female (age = 25.5 ± 5.0 yr., ht = 165.8 ± 6.1 cm, wt = 60.6 ± 6.5 kg) volunteers exercised for 20 minutes at a self-selected pace using the VR or nonVR stepper on separate days, in random order. There were significant ($p \leq .05$) 10% increases in VO_2 (29.8 vs. 32.6 ml/kg/min) and caloric expenditure (10.1 vs. 11.1 Kcal/min) with the VR compared to nonVR condition. There were no significant ($p > .05$) differences in RPE (14.9 vs. 14.6). No significant trends were observed by the psychological evaluations other than the normal exercise response. Follow-up questionnaires indicated a unanimous preference for the VR stepper over the nonVR stepper. It was believed by the investigator that the external stimuli provided by the VR stepper caused the subjects' attentional focus to shift externally which resulted in a higher level of exercise intensity, without the feeling of greater exertion.

PHYSIOLOGICAL AND PSYCHOLOGICAL RESPONSES TO
SELF-SELECTED EXERCISE USING A VIRTUAL REALITY
AND NONVIRTUAL REALITY STEPPER

A MANUSCRIPT STYLE THESIS PRESENTED
TO
THE GRADUATE FACULTY
UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
MASTER OF SCIENCE DEGREE

BY
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DECEMBER 1997

COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

UNIVERSITY OF WISCONSIN - LA CROSSE

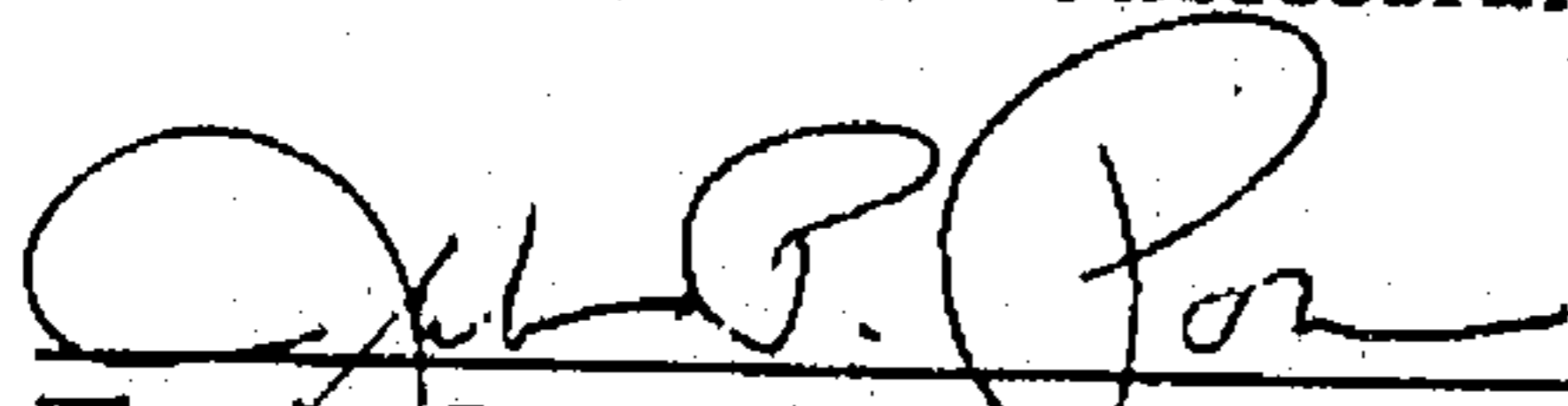
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Master of Science in Adult Fitness/Cardiac Rehabilitation

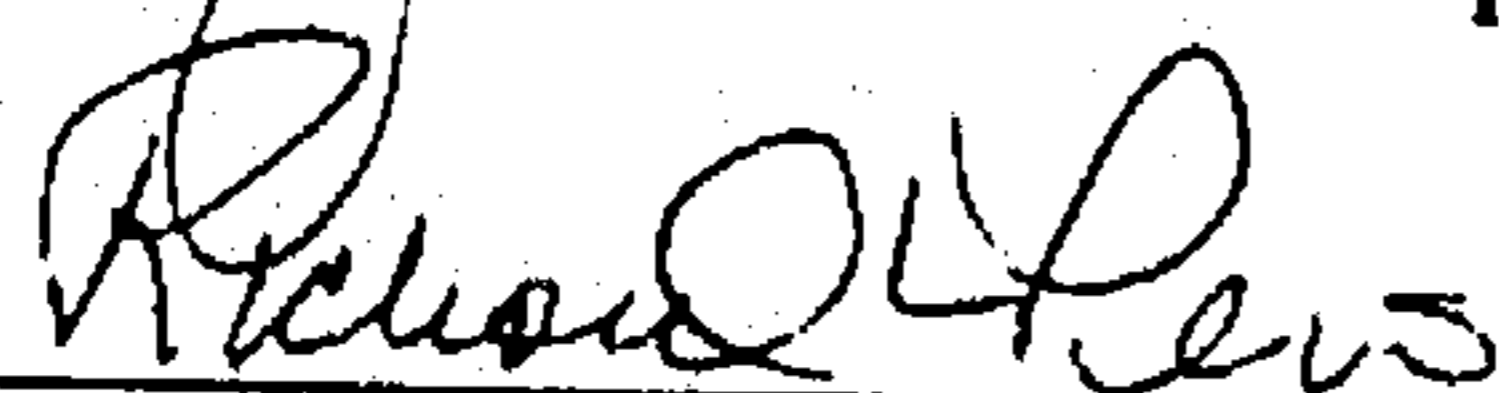
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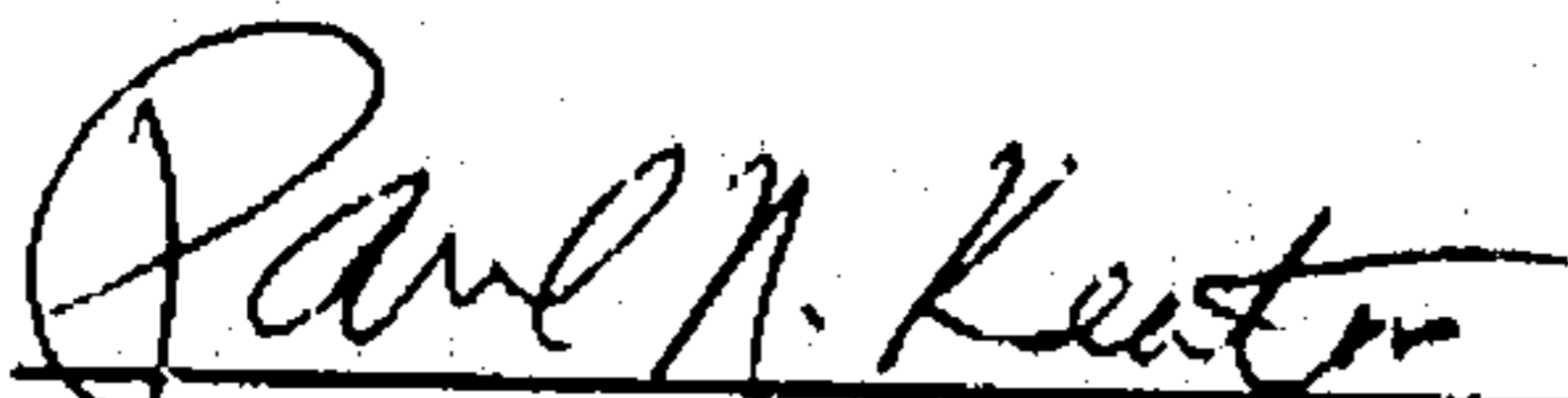
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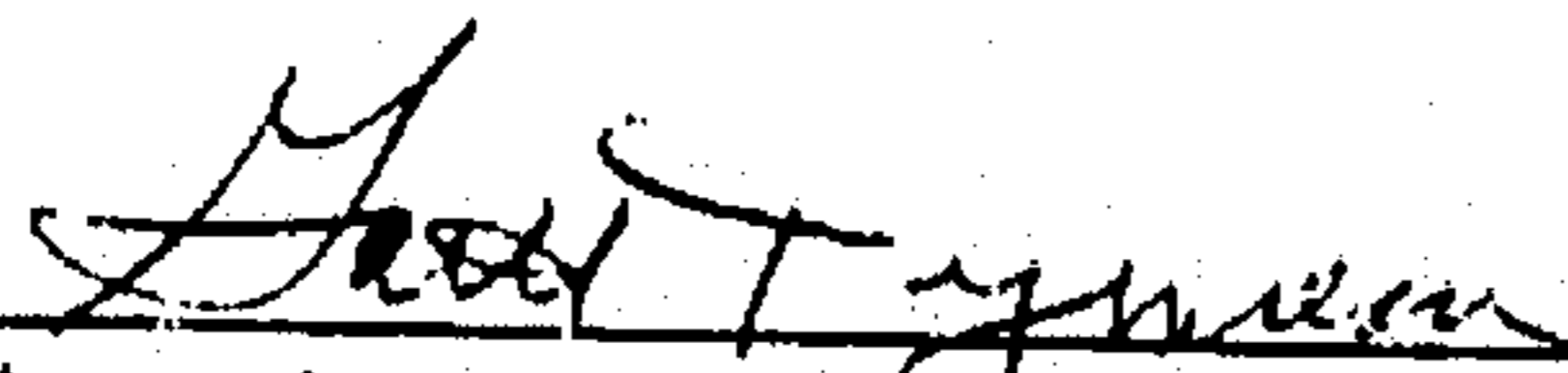


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ACKNOWLEDGMENTS

This thesis is dedicated to those who provided the foundation for my accomplishments:

To Dr. Oddou, of Temple University, who fueled my spark of interest in the field.

To Dr. Wilson and Dr. Orloff, of the University of Puget Sound, who provided continuous professional and personal guidance.

To my chairperson, Dr. Porcari, and committee members, Dr. Pein and Dr. Keaton, thank you for providing support and assistance in the completion of an academic milestone.

Most of all, to my daughter Marie, who serves as my anchor and eternal source of love and affection.

The purpose of life remains at all times, twofold:

1. To gain greater self-awareness, personal knowledge, a deeper level of consciousness, dispel the illusion of the ego, and move towards enlightenment.

2. To understand and feel the fundamental connection between all things in the Universe, and act at all times with Compassion to relieve the suffering of all people.

