ABSTRACT

MALDARI, M. M. *A comparison of the physiological and psychological responses to exercise on a virtual reality recumbent cycle versus a non-virtual reality recumbent cycle.* MS in Adult Fitness/Cardiac Rehabilitation, August 1997, 57 pp. (J. Porcari)

This study compared the physiological and psychological responses to exercise on a virtual reality (VR) cycle versus a non-VR cycle. Ss included 18 healthy volunteers (10M, 8F) between the ages of 21 and 41 years. During testing sessions, Ss completed pretest Exercise Induced Feeling (EFI) and Profile of Mood States (POMS) questionnaires, and performed 20 minutes of self-selected exercise on each cycle. HR, VO₂, RPE, RER and Kcal were recorded every minute. Posttest EFI and POMS questionnaires were completed after each exercise session. Significant increases (p < .05) were found for both VO₂ (12%) and Kcal expenditure (14%) during the VR condition compared to the non-VR condition. POMS scores indicated a significant (p < .05) reduction in Anger after the VR condition. Physical Exhaustion as measured by the EFI increased significantly (p < .05) after the VR condition. There were no significant between group differences on any of the POMS or EFI variables. Responses to a follow-up questionnaire indicated that all 18 Ss preferred the VR cycle over the non-VR cycle and felt that it would most likely influence the frequency and duration of their exercise sessions. Thus, it appears that the VR recumbent cycle may be effective in motivating individuals to exercise more frequently and at a higher VO₂ and Kcal expenditure than a standard, non-VR recumbent cycle.
A COMPARISON OF THE PHYSIOLOGICAL AND PSYCHOLOGICAL
RESPONSES TO EXERCISE ON A VIRTUAL REALITY
RECUMBENT CYCLE VERSUS A NON-VIRTUAL REALITY
RECUMBENT CYCLE

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
MONICA MARISA MALDARI
AUGUST 1997
Candidate: Monica Marisa Maldari

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science in Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature

Thesis Committee Member Signature

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This thesis is approved by the College of Health, Physical Education, and Recreation.

Associate Dean, College of Health, Physical Education, and Recreation

Dean of Graduate Studies

5-15-97

16 May 1997
ACKNOWLEDGMENTS

I would like to thank my chairperson, Dr. John Porcari, for his time, guidance, and support. I am excited that I will have the opportunity to present this project at the American College of Sports Medicine (ACSM) conference in Denver and I am grateful for Dr. Porcari’s help in getting it to this point. I would also like to thank Dr. Richard Pein and Dr. Paul Keaton for serving as thesis committee members.

Throughout my life I have had such incredible support from my parents, Mario and Nancy Maldari, and from my brothers, Mario Jr. and Enrico Maldari. I love you all very much and feel so fortunate to have you not only as family, but also as friends.

Finally, I would like to thank my best friend and fiancé, Shawn King, who made the ultimate sacrifice by packing up and moving out to Wisconsin so that we could be together. His love, encouragement, and humor have made even the most stressful times much easier to handle. I am so lucky to have you in my life, and I look forward to the rest of our lives together.
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INTRODUCTION

Many in the field of exercise and sport science agree that exercise not only promotes longevity and health, but is also associated with improvements in mood states and overall feelings of psychological well-being. Thus, many adults are initiating exercise programs in an attempt to achieve these benefits. Although it seems that many individuals are eager and willing to begin a program, about one-half of them drop out within the first 6 months (18). This attrition rate is primarily caused by the fact that few people find an exercise they enjoy enough to keep them motivated (13).

Therefore, it is of great concern for physiologists, psychologists, and other health professionals to determine the most effective ways to enhance interest in and motivation to exercise. Most often an individual’s subjective feelings of fatigue, pain, and boredom dictate the intensity they choose to work at, as well as whether or not they choose to maintain physical activity. These subjective sensations of pain, fatigue, and boredom are extremely complex and very personal, therefore making them difficult to quantify.

Despite the difficulty in measuring subjective feelings towards exercise, many researchers have found that external factors in the environment appear to distract people from their internal feelings. External factors are visual stimuli or sounds that often result in a delay of the onset of fatigue. Pennebaker and Lightner (15) have found that subjects who listened to distracting sounds during exercise reported less fatigue than subjects who
listened to an amplification of their own breathing. Other studies have investigated the influences of music and television on perceived exertion and exercise intensity and have found that these external distractions are associated with an altered perception of workload intensity at a given workload (3,7).