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INTRODUCTION

One of the primary goals of the health, physical education, and fitness fields is to increase the activity levels of the general population. Regular physical activity is a necessary component in one's overall physical and psychological well-being (1,8). Studies have repeatedly shown that regular exercise provides numerous benefits, ranging from greater cardiovascular and muscular efficiency, reduced risk for chronic disease, illness, and morbidity, to reduced levels of stress, better weight management, and feelings of greater self-esteem, body-image, and overall wellness (18,26,32). Unfortunately, the expansion of sedentary lifestyles throughout the country has caused a rapid rise in the levels of chronic diseases and illnesses, such as coronary heart disease, atherosclerosis, cancer, diabetes, and many others (28). The U.S. Department of Health and Human Services (28) reports that currently 50% of the annual deaths in the U.S. can be attributed to cardiovascular disease. The Surgeon General's Report (29) on Physical Activity and Health and the American Heart Association (2) have declared inactivity as an official health risk factor.

In a joint report sponsored by the U.S. Centers for Disease Control and Prevention and the American College of Sports Medicine (27), it was stated that "only 22% of adults engage in leisure time physical activity at the level recommended for health benefits" ... "24% of adult Americans are completely sedentary" ... and ... "the remaining 54% are inadequately active" to gain health benefits (p. 2). A recent study conducted by Blair and associates (4) has shown that people who were at a moderate level of fitness had lower rates of

all-cause mortality. Health information has been continuously reported and emphasized by agencies which promote physical activity and healthy lifestyles, yet the population at large remains mostly inactive (5,8).

According to Dishman (12) approximately 50% of new participants drop out of exercise programs, which tends to lead a person to remain inactive. The reasons for dropping out are varied and numerous, with the majority being motivational in nature, including boredom and nonenjoyment (11,12). Various research, primarily in the fields of psychology and sports psychology, has emphasized the role of personal perception (one's subjective awareness of the activity) as being a major determining factor in adherence (25,32). Likewise, this factor has been highlighted as a predictor for the likelihood of a person remaining active throughout their lifetime (24). In addition, researchers such as Wankel (31) identified that people's motivational factors differ from one person to another, and these perceptions often shift over time within the same person. Therefore, it is paramount that professionals in the field of health and fitness develop innovative approaches to helping participants attain their personal exercise goals. This will in turn facilitate long-term participation in regular physical activity.

One of the approaches to enhancing motivation and enjoyment of exercise has been in the area of visual and audio sensory diversions. Studies by Viteri (30) and Mertesdorf (21) have shown that when subjects were exposed to external stimuli, such as audio and visual, they tended to either exercise at a greater self-selected intensity level, or felt that a given intensity level was less difficult to maintain during exercise. By providing diversions during exercise, many positive outcomes can result concerning one's physical fitness. The exerciser can feel immersed within the experience and as a result

exercise for a longer duration, at a greater intensity level, and yet not feel overly exerted. These positive changes allow for a person to more likely achieve a higher aerobic capacity, lower body fat, and gain more enjoyment from the experience.

A combination of these external diversions has been created in the new Tectrix Virtual Reality (VR) aerobic exercise machines (Tectrix Fitness Equipment, Irvine, CA). The purpose of this investigation was to determine the effects of visual, audio, and interactive external stimuli, provided by a virtual reality (VR) stepper, on ratings of perceived exertion, self-selected exercise intensity, and exercise enjoyment when compared to a similar 'standard' (nonVR) stepper. This study may provide a beneficial insight into increasing regular physical activity, improving exercise adherence, and enhancing program retention.

METHODS AND PROCEDURES

Subject Selection

The subjects included 18 volunteers, 8 men and 10 women, from the La Crosse, WI area. An advertisement was listed in the local newspaper for subjects who were 21 - 39 years old, moderately active and apparently healthy, and had no known cardiovascular or orthopedic problems. Applicants were provided general information about the study and screened for the required criteria. Apparently healthy was indicated by not answering 'yes' to any of the Personal Activity Readiness Questionnaire (PAR-Q) questions on the personal health and information questionnaire (see Appendix A). Moderately active was determined if the subject aerobically exercised two to four times per week for 20 - 60 minutes per exercise session. Each of the accepted subjects signed an informed consent form (see Appendix B) prior to

participation in any phase of the study. No compensation was given to the subjects for participation in the study. The procedures for the study were evaluated by the Institutional Review Board at the University of Wisconsin-La Crosse (UW-L) and deemed that the participants would be placed at minimal risk.

Data Collection and Procedures

All testing and data collection was performed at the UW-L Human Performance Laboratory. A total of 4 days was required of each subject for data collection. Two days were orientation days in which the subjects became familiarized with the exercise and measurement equipment, and testing procedures. Two days were testing days with subjects randomly assigned to test first on either the VR or nonVR machine. The subjects were tested and measured as they exercised at a self-selected pace for 20 minutes on either the VR or nonVR stepper.

First Orientation (Day 1) The subjects arrived for a 30 minute session during the first day of orientation. The investigator provided a verbal overview of the study. Subjects completed a personal health and information questionnaire, and then read and signed the informed consent form. The Ratings of Perceived Exertion (RPE) Scale (6) (see Appendix C), Exercise Induced Feeling Inventory (EFI) (14) (see Appendix D), and Profile of Mood States (POMS) (20) (see Appendix E) were explained to the subject using a written script (see Appendix F) in order to increase uniformity of instruction.

Upon completion of the paperwork, the subjects were assigned a number which would be used throughout the study for purposes of identification. The subjects were then provided instruction as to the proper use of the aerobic exercise equipment (Tectrix VR stepper and Tectrix stepper).

The practice session consisted of starting and stopping the equipment, setting the exercise intensity levels, and engaging in the exercise activity.

Second Orientation (Day 2) The second day of orientation began with the researcher providing an oral overview of the test procedures, including explanation of the ratings of perceived exertion (RPE) scale (6) using the written script. The subjects practiced with both pieces of equipment (VR and nonVR), by starting and stopping the machines, increasing and decreasing the exercise intensity level, and otherwise engaging in the proper movement patterns until both the subject and researcher felt they were competent with the equipment.

During the remaining 15 minutes of the orientation session, the subjects were verbally informed about the direct ventilation measurements to be gathered using the Quinton Q-plex1 (Quinton Instruments Company, Seattle, WA). In addition, the subjects were fitted with a complete ventilation headgear and mouthpiece. The subjects then continued to practice on the exercise equipment with the head gear and mouthpiece in place. This procedure was conducted in order to better acquaint the subject to what they would be experiencing during testing.

First Testing (Day 3) Prior to the arrival of the subjects, the investigator assigned the subjects to the piece of equipment on which they would be tested (VR or nonVR). Subjects numbered 1 - 9 tested first on the VR stepper, while subjects 10 - 18 tested first on the nonVR stepper. The subjects arrived at the lab and completed the Exercise Induced Feeling Inventory (14) and then the Profile of Mood States questionnaire (20). A written script was read verbally to the subjects prior to completing the forms. Once the forms were completed, the subjects were weighed and fitted with a Polar heart rate

monitor and ventilation headgear. Prior to exercise, the subjects stood next to the exercise equipment for 1 minute in order to establish baseline measurements of VE, VO₂, VCO₂, RER, HR, and RPE, while the researcher explained the RPE scale using the written script.

The subjects exercised at a self-selected pace, for a total of 20 minutes while increasing and decreasing the intensity level without specific knowledge of the exact workload. External information regarding intensity and time, such as consoles and clocks, were covered up during the testing sessions. The Q-plex1 was calibrated before and after each subject using known gases and volumes. Every 15 seconds the Q-plex1 collected VE (L/min), VO₂ (ml/kg/min), VCO₂ (L/min), and RER. HR was recorded every minute, and RPE was assessed every 4 minutes on the data collection sheet (see Appendix G). At the end of the 20 minute exercise session the subjects were told to stop exercising and to rest while sitting in a chair. The subjects were considered recovered once their heart rates were below 100 bpm. Five minutes after the exercise session the EFI and POMS were readministered.

Second Testing (Day 4) The same procedure was followed for the second day of testing, with the difference being that the subjects exercised on the other piece of aerobic exercise equipment, VR or nonVR, respectively. Afterwards, the subjects were given a follow-up questionnaire (see Appendix H) to complete the next day and return within 1 week.

Statistical Treatment

Descriptive statistics were used to summarize the general physical characteristics of the subjects. A two-way ANOVA with repeated measures was used to determine if significant differences existed in the physiological responses between the males and females, and between the two types of

steppers (sex X condition). No significant interaction was found between males and females, therefore the data were combined for further analysis without regard for gender. Paired t-tests were used to determine the physiological differences between the VR and nonVR conditions. The psychological data were analyzed using a three-way ANOVA (sex X condition X pre - postexercise). No significant differences were found in the responses between males and females, therefore the data were collapsed and analyzed without regard for gender. Paired t-tests were used to determine the psychological differences between the two conditions, and between the pre - and postexercise scores within each condition. The alpha level was set at .05 to represent statistical significance.

RESULTS

The descriptive statistics of the subjects are displayed in Table 1.

Table 1. Descriptive physical characteristics of the subjects.

Variable	Age (yr) x ± SD (range)	Height (cm) x ± SD (range)	Weight (kg) x ± SD (range)
Males (8)	25.6 ± 3.8 (23 - 28)	174.6 ± 5.5 (166.4 - 181.6)	76.9 ± 7.0 (63.6 - 85)
Females (10)	25.5 ± 5.0 (21 - 39)	165.8 ± 6.1 (157.5 - 174.6)	60.6 ± 6.5 (50.4 - 67.7)

A comparison of physiological responses between the VR and nonVR conditions is presented in Table 2. Overall, the subjects produced greater self-

selected exercise intensities with the VR compared to the nonVR stepper in terms of VO_2 , Kcals, and HR. The increases in VO_2 and Kcals were statistically significant ($p \leq .05$), however the 7 bpm heart rate increase was not significant ($p > .05$). No significant differences ($p > .05$) were found between the RER and RPE variables.

Table 2. Physiological measurements of the subjects while exercising on the VR and nonVR steppers.

Category	VR Mean \pm SD	nonVR Mean \pm SD	Δ
VO_2 (ml/kg/min)	32.6 \pm 6.9	29.8 \pm 6.2	2.9*
Kcals/min	11.1 \pm 2.6	10.1 \pm 2.3	1.0*
HR(bpm)	163 \pm 13.6	156 \pm 12.3	7.0
RER	0.99 \pm 0.03	0.99 \pm 0.04	0.0
RPE	14.6 \pm 1.5	14.9 \pm 1.5	-0.3

* indicates significant difference ($p \leq .05$).

Table 3 displays the results of the Profile of Mood States questionnaire. The Total score from pre - to postexercise for both the VR and nonVR exercise machines showed a nonsignificant decrease ($p > .05$). The Total score was subdivided into six categories: Tension-Anxiety (T), Depression-Dejection (D), Anger-Hostility (A), Vigor-Activity (V), Fatigue-Inertia (F), and Confusion-Bewilderment (C). For the VR condition, a significant decrease ($p \leq .05$) was found in Tension, Depression, and Confusion from pre - to post exercise. For nonVR, only Anger was significantly decreased ($p \leq .05$).

Table 3. Exercise induced psychological changes as measured by the Profile of Mood States Questionnaire.

Category	Virtual Reality			Nonvirtual Reality		
	Pre	Post	Δ	Pre	Post	Δ
Total	105.5 \pm 24.5	99.4 \pm 17.7	-6.1	115.8 \pm 22.9	106.1 \pm 14.9	-9.7
T	7.5 \pm 5.6	4.5 \pm 3.4	-3.0*	8.2 \pm 6.1	5.6 \pm 3.0	-2.7
D	4.3 \pm 4.7	1.7 \pm 2.8	-2.6*	4.4 \pm 5.1	2.8 \pm 2.7	-1.6
A	3.6 \pm 4.7	2.6 \pm 5.9	-1.0	3.6 \pm 4.0	2.1 \pm 2.9	-1.5*
V	10.6 \pm 5.6	18.2 \pm 7.5	1.6	14.8 \pm 5.4	16.3 \pm 4.8	1.5
F	7.9 \pm 5.2	7.1 \pm 4.9	-0.9	8.1 \pm 5.6	7.4 \pm 4.4	-0.6
C	6.2 \pm 3.2	3.8 \pm 2.9	-2.4*	6.0 \pm 3.4	4.5 \pm 2.6	-1.5

* indicates significant difference ($p \leq .05$) between the pre - and postexercise scores.

T = Tension-Anxiety, D = Depression-Dejection, A = Anger-Hostility, V = Vigor-Activity, F = Fatigue-Inertia, C = Confusion-Bewilderment

following exercise. No significant interactions were observed between the VR and nonVR conditions, indicating that though there were some significant changes, they were not different between the two conditions.

The results of the EFI are presented in Table 4. The inventory was comprised of four categories: Revitalization (R), Tranquility (T), Positive Engagement (PO), and Physical Exhaustion (PE). The Revitalization category showed significant increases ($p \leq .05$) from pre - to postexercise for each modality (VR and nonVR). No significant differences ($p > .05$) were found in any of the other categories for either condition. No significant interactions

were observed between the VR and nonVR conditions, indicating that though there were some significant changes, they were not different between the two conditions.

Table 4. Exercise induced psychological changes as measured by the Exercise Induced Feeling Inventory.

Category	Virtual Reality			Nonvirtual Reality		
	Pre	Post	Δ	Pre	Post	Δ
R	4.9 \pm 2.6	7.9 \pm 2.6	3.1*	4.6 \pm 2.6	6.4 \pm 2.3	1.8*
T	6.9 \pm 3.1	6.4 \pm 2.6	-0.4	6.3 \pm 2.4	6.1 \pm 2.2	-0.2
PO	7.2 \pm 2.6	8.3 \pm 2.5	1.1	6.7 \pm 2.3	7.2 \pm 2.5	0.6
PE	5.0 \pm 3.2	4.7 \pm 2.8	-0.3	4.6 \pm 2.0	5.0 \pm 2.5	0.4

* indicates significant difference ($p \leq .05$) between the pre - and postexercise scores.

R = Revitalization, T = Tranquility, PO = Positive Engagement, PE = Physical Exhaustion

The results of the follow-up questionnaire showed a unanimous preference (18 of 18 subjects) for the VR stepper over the nonVR counterpart. Subjects indicated that they felt they would exercise longer, at a higher intensity, and more frequently if the VR stepper was available. The following is a compilation of the answers reported by the subjects. The questionnaire used a 10 point Likert scale from which the subjects ranked their answers from 1 "not at all effective/enjoyable" to 10 "highly effective/enjoyable". The first question asked "how enjoyable was your VR workout", and the scored

response was 8.7 ± 1.3 . Conversely, the second question asked the subjects "how enjoyable was your nonVR workout" and the reported score was 3.9 ± 1.3 . The remaining questions centered on the effectiveness of the VR machine in influencing certain aspects of their exercise regimen, namely frequency, duration, and choice of joining a specific program. The subjects reported they would exercise more frequently (7.6 ± 1.9), for a longer duration (8.2 ± 1.3), and would more likely join a health club offering the VR technology (6.7 ± 2.4). The results of the questionnaire clearly reflect a greater preference for the VR stepper over the nonVR stepper.

DISCUSSION

The purpose of this investigation was to determine the physiological and psychological responses to self-selected exercise on a VR and nonVR stepper. It was found that subjects chose to exercise at a greater intensity level while using the VR stepper, as indicated by the 10% increase in oxygen consumption and caloric expenditure, and the 7 bpm higher heart rate, than when exercising on the nonVR stepper. This greater exercise intensity was produced with no differences in the subjects' perceived exertion levels between conditions. It was hypothesized that the audio, visual, and proprioceptive external stimuli produced by the VR stepper caused the subjects to be more distracted during the exercise.

Attentional focus studies (7,22,23) have reported that when external stimuli were present during exercise, subjects tended to exercise either for a longer duration or at a higher intensity level than when no external stimuli were present. Psychologists describe this phenomenon as dissociation, whereby the subjects' attentional focus is shifted from internal cues of how hard they feel they are working. Studies by Pennebaker and Lightner (23)

support the viability of using external stimuli to alter the attentional focus away from internal cues. They showed that external stimuli, both visual and auditory, can reduce the feelings of exertion and fatigue while exercising. The researchers postulated that the subjects were focusing on external factors to a higher degree which caused the processing of internal sensations within the brain to be restricted. These results support those found in the current study.

Harte and Eifert (15) found that their subjects had greater feelings of exertion while running indoor as compared to running outdoor at the same pace. Similar results were reported in a study conducted by Ceci and Hassmen (9) when subjects were asked to replicate three RPE levels on a treadmill and outdoor track. For each level of RPE the subjects self-selected higher speeds during the outdoor track condition. This illustrated the effect of external stimulation on perception of effort.

Johnson and Slegel (16) discovered that active external stimuli caused a reduction of the rating of perceived exertion by 1.7 points, on a 6 - 20 scale, during high intensity exercise. These findings were comparable to the current study as subjects chose to exercise 10% harder on the VR stepper even though they perceived the effort to be the same as the nonVR stepper at a lower intensity level. Borg (6) states that perception is derived from numerous cues throughout the body. These cues originate from many sources, such as joint proprioceptors, muscle motor units, baroreceptors, and blood pH detectors. These factors interact with one another and are organized by the brain. Additional variables influence the configuration of these factors and include: past exercise performance, mood, emotional disposition, and goals. Once organized in the higher brain centers, these factors culminate into a single perception, or 'Gestalt' of how hard one is working (6). Though this

perception is transient, not only from one exercise session to another, but from moment to moment, it can be quantified through the use of the RPE chart.

According to Dishman (11), only a small percentage of people exercise at a level which promotes cardiovascular benefits. However, the results of this study appear to support the belief that by providing external stimuli participants will choose to exercise at a higher intensity level, yet not feel that they are working as hard. The ACSM (1) states that intensity is the most important component in exercise prescription designed to enhance physical fitness. Physiological benefits, such as a higher aerobic capacity and lower body fat percentages, are more easily attained by the participants if they exercise more intensely (33). In addition to the physiological measurements observed in the study, specific psychological factors were investigated.

Exercising on both the VR and nonVR steppers resulted in similar psychological changes, with no significant differences between one another. This indicated that the changes were most likely due to the exercise itself and not the specific exercise condition. Psychological factors are part of the integrative perception of exercise and play a role in exercise adherence (19). Regular physical exercise has been shown to decrease depression and anxiety, and increase the sense of overall well-being (1,2,8).

The POMS serves to measure the changes in a person's mood state due to an exercise intervention. There are six categories which aid in specifying these mood changes. It was expected that following an acute bout of exercise all of the categories should decrease, except Vigor (20). This trend was evident as Tension, Depression, Anger, Fatigue, and Confusion scores decreased while Vigor increased after the 20 minutes of self-selected exercise, for both the VR

and nonVR stepper, with no significant differences between the two conditions. In a study by Harte and Eifert (15) they found that those subjects who ran outdoor for 45 minutes were significantly less anxious, less depressed, less hostile, less fatigued, and more invigorated, with no change in confusion. In the current study the observed changes were the normal psychological responses expected after exercise as reported in the literature (14,16,17,20).

Tension, Depression, and Confusion were the three variables which significantly decreased during the VR condition. Anger was the only variable which significantly decreased for the nonVR condition. The important point of this psychological investigation was the direction of change for each category, which indicated normal acute exercise responses, even though most of the changes were not significant. The nonsignificant changes may be due solely to the short duration of exercise or the specific exercise modality. Since the changes observed between the VR and nonVR conditions were not significantly different from one another, it can be assumed that the changes were mainly due to the acute bout of exercise and not the fact that they were exercising on a VR stepper.

The EFI is sensitive to how a person feels toward a given exercise intensity. Gauvin and Rejeski (14) state that a combination of variables contribute to a person's willingness to exercise, and include: social, environmental, cognitive, emotional, exercise intensity, and personal history. Increases in EFI scores should be observed in revitalization, tranquility, and positive engagement, while the physical exhaustion score should decrease (14). For this study, the revitalization score was the only feeling state which significantly increased, for both the VR and nonVR conditions. No

significant changes were observed in tranquility, positive engagement, or physical exhaustion, in either exercise condition. The changes did not adhere exactly to the expected trend, as shown by the small decreases in tranquility of 0.2 and 0.4. The reason for this may be due to the short length of the exercise session or the specific exercise modality itself. However, according to Gauvin and Rejeski (14), Massie and Shephard (18), and McNair, Lorr, and Droppleman (20) the observed changes were indicative of moods after an acute bout of exercise, namely feeling energized, yet calm, and deriving a greater sense of enjoyment from the experience.