Previous research has also indicated that the ability to choose between various activities positively affects program attendance (16). Thus, many exercise equipment manufactures are developing new and innovative exercise machines that are not only aerobically effective, but also are novel or fun for the exerciser. One of the most recent of these machines is the virtual reality (VR) recumbent cycle developed by Tectrix, Inc. (Irvine, CA). This VR exercise machine attempts to mimic the actual feeling of riding a recumbent cycle outside by providing proprioceptive, visual, and audio cues to the exerciser. The purpose of the present investigation was to investigate the effects of a VR recumbent cycle on self-selected intensity, rating of perceived exertion, and mood states during exercise, as well as attitude towards and overall enjoyment of exercise.

METHODS

Subject Selection

Ten male and eight female subjects, ranging in age from 21 to 41 years volunteered to participate in the study. Subjects were recruited from the University of Wisconsin-La Crosse and the surrounding community. All subjects were apparently healthy and participated in regular aerobic activity (at least 3 days per week for at least 20 minutes). Prior to the testing sessions, each subject read and signed both a Physical Activity
Readiness Questionnaire (PAR-Q) (1) (see Appendix A) and an informed consent form (see Appendix B). The testing protocol was approved by the Institutional Review Board at the University of Wisconsin-La Crosse.

**Practice Sessions**

Subjects were required to attend two practice sessions on both the VR and non-VR cycles before completing the actual testing session. The practice sessions occurred 2 to 4 days before the actual testing on the VR cycle or non-VR cycle. In the laboratory, subjects’ height (cm) and weight (kg) were measured and proper use of both the VR cycle and non-VR cycle was demonstrated. After the demonstration, subjects were asked to practice on each machine until they felt comfortable and did not experience any awkwardness in operating the machines. During the second practice session, subjects practiced using the exercise machines while wearing the headgear and mouthpiece that they would be required to wear for gas collection purposes during the actual test.

**Day 1 Testing**

During testing, all of the laboratory clocks were covered and subjects were asked to remove their wrist watches. This was done so that the subjects had no knowledge of how much time had passed during the 20 minute exercise session. Subjects’ height and weight were once again recorded and the researcher explained and read specific instructions on the proper use of the Rating of Perceived Exertion (RPE) scale (2) (see Appendix C). The researcher also explained the Exercise Induced Feeling Inventory (EFI) (10), the Profile of Mood States (POMS) (14), and all test procedures. The subjects then
completed the preexercise EFI (see Appendix D) and POMS (see Appendix E). Once finished with the questionnaires, the subjects were randomly assigned to the VR cycle or non-VR cycle and were instructed to ride at a self-selected pace for 20 minutes. During the VR condition, subjects were given a choice of riding a preset race course or following a tour guide. Both courses were similar in that they traveled up and down hills as well as underwater. The researcher did not make any comments or give any kind of encouragement during the test. HR, VO$_2$, RER, and Kcal were recorded every minute and RPE every 3 minutes (see Appendix F). After exercise, subjects were allowed to cool down and then completed the postexercise EFI and POMS questionnaires.

The Q-Plex I (Quinton Instrument Company, Seattle, WA), an automated open-circuit gas system, was used to collect and analyze the expired air and to calculate absolute and relative oxygen consumption, caloric expenditure, and respiratory exchange ratio. The Q-Plex I was calibrated prior to testing each subject using calibration gases whose compositions were determined by the micro-Scholander technique. The flow meter volume was calibrated using a 3.002 L syringe pump at various flow rates. Heart rates were monitored using the Polar Vantage XL HR system (Polar, Inc., Stamford, CT).

**Day 2 Testing**

The same procedures as Day 1 were followed during the second day of testing, the only exception being that the subject exercised on the recumbent cycle they did not use on Day 1.
Posttest Follow-Up

Approximately 2 days after the successful completion of exercise sessions on both the VR and non-VR cycles, a follow-up questionnaire was mailed to the subjects (see Appendix G). Subjects were requested to complete the questionnaire and return it in the self-addressed, stamped envelope provided. The questionnaire inquired about their experiences on both the VR and non-VR cycles and whether or not access to a VR cycle would affect their exercise intensity, frequency, or duration during their personal exercise sessions.

Statistical Analyses

Data analysis was performed using the SPSS statistical software (Lawrence Erlbaum Associates, Publishers, Hillsdale, US). Descriptive statistics, including means and standard deviations were computed for all variables. A two-way ANOVA with repeated measures was used to test for significant physiological differences between males and females and between conditions. No significant differences ($p > .05$) were found between genders, therefore the data were collapsed and paired t-tests were used to compare the responses to the VR and non-VR conditions. A three-way ANOVA with repeated measures (sex by condition by pre-post) was used to analyze the POMS and EFI questionnaires. There were no significant differences ($p > .05$) between the males' and females' responses to each condition, thus data were collapsed across gender for analysis.