Overall, the subjects reported greater enjoyment during exercise with the VR stepper than when using the nonVR stepper. The follow-up questionnaire found that the subjects unanimously preferred the VR stepper over the nonVR stepper. They expressed greater enjoyment with the interactive nature of the device, and with being distracted during the exercise which made the exercise feel less tiring, and the time to pass more quickly. This finding coincided with a study by Boutcher and Trenske (7) who observed greater feelings of enjoyment in subjects who listened to music while exercising. Likewise, Harte and Elfert (15) found that enjoyment of vigorous activity rose as external stimuli increased and the focus of attention for each subject shifted externally. Exercise enjoyment is a component in the perception of exercise intensity and continued lifelong participation (19).

The subjects enjoyed the VR condition more than the nonVR, and they indicated that they would have a greater tendency to continue an exercise regimen which included such a machine. By maintaining an exercise regimen, and at a higher intensity level as shown by this study, the subjects would be more likely to achieve greater physiological and psychological

benefits. Studies by Wankel (31) and Custer and Doty (10) indicated that when participants believed they were receiving health benefits and making observable personal gains with their exercise routine, they tended to remain with the program. Thus it could be hypothesized that observable gains elicited through the higher intensity level of the VR machine over the duration of an exercise regimen would enhance the likelihood of a person staying with the program.

Dishman (13) reported that drop out rates increased as intensity levels increased. In the current study perception of the exercise intensity was lower and enjoyment of the exercise greater with the VR condition, therefore participants would be more likely to remain. Adherence is a multifaceted challenge faced by all professionals in the field of health, exercise, and fitness. By engaging participants in as many positive ways as possible the outcome for continued regular physical activity over a lifetime is promising (3).

In summary, the results of this study found that people produced a 10% higher VO_2 and caloric expenditure on the VR stepper, without feeling that they exercised any harder. This observation suggests that by providing people with external stimuli, such as with the VR technology, greater health benefits may result, including higher aerobic capacity, decreases in body fat, enjoyment of the exercise, and increased adherence.

Future studies should compare varying levels of external stimuli to investigate the minimal amounts required to produce increased intensity levels with no changes in perceived exertion. A more refined questionnaire should be devised which defines and tracks the subjects' attentional focus before, during, and after exercise. Screening subjects prior to exercise for individual attentional focus tendencies may allow future investigators to

observe changes in these groups. The results of these investigations may allow researchers to focus on specific attentional stimuli and modify existing modalities to optimize physiological and psychological outcomes.

REFERENCES

1. American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, ed 5. Philadelphia, PA: Williams and Wilkins, 1995.
2. American Heart Association: Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circul.* 91:580-615, 1995.
3. Biddle, S., & A. Smith. Motivating adults for physical activity: towards a healthier present. *J. P. E. R. D.* 62:39-43, 1991.
4. Blair, S. N., J. B. Kampert, H. W. Kohl, C. E. Barlow, C. A. Macera, R. S. Paffenbarger, and L. W. Gibbons. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *J. A. M. A.* 274:205-210, 1996.
5. Blair, S. N., H. W. Kohl, R. S. Paffenbarger, D. G. Clark, K. H. Cooper, and L. W. Gibbons. Physical fitness and all-cause mortality: a prospective study of healthy men and women. *J. A. M. A.* 262:2395-2401, 1989.
6. Borg, G. Perceived exertion: a note on "history" and methods. *Med. Sci. Sports* 5:90-93, 1973.
7. Boutcher, S.H., and M. Trenske. The effects of sensory deprivation and music on perceived exertion and affect during exercise. *J. Sport Exerc. Psychol.* 12:167-176, 1990.
8. Brill, P.A., H. W. Kohl, and S. N. Blair. Anxiety, depression, physical fitness, and all-cause mortality in men. *J. Psychosom. Res.* 36:267-273, 1992.
9. Ceci, R., and P. Hassmen. Self-monitored exercise at three different PE intensities in treadmill vs field running. *Med. Sci. Sports Exerc.* 23:732-738, 1991.
10. Custer, S., and C. Doty. Assessment of self-motivation and selected physiological characteristics as predictors of adherence to exercise in a corporate setting. *J. Health Ed.* 23:232 - 237, 1992.

11. Dishman, R. K. Health psychology and exercise adherence. *Quest* 33:166-180, 1982.
12. Dishman, R. K. Exercise compliance: a new view for public health. *Phys. & Sportsmed.* 14:127-143, 1986.
13. Dishman, R. K. Prescribing exercise intensity for healthy adults using perceived exertion. *Med. Sci. Sports Exerc.* 26:1087-1094, 1994.
14. Gauvin, L., and J. W. Rejeski. The Exercise Induced Feeling Inventory: development and initial validation. *J. Sport Exerc. Psychol.* 15:403-423, 1993.
15. Harte, J. L., and G. H. Eifert. The effects of running, environment, and attentional focus on athletes' catecholamine and cortisol levels and mood. *Psychophys.* 32:49-54, 1995.
16. Johnson, J., and D. Siegel. Active vs. passive attentional manipulation and multidimensional perceptions of exercise intensity. *Can. J. Sport Sci.* 12:41-45, 1987.
17. Martin, J. E., and P. M. Dubbert. Exercise applications and promotion in behavioral medicine: current status and future directions. *J. Consult. Clin. Psychol.* 50:1004-1017, 1982.
18. Massie, J. F., and R. J. Shephard. Physiological and psychological effects of training. *Med. Sci. Sports* 3:110-117, 1971.
19. McAuley, E. Understanding exercise behavior: a self-efficacy perspective. In: *Motivation in Sport and Exercise*. G. C. Roberts (Eds.). Champaign, IL: Human Kinetics, 1992, pp. 107-127.
20. McNair, D. M., M. Lorr, and L. F. Droppleman. *Profile of Mood States Manual*. San Diego, CA: EdITS/Educational and Industrial Testing Service, 1992.
21. Mertesdorf, F. L. Cycle exercising in time with music. *Percept. & Motor Skills* 78:1123-1141, 1994.
22. Morgan, W.P., A. C. Horstman, A. Cymerman, and J. Stokes. Facilitation of physical performance by means of cognitive strategy. *Cognit. Ther. Res.* 7:251-264, 1983.

23. Pennebaker, J. W., and J. M. Lightner. Competition of internal and external information in an exercise setting. *J. Personality & Social Psychol.* 39:165-174, 1980.
24. Rejeski, W. J. Motivation for exercise behavior: a critique of theoretical directions. In: *Motivation in Sport and Exercise*. G.C. Roberts (Ed.). Champaign, IL: Human Kinetics, 1992, pp. 129-157.
25. Skinner, J. S., R. Hutsler, V. Bergsteinova, and E. R. Buskirk. Perception of effort during different types of exercise and under different environmental conditions. *Med. Sci. Sports* 5:110-115, 1973b.
26. Sonstroem, R. Psychological models. In: *Exercise Adherence: Its Impact On Public Health*. R. Dishman (Ed.). Champaign, IL: Human Kinetics, 1988, pp. 125-153.
27. U.S. Department for Disease Control and Prevention, and the American College of Sports Medicine. Summary Statement: Workshop on Physical Activity and Public Health. *Sports Med. Bulletin* 28, 1993.
28. U.S. Department of Health and Human Services. *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. DHHS Publication, No. PHS 91-502131. Washington, DC: Public Health Service, 1990.
29. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Center for Chronic Disease Prevention and Health Promotion. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: Public Health Service, 1996.
30. Viteri, J. E. The effects of television viewing on the self-regulation of exercise intensity. *Microform Publications*. University of Oregon, Eugene, OR: International Institute for Sport and Human Performance, 1995.
31. Wankel, L. M. Personal and situational factors affecting exercise involvement: the importance of enjoyment. *Res. Q. Exercise Sport* 56:275-282, 1985.
32. Williams, J.G., and R. G. Eston. Determination of the intensity dimension in vigorous exercise programmes with particular reference to the use of the rating of perceived exertion. *Sports Med.* 8, 177-189, 1989.
33. Willis, J. D., & L. F. Campbell. *Exercise Psychology*. Champaign, IL: Human Kinetics, 1992.

APPENDIX A
PERSONAL HEALTH AND INFORMATION QUESTIONNAIRE

Personal Data Information:

Name: (last) _____ (first) _____ (middle) _____

Address: _____

(city) _____ (state) _____ (zip code) _____

Telephone: (home) _____ (work) _____ (ext.) _____

Date of Birth: ____/____/____ Age: _____ Gender: _____

Height: (in) _____ (cm) _____ Weight: (lb) _____ (kg) _____

Family Physician: _____ Clinic: _____

Date of last physical examination: ____/____/____

Personal Activity Readiness Questionnaire (PAR-Q)*:

The PAR-Q is a standard form designed to determine your initial health and activity level. The test identifies those individuals who may be at risk if they engage in this study. Answer the following questions to the best of your ability. Check 'YES' or 'NO' to answer the questions as they pertain to you.

YES NO

- | | | |
|-----|-----|--|
| ___ | ___ | 1. Has your doctor ever said you have heart trouble? |
| ___ | ___ | 2. Do you frequently have pains in your heart and chest? |
| ___ | ___ | 3. Do you often feel faint or have spells of dizziness? |
| ___ | ___ | 4. Has a doctor ever said your blood pressure was too high? |
| ___ | ___ | 5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise? |
| ___ | ___ | 6. Is there a good reason not mentioned here why you should not follow an activity program even if you wanted to? |

*American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, ed 5. Philadelphia, PA: Williams and Wilkins, 1995.

APPENDIX B
INFORMED CONSENT

Informed Consent to Act as a Subject in a Research Study

Title:

Physiological and psychological responses to self-selected exercise using a virtual reality and nonvirtual reality stepper.

Investigators:

John Porcari, Ph.D. - Committee Chairperson
Exercise and Sports Science Department Room 216 Phone # 785-8684

Jason Zedaker, B.S. - Graduate student, UW - La Crosse

Source of Support:

Technical and material support provided by the Tectrix Fitness Equipment corporation.

Explanation of the Tests:

The purpose of this study is to determine if there are greater positive effects derived from the VR aerobic exercise equipment when compare to 'standard' similar aerobic exercise equipment, in terms of how hard you work, how hard you think you are working, and how much you enjoy the exercise. During this test you will be asked to exercise at your own pace on both the VR stepper and nonVR stepper, on separate days. Physiological measurements will be measured while you exercise, and include: direct ventilation, using Quinton Q-plex1 metabolic equipment, and heart rate using a Pacer heart rate monitor chest strap and watch. Perceptual measurements will also be measured to include: Ratings of Perceived Exertion using a Borg scale, exercise enjoyment using an Exercise Induced Feeling Inventory (EFI), and feelings using a Profile of Mood States (POMS) questionnaire.

Two familiarization days will be conducted prior to any testing and will take 30 minutes each day. On the first day of orientation, you will complete a personal health and information questionnaire (PAR-Q) and informed consent. During the two orientation days you will utilize and become acquainted with both pieces of exercise equipment and the testing procedure. Two testing days will be conducted following the two orientation days. On

each testing day, you will complete two questionnaires: a feeling inventory (EFI) and Profile of Mood States (POMS) before and after the exercise. You will exercise on one of the aerobic steppers (VR or nonVR) for 20 minutes at your own pace while the previously listed physiological and perceptual measurements are being taken. You will not be required to exercise at a rate greater than you normally attain. Total time required for each test day will be 1 hour. On the fourth day you will be given a follow-up questionnaire to complete and return within one week.

Risks and Discomforts:

With any type of physical activity, there is a certain amount of risk. Though the investigators have endeavored to minimize any possible risk, it is important for you to understand the potential risks. The risks include, but are not limited to: discomfort; injury to bones, muscles, ligaments, tendons, and joints; soreness; fainting; heart attack; and even death. In order to reduce these risks further, it is important for you to divulge any and all pertinent information concerning your health history requested by the staff and on the designated forms to the best of your ability. In addition, remember to only exercise at your normal self-selected exercise intensity during the tests, and to report any unusual feelings before, during, or after the test to the technicians.

Inquiries:

You are encouraged to ask any questions you may have concerning the test and the procedures. The researchers will be pleased to provide any further explanation you require.

Confidentiality:

Any information obtained from this research study specifically concerning you will be kept strictly confidential. Your identity will not be revealed in any description or publication of this research.

Potential Benefits:

As a result of this study, you will be exposed to additional aspects of the field of exercise and health, and will gain a better understanding of your own physical fitness. In addition, you will gain the personal knowledge of being part of a research study investigating the latest development of virtual reality aerobic exercise equipment, self-selected exercise intensities, and exercise perception and adherence.

Freedom of Consent:

Your participation in this study is completely voluntary. You are free to terminate the tests at any time. Prior to engagement in the testing procedures, an informational sheet will be distributed which provides a synopsis of the procedure. You will not be entitled to any compensation for participating in this study.

I, _____, have carefully read this form and understand the test procedures and I am fully aware of the possible risks. I give my consent to participate in this study.

Signature

Date

Witness

APPENDIX C
RATINGS OF PERCEIVED EXERTION SCALE

Ratings of Perceived Exertion Scale *

7	very, very light
8	
9	very, light
10	
11	fairly light
12	
13	somewhat hard
14	
15	hard
16	
17	very hard
18	
19	very, very hard
20	

*Borg, G. Perceived exertion: a note on "history" and methods. *Med. Sci. Sports* 5:90-93, 1973.

APPENDIX D
EXERCISE INDUCED FEELING INVENTORY (EFI)

EXERCISE INDUCED FEELING INVENTORY*

Instructions: Please use the following scale to indicate the extent to which each work below describes how you feel at this moment in time. Record your responses by circling the appropriate number next to each word.

0 = Do Not Feel (DNF)
1 = Feel Slightly
2 = Feel Moderately
3 = Feel Strongly
4 = Feel Very Strongly (FVS)

- | | |
|---------------------------------------|------------------------------------|
| 1. Refreshed (DNF) 0 1 2 3 4 (FVS) | 7. Happy (DNF) 0 1 2 3 4 (FVS) |
| 2. Calm (DNF) 0 1 2 3 4 (FVS) | 8. Tired (DNF) 0 1 2 3 4 (FVS) |
| 3. Fatigued (DNF) 0 1 2 3 4 (FVS) | 9. Revived (DNF) 0 1 2 3 4 (FVS) |
| 4. Enthusiastic (DNF) 0 1 2 3 4 (FVS) | 10. Peaceful (DNF) 0 1 2 3 4 (FVS) |
| 5. Relaxed (DNF) 0 1 2 3 4 (FVS) | 11. Worn-out (DNF) 0 1 2 3 4 (FVS) |
| 6. Energetic (DNF) 0 1 2 3 4 (FVS) | 12. Upbeat (DNF) 0 1 2 3 4 (FVS) |

*Gauvin, L., and J. W. Rejeski. The Exercise Induced Feeling Inventory: development and initial validation. *J. Sport Exerc. Psychol.* 15:403-423, 1993.

APPENDIX E
PROFILE OF MOOD STATES (POMS)

Five selected adjectives from the Profile of Mood States Questionnaire.*

- 0 = Not at all
- 1 = A little
- 2 = Moderately
- 3 = Quite a bit
- 4 = Extremely

1. Active	0	1	2	3	4
2. Relaxed	0	1	2	3	4
3. Fatigued	0	1	2	3	4
4. Anxious	0	1	2	3	4
5. Alert	0	1	2	3	4

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*McNair, D. M., M. Lorr, and L. F. Droppleman. *Profile of Mood States Manual*. San Diego, CA: EdITS/Educational and Industrial Testing Service, 1992.

APPENDIX F
SCRIPTS FOR RPE, EFI, AND POMS

The RPE script was read as follows:

During the test I will ask you how hard you feel you are exercising. The RPE chart ranges from six to twenty, with six indicating no exertion at all and twenty being a maximal effort. There are some descriptive words on the scale to aid you in your number selection. There are no right or wrong answers, the number is entirely your personal perception. I simply want you to point to the number which indicates how you are feeling at that time.

The EFI script was read as follows (Gauvin & Rejeski, 1993):

Please use the following scale to indicate the extent to which each word below describes how you feel at this moment in time. Record your responses by circling the appropriate number next to each word.

The POMS script was read as follows (McNair, Lorr, & Droppleman, 1992):

Below is a list of words that describe feelings people have. Please read each one carefully. Then fill in ONE circle under the answer to the right which best describes HOW YOU FEEL TODAY.

APPENDIX G
DATA COLLECTION SHEET

Data Collection Sheet

Date: / /

Subject # Height (in): Weight (lb): Age:

Time (min) VE (L/min) VO₂ (ml/kg/min) HR (bpm) RPE

<u>Pre-Ex</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>0 - 2</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>2 - 4</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>4 - 6</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>6 - 8</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>8 - 10</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>10 - 12</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>12 - 14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>14 - 16</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>16 - 18</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>18 - 20</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>PostEx</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>

APPENDIX H
FOLLOW-UP QUESTIONNAIRE

Postexercise Questionnaire

1. Which exercise did you prefer (circle one)?

Virtual Reality (VR) Stepper Nonvirtual Reality (nonVR) stepper

2. Why did you prefer this bike over the other (please be specific)?

3. How enjoyable was your **Virtual Reality (VR)** workout?

Not at all Enjoyable				Enjoyable						Highly Enjoyable
1	2	3	4	5	6	7	8	9	10	

4. How enjoyable was your **Nonvirtual Reality (nonVR)** workout?

Not at all Enjoyable				Enjoyable						Highly Enjoyable
1	2	3	4	5	6	7	8	9	10	

5. Was VR technology effective in making the exercise more enjoyable?

Not at all Enjoyable				Enjoyable						Highly Enjoyable
1	2	3	4	5	6	7	8	9	10	

6. How effective would VR technology be in influencing how often or how frequently you exercise?

Not at all Enjoyable					Enjoyable					Highly Enjoyable
1	2	3	4	5	6	7	8	9	10	

7. How effective would VR technology be in extending the length of your average workout time (e.g., from 20 to 30 minutes a session)?

Not at all Enjoyable					Enjoyable					Highly Enjoyable
1	2	3	4	5	6	7	8	9	10	

8. How effective would the availability of machines which utilized the VR technology be in impacting your decision to join one particular health club over another?

Not at all Enjoyable					Enjoyable					Highly Enjoyable
1	2	3	4	5	6	7	8	9	10	

9. Please list any other comments or observations you had about your experience on the VR stepper.

10. Please list any other comments or observations you had about your experience on the nonVR stepper.

THANK YOU FOR YOUR PARTICIPATION IN THIS STUDY!!!

APPENDIX I
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Introduction

Regular physical activity aids in maintaining a person's overall health and well-being and provides numerous physiological and psychological benefits. Numerous studies have shown that regular activity reduces many of the risk factors involved in early mortality and morbidity, such as obesity, stress, and hypertension, and improves many other facets of a person's life. However, adherence to regular physical exercise remains a constant problem for exercise professionals. This review of literature examines the physiological and psychological health benefits of exercise, and investigates the factors which influence adherence, such as exercise intensity, attentional focus and external stimuli, motivation, and enjoyment.

Physiological and Health Benefits of Regular Physical Exercise

Comprehensive studies by Blair and colleagues (5,6) sought to determine the effect of regular physical fitness on all-cause mortality. There were 10,224 men and 3,120 women, and 25,341 men and 7,080 women respectively, who were involved in the two studies. Full medical examinations were administered, as well as a maximal exercise test using a treadmill, to determine fitness levels. After approximately 8 years of follow-up the researchers stated that the results "show a strong, graded, and consistent inverse relationship between physical fitness and mortality in men and women" (p. 2401). Three main findings were demonstrated by the two studies: 1) moderately fit subjects had a lower incidence of mortality than subjects who had a low fitness level; 2) low fitness levels were found to be

a predictor of future cardiovascular disease and early mortality; and 3) highly fit subjects even with other health risk factors, such as smoking and hypertension, had lower levels of mortality than low fit subjects with no risk factors. From these findings the researchers recommended that low physical fitness levels should be treated as a risk factor for early mortality, and they emphasized the important role that regular physical activity plays in overall health and wellness (5,6).