RESULTS

The physical characteristics of the subjects are presented in Table 1.
Table 1. Descriptive Characteristics of the Subject Population (N = 18)

<table>
<thead>
<tr>
<th>Gender  (n)</th>
<th>Age (years) X ± SD (range)</th>
<th>Height (cm) X ± SD (range)</th>
<th>Weight (kg) X ± SD (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females (8)</td>
<td>30.0 ± 8.33 (23–41)</td>
<td>161.0 ± 10.9 (160–175)</td>
<td>62.5 ± 9.5 (51.1–82.8)</td>
</tr>
<tr>
<td>Males (10)</td>
<td>30.3 ± 7.2 (21–40)</td>
<td>179.6 ± 7.9 (170.2–188.0)</td>
<td>81.9 ± 9.5 (70.6–98.2)</td>
</tr>
</tbody>
</table>

Table 2 summarizes the physiological responses to exercise for each condition. It was found that exercise on the VR cycle elicited a significantly higher (p < .05) VO₂ (12%) and caloric expenditure (14%) than exercise on the non-VR cycle. However, no significant differences (p > .05) were found for HR, REIs, and RPE between conditions.

Table 2. Physiological Responses to Exercise on the VR and Non-VR Cycles

<table>
<thead>
<tr>
<th>Variable</th>
<th>Non-VR X ± SD</th>
<th>VR X ± SD</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (bpm)</td>
<td>140 ± 19.3</td>
<td>145 ± 15.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Kcal</td>
<td>8.6 ± 2.0</td>
<td>9.8 ± 2.2</td>
<td>1.2*</td>
</tr>
<tr>
<td>VO₂ (ml·kg⁻¹·min⁻¹)</td>
<td>23.8 ± 5.7</td>
<td>26.6 ± 4.2</td>
<td>2.8*</td>
</tr>
<tr>
<td>RER</td>
<td>0.98 ± .004</td>
<td>1.00 ± .003</td>
<td>0.02</td>
</tr>
<tr>
<td>RPE</td>
<td>14.6 ± 1.8</td>
<td>14.8 ± 1.9</td>
<td>0.2</td>
</tr>
</tbody>
</table>

* Significant difference (p < .05) between VR and non-VR
Profile of Mood States (POMS)

The results of the POMS scores are summarized in Table 3. For the VR condition, there were no significant changes (p > .05) from pre- to posttesting for the Total Mood Disturbance score or for the following subscales: Tension (T), Depression (D), Vigor (V), Fatigue (F), and Confusion (C). There was a significant reduction (p < .05) in the Anger subscale, indicating that the VR exercise bout reduced overall feelings of anger and hostility. There were no significant changes (p > .05) on any of the POMS variables for the non-VR condition. No significant interactions were observed between the VR and non-VR conditions, indicating that there were similar trends for both conditions from pre to posttesting.

Table 3. Responses to the Profile of Mood States (POMS) Questionnaires

<table>
<thead>
<tr>
<th>Factor</th>
<th>Virtual Reality</th>
<th>Non-Virtual Reality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Total</td>
<td>98.4 ± 15.6</td>
<td>95.3 ± 10.7</td>
</tr>
<tr>
<td>V</td>
<td>16.7 ± 5.0</td>
<td>18.0 ± 5.1</td>
</tr>
<tr>
<td>T</td>
<td>4.0 ± 2.9</td>
<td>3.9 ± 2.2</td>
</tr>
<tr>
<td>C</td>
<td>3.8 ± 3.5</td>
<td>2.3 ± 1.9</td>
</tr>
<tr>
<td>D</td>
<td>1.2 ± 2.7</td>
<td>0.3 ± 0.9</td>
</tr>
<tr>
<td>F</td>
<td>4.3 ± 5.0</td>
<td>5.9 ± 4.7</td>
</tr>
<tr>
<td>A</td>
<td>1.9 ± 2.8</td>
<td>0.8 ± 2.3</td>
</tr>
</tbody>
</table>

*Significant difference (p < .05) between pre- and posttesting scores
V = Vigor, T = Tension, C = Confusion, D = Depression, F = Fatigue, A = Anger
Exercise-Induced Feeling Inventory (EFI)

The results of the EFI questionnaire are presented in Table 4. During the VR condition, there was a significant increase (p < .05) in Physical Exhaustion scores between pre- and posttesting. There were no significant changes (p > .05) from pre- to posttesting on any of the remaining EFI factors. No significant differences were found (p > .05) between any of the factors on the non-VR condition. Significant interactions (p > .05) were not observed between the VR and non-VR condition, indicating that the EFI response to both conditions were similar over time.