From this epidemiological evidence, public health organizations at local, state, and national levels have worked together to develop a cooperative approach toward health promotion and disease prevention. The U.S. Department of Health and Human Services (36) and the Surgeon General (37) emphasize physical fitness and exercise as playing an integral role in achieving these public health goals. Healthy People 2000 (37) promotes moderate levels of exercise for the general population, specifically for the positive health benefits of disease prevention through risk factor modification. These goals are recommended to get as many people active as possible. Therefore, the approach must be to encourage exercise and activity programs which are adapted to individuals abilities, interests, and goals.

The American College of Sports Medicine (ACSM) (1) also supports the move to moderate levels of activity as the most recent guidelines state that "public health efforts should be directed toward getting more people active more of the time rather than elevating everyone to an arbitrary fitness or activity level" (p. 4). The American Heart Association (2) is another professional health and exercise organization which supports moderate intensity exercise for the general population.

There are many physiological changes which result from regular physical activity. Documented changes range from improvements in ventilatory capacity and muscular strength and endurance, to losses in body fat (22). Exercise intensity is considered by the ACSM (1) to be the most important component when designing a fitness program. Aerobic intensity refers to the stress or strain imposed upon the cardiovascular system, and can be measured in units of oxygen consumed and heart beats per minute. This imposed strain upon the cardiovascular system causes the body to positively adapt and become a more efficient utilizer of oxygen and distributor of blood (19).

Aerobic activities use large muscle groups continuously for 20 - 60 minutes at a level which elevate breathing and heart rate to cause the desired training effect. VO_2 has been defined by McArdle, Katch, and Katch (26) as the amount of oxygen consumed by the body in a given amount of time as measured through ventilation procedures. VO_2 reflects the body's ability to transport oxygen via the cardiorespiratory system to the working muscle cells which extract and utilize the oxygen for the production of energy in aerobic metabolism. Caloric expenditure (Kcals) is a derivative of VO_2 in that it is the amount of energy produced through the utilization of oxygen for the specific purpose of creating adenosine triphosphate (26). Caloric expenditure, due to activity, in excess of normal resting basal metabolism and daily caloric intake requires the body to utilize stored energy.

The energy stores, glycogen in the liver and lipids in adipose tissue, are mobilized to meet the increased energy demands. Continued use of these energy stores through regular physical activity causes them to be reduced. This reduction results in a lower total body fat percentage (26). As obesity is a

risk factor for many chronic diseases, and tends to exacerbate existing illnesses and diseases, regular physical activity could help to control or eliminate these health risks. It has been repeatedly found that regular physical exercise at moderate intensity levels induce physiological improvements, such as higher aerobic capacity, better glucose tolerance, improved lipid profiles, denser bones, lower body fat, and increased muscular strength and endurance (1,2). Health benefits associated with increased physical activity include reduced risk for chronic diseases and early mortality, as well as an enhanced sense of well-being (5,6,10).

Other physiological changes which manifest from physical activity include neurological, or brain chemistry alterations. Martin and Dubbert's (25) review cites these temporary changes as increases in beta endorphins and catecholamines after exercise. It has been proposed by various researchers that these hormonal changes may be linked to the alleviations of anxiety and depression often observed following exercise (25).

In a unique approach to this intriguing question Harte and Eifert (20) tested the affect of the environment and attentional focus on neuroendocrinal levels. Ten male runners ran four times at the same pace on separate days for 45 minutes. Four conditions were tested: outdoor running, indoor treadmill running while listening to outdoor sounds, indoor treadmill running while listening to one's own internal breathing sounds, and a control of sitting comfortably. The researchers observed increases in adrenaline, noradrenaline, and cortisol after each activity session. In addition to changes in hormone levels, the investigators sought to determine changes in attentional focus during the four sessions and the effect upon perceived exertion, mood changes, and enjoyment of the exercise. They found that

when subjects exercised outdoors their attentional focus shifted externally, while when indoors it shifted to an internal focus (20).

Harte and Eifert (20) proposed that a person's attentional focus may be an indicator of their individual perception of the relative ease or difficulty of the exercise. As such those people with an internal focus would generally feel more fatigued at the same intensity level when compared to those with an external focus. The subjects in their study were evaluated as being less anxious, depressed, hostile, and fatigued after running outdoors as compared running indoors. The subjects reported that they enjoyed the outdoor run more than the indoor runs. Also, the indoor run with the specific internal focus was enjoyed the least, with the rating of perceived effort reported as being the highest during this session. The researchers attributed these various changes not only to hormonal, psychoneuroendocrinological effects, but also to environmental settings and the influence of external stimuli on attentional focus. It was concluded that "vigorous exercise can have a beneficial effect on mood, but the environment and setting in which it occurs and the attentional focus seem to exert a mediating effect" (p. 53).

Psychological Benefits of Regular Physical Exercise

Psychological factors are part of the integrative perception of exercise and play a role in exercise adherence. Specific observable psychological changes have been shown to occur in numerous studies after regular physical activity. These changes include the alleviation of depression and anxiety, and improvement in self-efficacy and self-concept (1,2,10,22).

An 18 month study was conducted by Heinzelmann and Bagley (21) with 239 sedentary males aged from 45 to 59 years who were at risk for coronary heart disease. They participated in a supervised physical activity

program for 1 hour three times a week. After 18 months, the subjects showed positive changes in their attitudes, behaviors, and self-image. Other areas of their life were also affected, such as increased work performance, better stress management, greater endurance, weight loss, and a better feeling overall (21).

Kavussanu and McAuley (24) found that people who performed high and moderate levels of physical activity tended to think more highly of themselves. A cross-sectional study was performed on 188 subjects. Subjects completed questionnaires which investigated physical activity and various psychological dimensions. Those regularly active were shown to be less depressed and anxious, and have a greater sense of well-being. Also, it was found that highly active individuals were more optimistic, and high and moderately physically active individuals had a better self-image than low active and inactive individuals. However, it was expressed by the authors that optimists in general may perform more health promoting activities than pessimists, and therefore the data needed to be interpreted with some precautions (24).

Factors Which Influence Exercise Adherence

Even though these health facts and risk factors have been made abundantly clear to the public via official agencies such as the Centers for Disease Control (CDC), the Surgeon General, and the President's Council on Fitness and Exercise, as well as other health and fitness organizations, approximately 60% of the population does not exercise on a regular basis (36,37). Martin and Dubbert (25) conducted a comprehensive summary on available literature in the area of exercise promotion in clinical settings. They found that approximately two-thirds of the U.S. population does not exercise

regularly, with a significant portion remaining entirely sedentary. It was also emphasized that those people who do not adhere to exercise programs and remain inactive tend to be the people who would most benefit from the exercise program.

Dishman (14) completed an overview of available adherence studies and found similar trends in those people who dropped out. A framework was constructed to create cohesion, highlight central points, and give direction for future investigations. He found that 50% of new participants tend to drop out of exercise programs within 6 months, however, those individuals who remained active in some sort of program beyond 6 months tended to be more active for the rest of their life. Factors associated with dropping out of a program include: work conflicts, facility inaccessibility, self-efficacy issues, nonenjoyment of exercise, poor family support, and lack of observable improvements, as well as a few others.

Dishman (15) supported his previous findings in an article published 4 years later. He emphasized the need for additional adherence approaches and solutions to the growing problem of widespread sedentarism and related diseases throughout society. In this paper he discussed four theories to potentially aid in enhancing program adherence. These theories incorporated the numerous variables emphasized in other studies and congealed them into the following four main topics: health beliefs, reasoned action, self-efficacy, and self-esteem. He believed that through additional studies on adherence and the use of existing models for adherence, that professionals will better be able to motivate and encourage the general population to remain regularly active (15).

Through manipulation of these observed variables, both internal and external, exercise compliance can be improved. This highlights the need to develop individualized programming tailored specific to the person as suggested by Heyward (22). The approach needs to take into consideration all of the behavior factors, as well as the establishment of realistic short and long-term goals for the participant (22).

A study by Wankel (39) indicated that when participants believed they were receiving health benefits and making personal gains with their exercise routine, they tended to remain with the program. Those subjects who remained with the program indicated more enjoyment and higher levels of socialization than those who dropped out. Exercise adherence is a complex problem which needs to be addressed in a comprehensive manner. Not only are health-related factors important, but additional external and internal factors as well. It was proposed by the researchers that observable gains elicited over the duration of an exercise regimen, plus enjoyment of the program in general because of the individualized approach, would enhance the likelihood that a person remained with the program (39).

Lack of adherence to exercise programs has been a topic of concern and a focus for research over the past decade, specifically in the areas of psychology, sports psychology, and exercise physiology. However, of all the research conducted, no single cause has been identified, nor has an optimal retention program been developed. One of the reasons, according to Martin and Dubbert (25), for the lack of a single theoretical model is the fact that a specific definition for adherence has not been created. However, of all the adherence studies performed, common determinants of drop-out or

adherence to programs have been observed. The categories involved include exercise intensity, perception, attentional focus, and enjoyment.

Exercise Intensity and Adherence

Training intensity is generally expressed as a percentage of an individual's aerobic capacity. Levels of 50 - 85% VO_2 max, and 60 - 90% HR max have been found to induce aerobic improvements and are deemed appropriate for healthy, active adults (1,22). Even lower intensity levels, such as 40 - 50% of the values has been shown to improve aerobic capacity and reduce body fat percentages in sedentary individuals (1,37). An increase in aerobic exercise intensity translates to a greater potential for people making positive physiological changes in their aerobic capacity and body composition.

According to a review of various exercise intensity and perception studies by Dishman (16), only a small percentage of people exercise at a level which promotes cardiovascular benefits. Conversely, drop out rates have been shown to increase when intensity levels increase. He found that this occurrence was often due to inaccurate regulation and perception of exercise intensity by the participants. This fact seems problematic for professionals involved in exercise prescription and can be potentially difficult to correct.

Additional clinical studies have been recommended by the investigator which specifically investigate common, daily activities that the general public performs, mostly at a low aerobic level, such as walking, swimming, and yard work. Suggestions were made by the author to examine other indicators of exertion, such as breathlessness and lightheadedness, as well as using various populations, to include the inactive and diseased. In addition, he recommends more studies which use self-selected exercise intensity so that

better methods can be developed which to promote regular, moderate activity for the general population (16).