Table 4. Responses to the Exercise-Induced Feeling Inventory (EFI) Questionnaires

<table>
<thead>
<tr>
<th>Factor</th>
<th>Virtual Reality</th>
<th>Non-Virtual Reality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>PH</td>
<td>2.9 ± 2.8</td>
<td>5.6 ± 3.0</td>
</tr>
<tr>
<td>PE</td>
<td>7.3 ± 2.6</td>
<td>7.9 ± 2.1</td>
</tr>
<tr>
<td>R</td>
<td>5.1 ± 1.8</td>
<td>6.5 ± 3.5</td>
</tr>
<tr>
<td>T</td>
<td>6.6 ± 2.8</td>
<td>6.4 ± 2.0</td>
</tr>
</tbody>
</table>

*Significant difference (p < .05) between pre- and posttesting
PH = Physical Exhaustion, PE = Positive Engagement, R = Revitalization, T = Tranquility

Follow-up Questionnaire

The follow-up questionnaire indicated that the subjects unanimously preferred the VR cycle over the non-VR cycle. A Likert scale with a rating of “1” being “not at all
effective/enjoyable,” and a rating of “10” being “highly effective/enjoyable” was used to assess subjects’ reactions to exercise during each condition. Subjects averaged a score of 9 when asked “How enjoyable was your VR workout?” whereas they only averaged a score of 4 when asked “How enjoyable was your non-VR workout?” Subjects also indicated by an average score of 8 that VR technology would influence how frequently they exercised. When asked how effective VR technology would be in extending the length of workout time, subjects indicated with a score of 9 that a VR cycle would be highly effective in extending the duration of their workout. Finally, subjects indicated with a score of 8 that the availability of a VR machine might have an impact on their decision to join one particular health club over another.

**DISCUSSION**

This study investigated the physiological and psychological effects of exercising on a virtual reality (VR) recumbent cycle versus its non-virtual reality (non-VR) counterpart. It was found that, at similar levels of perceived effort, exercise during the VR condition resulted in a 12% significantly higher oxygen consumption and 14% significantly higher caloric expenditure than the non-VR condition.

Several theories may be offered to explain the increases in VO₂ and Kcal expenditure measured during exercise on the VR cycle. The first is that these increases may be a result of the subjects’ focus on the external environment of the VR screen rather than their body’s internal sensations. It is possible that this focus on external cues during the VR condition was effective enough to delay the subjects’ feelings of fatigue, thus
allowing them to work at a higher VO$_2$ and caloric expenditure than during the non-VR condition. This finding agrees with Pennebacker and Lightner’s (15) research investigating the effects of attentional focus on running times. They found that subjects who ran on a wooded cross-country trail ran faster than they did when they ran the same distance on a track. The authors proposed that during the cross-country condition, runners attended more toward their external surroundings than they did when running on the track. It is believed that this shift of attention from the internal sensations of pain and fatigue to the external environment of the cross country course contributed to the faster running times.

The VR cycle’s riding environment also may have been a contributing factor in the increase in VO$_2$ and caloric expenditure measured during the VR condition. The VR cycle incorporated sounds related to the environment of the cycling program (i.e., bird songs, Caribbean music, and the sound of waves). These sounds were not present during the non-VR condition. This auditory stimulus provided by the VR condition may have also contributed to the subjects’ external shift of attention. This theory is supported by Copeland and Franks (7), who found that listening to certain types of music caused an external focus of attention during exercise and resulted in an increased time to exhaustion during treadmill walking. Pennebacker and Lightner (15) found that subjects who listened to street sounds (e.g., passing cars and parts of conversations) while walking on a treadmill reported less fatigue than did subjects who listened to an amplification of their
own breathing, thus suggesting that attention to internal bodily information increased perceived fatigue.