It is important to realize that people tend to regularly exercise only to a certain level of exertion, generally 11 - 13 (fairly light to somewhat hard) on the 20-point Borg (7) scale. When this normal exertion level is exceeded, then intensity level, as discussed previously by Dishman (16) tends to be a precursor to program dropout. It would therefore be beneficial to develop a program or provide a means by which individuals could exercise intensely without feeling they were working hard. Numerous studies have found that a higher level of work can be achieved when people are distracted during exercise.

Audio, visual, and interactive external stimuli have been used in various studies to affect a person's attention and focus during exercise so that they feel less fatigued during and after the bout of exercise. It is believed that this phenomenon occurs due to a shifting of attention away from one's internal focus to an external focus, thus altering the perception of the experience. By providing people with programs involving external stimuli to distract participants from negative perceptions of exercise, then more health benefits may result, including higher aerobic capacity, decreases in body fat, enjoyment of the exercise, and thus increased compliance.

Program adherence and improved fitness levels for their clients are the goals for all exercise professionals and program developers. These goals can be accomplished by reducing the negative perception of exercise through both internal and external positive feedback, and greater sensory interaction and external distraction during exercise. The participants are then much more

likely to stay with a program and remain physically active throughout their lifetime.

Perception and Exercise Adherence

Borg (8) has theorized that perception is the integration of several aspects of an individual which provide feedback about the exercise experience. Certain components can be manipulated or added to a program which affects people's perception of exercise and how hard they believe they are working. During exercise the participant has internal cues or messages which relay information to higher brain centers on how hard or intense the body is working during the experience. The ratings of perceived exertion (RPE) scale, developed by Borg (7), is a very common assessment instrument in both the laboratory and field setting. It is used to gauge, in a quantifiable manner, the subjective feelings of how hard a person is exercising. RPE has been defined by Borg (7) as a process which "integrates various information, including the many signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions, and from the central nervous system" to describe how hard one feels they are working (p. 377).

Since the development of the RPE scale, numerous validation studies have been conducted using a variety of conditions, from differing workloads and subjects to various modes and durations of activity. Many researchers have verified Borg's findings and have created applications for clinical and field use (17,18,29,30), while others have validated the scale using other modes and subject groups (33,35). Skinner, Hutsler, Bergsteinova, and Buskirk (33) performed a validity and reliability study using eight lean and eight obese men. The subjects exercised on a cycle ergometer in two sets of

trials with differing workload progressions, but to the same overall workload. No significant differences were found between the trials or subjects, therefore the RPE scale was considered both valid and reliable (33).

Robertson and colleagues (32) investigated the influences of cross-modal exercise on RPE. Eight male subjects exercised at constant loads for 12 minutes at an intensity which achieved 70% VO_{2max} as measured through a ventilatory process. The subjects performed on a treadmill, cycle ergometer, and bench steps using hand weights. The exertions were higher with the cycle and stepping as compared to the treadmill, however the investigators point out that exercising at this absolute value would definitely be of greater work since smaller muscle mass was utilized to perform the same amount of work. When the RPE's were adjusted for relative VO_2 there were no significant differences between modes. It was concluded that RPE was valid for use in a variety of exercise modes as long as relative VO_2 was used for exercise prescription (32).

Studies have repeatedly demonstrated the link between personal perception and levels of physical activity, and the self-regulation of exercise. RPE is often used in a nonlaboratory setting to self-regulate one's exercise intensity level, generally in a fitness center or phase III cardiac rehabilitation program. The ACSM (1) and cardiac population studies by Chow and Wilmore (12) recommend using RPE to regulate exercise intensity.

Ceci and Hassmen (11) conducted a study involving the self-regulation of three exercise RPE levels using both the treadmill and outdoor track. Eleven males were asked to replicate an RPE of 11, 13, and 15 both on a treadmill and outdoor track while measuring velocity, heart rate, and lactic acid levels. The researchers found good consistency between and within

sessions of the same exercise mode, however the outdoor physiological variables were higher than the treadmill even though the RPE levels were the same. It was concluded that some factor of outdoor exercise, such as a shifting of internal focus to external focus, contributed to the subjects performing a greater amount of physical exercise while feeling that they worked at the same intensity level.

A study by Bayles and associates (3) examined the effect of a perceptual reinforcement program in regulating exercise intensity using the RPE scale. Thirty men replicated exercise intensities of low (40% VO_{2max}), moderate (60% VO_{2max}), and high (80% VO_{2max}) intensities, twice on a treadmill and twice on an indoor track. Three groups were designated: practice with feedback, practice without feedback, and control. As expected, those subjects receiving constant reinforcement of perceptual regulation were better able to replicate the intensity levels. It was found by the researchers that all of the subjects worked harder on the track compared to the treadmill while maintaining the same RPE level. This observation may show the influence of increased external stimulation on perceived effort (3).

Perception has been expressed by Borg (7) as being derived by the individual from numerous cues throughout the body. These cues originate from many sources, such as joint proprioceptors, muscle motor units, baroreceptors, and blood pH detectors, as well as other physiological gauges. The signals interact with one another and are organized by the brain. Additional variables influence the configuration of these signals and include: past exercise performance, mood, emotional disposition, and goals. Once organized in the higher brain centers, these signals culminate into a single perception, or 'Gestalt', of how hard one is working (7). However, this

perception is transient, not only from one exercise session to another, but from moment to moment. Johnson and Siegel (23) have highlighted the relationship between perception and how it is affected by these various signals and other stimuli.

Attentional Focus, External Stimuli and Exercise Adherence

Johnson and Siegel (23) studied the effects of an active attentional focus (performing arithmetic problems), a passive attentional focus (listening to music), and a control (no stimulus) on a group of 26 female subjects while they exercised on a cycle ergometer for 5 minutes at 60 and 90% of their maximal VO_2 . A personal activity questionnaire (PAQ) and RPE scores were collected during the study. It was found that at a higher work load, the active intervention produced lower ratings of perceived exertion than either the music or no stimuli. A trend was also observed in that both the active and passive foci groups' RPE were less than the control group, indicating that any stimulus in general works to alter perception of exercise. It was concluded by the researchers that a more active stimulus results in less perceived exertion than with a less active stimulus. The researchers recommend that future studies be conducted for a longer exercise duration while measured with a test that is more sensitive to fatigue factors (23).

A study by Wrisberg and Pein (40) investigated the effect of previous running experience on individual attentional focus. Forty-nine men and 38 women were experienced runners and 66 men and 34 women were inexperienced runners who were given an attentional focus questionnaire. The results of the questionnaire reported that women in general dissociated more while running, and that experienced runners in general dissociated more while running. It was suggested by the investigators that since

experienced runners dissociate more than inexperienced runners, they are then better able to block out negative bodily cues during their exercise sessions (40).

A number of studies have investigated the effects of introducing a stimulus into the exercise environment to serve as a diversionary source in order to make exercise less tedious and/or more enjoyable. The perceptual configuration of internal cues can be altered by external information (11). It is believed that there is a limited capacity to the amount of attentional focus, and that when certain actions demand more attention, there is a shifting of attention away from internal sensations resulting in a lower perception of effort. External stimuli influences attention by adding to all of the messages within the brain, however some contribute less of an influence, while others produce more.

A study by Pennebaker and Lightner (31) compared the effects that external stimuli, both visual and auditory, had on reducing the feelings of exertion and fatigue while exercising. They found a significant decrease in self-reported fatigue levels when subjects ran at a self-selected pace on a treadmill while listening to external sounds, as opposed to when they listened only to their own internal breathing. Additionally, a second study was performed in which subjects ran 1800 m at a self-selected pace on both the treadmill and a cross-country course. No significant differences were reported in RPE levels, however the times for the cross-country course was 51 seconds less than times on the track. The researchers postulated that "subjects were focusing on external factors to a higher degree" ... and thus, "their processing of internal sensations were restricted (p. 171). It was theorized that the

introduction of an external focus, such as running outdoors, reduced the awareness of internal sensations and cues which detect fatigue (31).

An unpublished study by Viteri (38) tested the influences of television viewing on subjects while they exercised. Twelve volunteer female subjects were apparently healthy and regularly active. They performed two separate 30 minute exercise sessions at their own pace using a cycle ergometer with 1 kp resistance, once while watching television, and once without television. Perceived intensities of exertion, feeling scales, RPE, and HR were collected. No significant differences were observed between the two conditions for feeling scales, RPE and HR. However, subjects chose to exercise at a significantly lower pace while watching television than while exercising in a sterile environment. These findings are in contrast to the findings of Pennebaker and Lightner (31). The researcher emphasizes that boredom is a factor in the lack of adherence which tends to negatively affect future physical activity. The subjects who exercised in a sterile environment were self-reported as bored, which may have prompted more short-term work. However, it was expressed by the researcher that the use of television may enhance long term adherence to an exercise program.

A study by Boutcher and Trenske (9) supports the findings of Pennebaker and Lightner, as they examined the role that music plays on perception of effort during exercise. Twenty-four women exercised on a cycle ergometer during three separate 18 minute conditions at light (60% work capacity), moderate (75%), and heavy (85%) workloads for 6 minutes each. The three conditions included a control, visual and auditory deprivation, and self-selected music. It was found that there was a significantly lower RPE for the music condition than the deprivation condition at all intensity levels.

Also, there was a significantly lower RPE for the music condition than the control condition at a moderate intensity level. The subjects reported feeling better during the music session at moderate and high level of exercise compared to the deprivation condition. This study highlights the importance of external stimuli on perception of effort and the feeling of enjoyment during exercise (9).

Enjoyment and Exercise Adherence

Exercise enjoyment influences all aspects of the perception of exercise and activity, from intensity level and motivation to self-selected pace and adherence. The more a person enjoys an activity, the less they perceive the effort as being too demanding or vigorous. They receive rewards, such as success and pleasure which counterbalance the feelings of exertion or fatigue. The two major categories into which many of the adherence factors fall are motivation and exercise enjoyment. Exercise enjoyment is one of the primary determinants in long-term regular physical activity participation (16,34). Exercise enjoyment is a blend of what the program provides in terms of benefits and perks to the clients and what the participant believes is enjoyable.

A study by Mertesdorf (28) involved six male subjects who performed six different exercise sessions using a Schwinn Air-Dyne. There were three conditions involving music while pedaling at two different cadences of 65 and 70 rpm. For each cadence (65 or 70 rpm), the subject exercised first with a simple cadence rhythm, then in time with a musical tempo, and last in time with a musical tempo which increased or decreased based upon the speed of the cycle. It was found that subjects preferred the movement controlled tempo when compared to the simple rhythm device. There were no

differences between the feelings of exertion for all of the conditions. The important point was that enjoyment of the exercise at either cadence was highest when subjects could control the tempo and had a greater variety of music from which to listen. Since exercise enjoyment is an indicator for continued program compliance, then providing such configurations in music may aid in reducing attrition levels.

Motivation and Exercise Adherence

Motivation serves as a general grouping term for many of the adherence variables, and can be highlighted as one of the primary determinants in retaining individuals in an exercise program. It is paramount that professionals encourage and motivate their clients through a variety of means so that a higher retention rate can be realized. It is only through regular, continuous exercise and daily activity that people will gain the necessary health benefits (1).

Each person is unique, with the aspects within motivation ranked differently. According to McAuley (27) not only are these aspects different for each person, but they can even change many times throughout one's life. An individual's perception of exercise, benefits, outcomes, and specifically of self is crucial. Since this perception is slightly different for each person and can change based on other influencing factors it illustrates the need for individualized programs. Martin and Dubbert (25) found that an individual's self-perception and attitude plays a large part in program compliance, as many adherence aspects are related to an individual's attitude, such as personality, self-concept, and other personal thoughts. Motivation, from within or without, significantly affects retention levels in an exercise program. They also found that achievement of personal goals while in a program helps to

maintain the cohesiveness of the various physical and psychological improvements obtained in the program (25).

A personalized approach is also recommended by other professionals (13,14,22) by using programs which best suit clients' needs. The exercise specialist achieves these results by influencing modifiable factors, such as exercise intensity, attentional focus, external stimuli, and enjoyment. Biddle and Smith (4) highlight specific external and internal factors which influence exercise adoption. External factors include social support, from family members and friends, the convenience of the facility, adequate supervision, and income level of the participants, while internal factors range from anxiety and depression to goal achievement and type-A behavior. Biddle and Smith (4) recommend using programs which involve both internal and external factors, such as establishing realistic goals, providing verbal encouragement, prescribing a low to moderate intensity exercise program, and making the entire experience enjoyable for the client. By following this approach of incorporating both internal and external factors in a program, then participants will be more likely to remain.

Wankel (39) compared the type of program, and personal and social factors involved in continuing participants and drop-out participants of a male employee fitness program. The most important reason for beginning the program was to gain health-related benefits. The investigator found that continuous participants achieved more personal goals, had more support from family and friends, felt better after exercise, and developed more social interactions than drop-outs. This illustrates the multifaceted nature of adherence and the many factors which contributed to keeping a person within an exercise program. This study provided greater insight into the

reasons why a person stays with a program. The investigators suggest programs be developed which work to meet these individual needs (39).

Summary

By maintaining an exercise regimen participants are more likely to obtain positive physiological and psychological benefits. This creates a cascade of benefits which support exercise adherence. Adherence is a multifaceted challenge faced by all professionals in the fields of health, exercise, and fitness. It will continue to be an area which requires constant innovation. By engaging the participants in as many positive ways as possible, through integration of the various adherence factors, the outcome for continued regular physical activity during a lifetime is promising.

REFERENCES

1. American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, ed 5. Philadelphia, PA: Williams and Wilkins, 1995.
2. American Heart Association: Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circul.* 91:580-615, 1995.
3. Bayles, C. M., F. M. Kenneth, R. Robertson, F. L. Goss, J. Cosgrove, and D. McBurney. Perceptual regulation of prescribed exercise. *J Cardiopulm Rehab.* 10:25-31, 1990.
4. Biddle, S., & A. Smith. Motivating adults for physical activity: towards a healthier present. *J. P. E. R. D.* 62:39-43, 1991.
5. Blair, S. N., H. W. Kohl, R. S. Paffenbarger, D. G. Clark, K. H. Cooper, and L. W. Gibbons. Physical fitness and all-cause mortality: a prospective study of healthy men and women. *J. A. M. A.* 262:2395-2401, 1989.
6. Blair, S. N., J. B. Kampert, H. W. Kohl, C. E. Barlow, C. A. Macera, R. S. Paffenbarger, and L. W. Gibbons. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *J. A. M. A.* 276:205-210, 1996.
7. Borg, G. Perceived exertion: a note on "history" and methods. *Med. Sci. Sports* 5:90-93, 1973.
8. Borg, G. Psychological bases of perceived exertion. *Med. Sci. Sports Exerc.* 14:377-381, 1982.
9. Boutcher, S.H., and M. Trenske. The effects of sensory deprivation and music on perceived exertion and affect during exercise. *J. Sport Exerc. Psychol.* 12:167-176, 1990.
10. Brill, P.A., H. W. Kohl, and S. N. Blair. Anxiety, depression, physical fitness, and all-cause mortality in men. *J. Psychosom. Res.* 36:267-273, 1992.

11. Ceci, R., and P. Hassmen. Self-monitored exercise at three different PE intensities in treadmill vs field running. *Med. Sci. Sports Exerc.* 23:732-738, 1991.
12. Chow, R. J., and J. H. Wilmore. The regulation of exercise intensity by ratings of perceived exertion. *J. Cardiac Rehab.* 4:382-387, 1984.
13. Custer, S., and C. Doty. Assessment of self-motivation and selected physiological characteristics as predictors of adherence to exercise in a corporate setting. *J. Health Ed.* 23:232 - 237, 1992.
14. Dishman, R. K. Health psychology and exercise adherence. *Quest* 33:166-180, 1982.
15. Dishman, R. K. Exercise compliance: a new view for public health. *Phys. & Sportsmed.* 14:127-143, 1986.
16. Dishman, R. K. Prescribing exercise intensity for healthy adults using perceived exertion. *Med. Sci. Sports Exerc.* 26:1087-1094, 1994.
17. Dunbar, C. C., R.J. Robertson, and R. Baun. The validity of regulating exercise intensity by ratings of perceived exertion. *Med. Sci. Sports Exerc.* 24:94-99, 1992.
18. Glass, S. C., R. G. Knowlton, and M. D. Becque. Accuracy of RPE from graded exercise to establish exercise training intensity. *Med. Sci. Sports Exerc.* 24:1303-1307.
19. Guyton, A. C. and J. E. Hall. *Textbook of Medical Physiology*, ed 9. Philadelphia, PA: W.B. Saunders Company, 1996.
20. Harte, J. L., and G. H. Eifert. The effects of running, environment, and attentional focus on athletes' catecholamine and cortisol levels and mood. *Psychophys.* 32:49-54, 1995.
21. Heinzelmann, F., and R. W. Bagley. Response to physical activity programs and their effects on health behavior. *Public Health Report* 85:905-911, 1970.
22. Heyward, V. H. *Advanced Fitness Assessment & Exercise Prescription*, ed 2. Champaign, IL: Human Kinetics, 1991.
23. Johnson, J., and D. Siegel. Active vs. passive attentional manipulation and multidimensional perceptions of exercise intensity. *Can. J. Sport Sci.* 12:41-45, 1987.

24. Kavussanu, M., and E. McAuley. Exercise and optimism: are highly active individuals more optimistic? *J. Sport Exerc. Psychol.* 17:246-258, 1995.
25. Martin, J. E., and P. M. Dubbert. Exercise applications and promotion in behavioral medicine: current status and future directions. *J. Consult. Clin. Psychol.* 50:1004-1017, 1982.
26. McArdle, W. D., F. I. Katch, and V. L. Katch. *Essentials of Exercise Physiology*, ed. 4. Philadelphia, PA: Lea & Febiger, 1994.
27. McAuley, E. Understanding exercise behavior: a self-efficacy perspective. In: *Motivation in Sport and Exercise*. G. C. Roberts (Eds.). Champaign, IL: Human Kinetics, 1992, pp. 107-127.
28. Mertesdorf, F. L. Cycle exercising in time with music. *Percept. & Motor Skills* 78:1123-1141, 1994.
29. Noble, B. J. Clinical applications of perceived exertion. *Med. Sci. Sports Exerc.* 14:406-411, 1982.
30. Pandolf, K. B. Differential ratings of perceived exertion during physical exercise. *Med. Sci. Sports Exerc.* 14:397-405, 1982.
31. Pennebaker, J. W., and J. M. Lightner. Competition of internal and external information in an exercise setting. *J. Personality & Social Psychol.* 39:165-174, 1980.
32. Robertson, R. J., F. L. Goss, T. E. Auble, D. A. Cassinelli, R. J. Spina, E. L. Glickman, R. W. Galbreath, R. M. Silberman, and K. F. Metz. Cross-modal exercise prescription at absolute and relative oxygen uptake using perceived exertion. *Med. Sci. Sports Exerc.* 22:653-659, 1990.
33. Skinner, J. S., R. Hutsler, V. Bergsteinova, and E. R. Buskirk. Perception of effort during different types of exercise and under different environmental conditions. *Med. Sci. Sports* 5:110-115, 1973b.
34. Sonstroem, R. Psychological models. In: *Exercise Adherence: Its Impact on Public Health*. R. Dishman (Ed.). Champaign, IL: Human Kinetics, 1988, pp. 125-153.
35. Swaine, I. L., J. Emmett, D. Murty, C. Dickson, and M. Dudfield. Rating of perceived exertion and heart rate relation to ventilatory threshold in women. *Br. J. Sports Med.* 29:57-60, 1995.

36. U.S. Department of Health and Human Services. *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. DHHS Publication, No. PHS 91-502131. Washington, DC: Public Health Service, 1990.
37. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Center for Chronic Disease Prevention and Health Promotion. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: Public Health Service, 1996.
38. Viteri, J. E. The effects of television viewing on the self-regulation of exercise intensity. *Microform Publications*. University of Oregon. Eugene, OR: International Institute for Sport and Human Performance, 1995.
39. Wankel, L. M. Personal and situational factors affecting exercise involvement: the importance of enjoyment. *Res. Q. Exercise Sport* 56:275-282, 1985.
40. Wrisberg, C. A., and R. L. Pein. Past running experience as a mediator of the attentional focus of male and female recreational runners. *Percept. & Mot. Skills*. 70:427-432, 1990.