During exercise on the VR machine, subjects cycled up hills, through water, and over various terrain, all of which increased the intensity of the workload. Subjects were also able to participate in a race against computer-generated cyclists. The addition of competition to the exercise session often forced participants to pedal much harder than when no competition was presented. Conversely, on the non-VR cycle, subjects rode at a self-selected pace and rarely adjusted the pedaling resistance in order to vary the intensity of their workload. There were no visual or auditory stimuli to focus on during the non-VR condition. This may have led subjects to concentrate more on their internal environments (i.e., breathing, body temperature, and heart rate). Thus, it appears that the interactive nature of the VR cycle’s changing environment required the subjects to focus their attention externally, thereby reducing their awareness of internal sensations and causing them to exercise at a higher oxygen consumption and caloric expenditure than on the non-VR cycle. In addition, the VR cycle also required subjects to use their upper body to tilt their seat and “steer” the cycle through the environment. This utilization of upper body musculature may have also contributed to the increased oxygen consumption and caloric expenditure.

Analysis of the psychological questionnaires revealed few statistically significant results. It was expected that exercise on both cycles, but more specifically the VR cycle, would result in a more favorable psychological profile after exercise. This, however, was
not the case. Examination of the POMS concluded that exercise on the VR cycle only resulted in a significant decrease in Anger. There were no other significant differences on any of the other POMS subscales for either condition. These findings do not agree with previous research indicating that exercise results in improvements in psychological profiles (4,12,17).

Significant changes, as measured by the POMS, appear to be dependent upon the initial psychological status of the subjects. Several studies (9,17) show that those who had poorer psychological profiles at the beginning of an exercise program had greater psychological improvement, while those who initially had good profiles showed little, if any, improvement after exercise. Subjects in the present investigation had lower than average POMS scores prior to their exercise sessions. Because of these initial values, any additional psychological gains from exercise may have been too slight to be considered significant.

The EFI questionnaire (10), designed to assess feeling states that occur in conjunction with acute bouts of physical activity, showed significant increases only in Physical Exhaustion after exercise on the VR cycle. This is most likely related to the fact that the subjects exercised at a higher VO₂ and caloric expenditure during the VR condition. There were no significant differences between any of the remaining factors during either condition, possibly due to the fact that the EFI's subscales could not appropriately assess feelings associated with the interactive type of exercise that the VR cycle provided.
The results of the present study offer many practical implications. It appears that exercise on a VR cycle elicits a higher oxygen consumption and caloric expenditure at the same RPE as exercise on a non-VR cycle. Subjects also indicated, via questionnaire, that exercise on the VR cycle would most likely increase both the frequency and the duration of their workouts. The combination of elevated physiological responses as well as increased exercise frequency and duration with the VR cycle may elicit gains in aerobic capacity and improvements in body composition more quickly and to a greater degree than exercise on non-VR equipment.

It has been well documented that individuals drop out of exercise programs due to lack of motivation or boredom (5,6,8,11). Thus, the aforementioned improvements in aerobic capacity and body composition resulting from exercise on the VR machine may motivate individuals to maintain their exercise programs. In addition, exercise on a VR cycle may elicit a shift in attentional focus that serves to decrease subjective feelings of boredom and fatigue and thus increase exercise adherence.

The results of this study provide a basis upon which further research may investigate other physiological and psychological aspects of VR and its effects on exercise enjoyment and adherence. Future research might attempt to evaluate subjects' specific attentional foci during each condition, either through the analysis of eye focus during activity or via questionnaire. Additional research might also group subjects into those who focus internally and those who focus externally during exercise and compare their physiological and emotional reactions to exercise on the VR cycle.
REFERENCES


APPENDIX A

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)
Personal Data Information:

Name: (last) ____________________________ (first) ____________________________

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: ___/___/____

Physical 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?

APPENDIX B

INFORMED CONSENT FORM
Informed Consent to Act as a Subject in a Research Study

Title: A comparison of virtual reality aerobic exercise equipment and non-virtual reality aerobic exercise equipment in terms of ratings of perceived exertion, self-selected exercise enjoyment, overall exercise enjoyment.

Investigators:
John Porcari, Ph.D. - Committee Chairperson
Exercise and Sports Science Department, Room 216 Mitchell Hall
Phone: 785-8684
Monica Maldari, 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 how virtual reality (VR) exercise equipment affects exercise intensity, perception of exertion, and overall exercise enjoyment when compared to non-virtual reality exercise equipment. During this test, you will be asked to exercise at your own pace on both the VR and non-VR recumbent cycles while perceptual and physiological measurements are being taken. The physiological measurements will include heart rate which will be measured by a heart rate monitor worn around the chest during exercise. Oxygen consumption will be determined throughout the test. You will wear a head harness, which holds a mouthpiece (similar to a snorkel mouthpiece), and a nose clip during the testing. You will breathe room air through plastic tubing via a 2-way valve. The air you breathe out will be channeled to gas analyzers in order to accurately determine your oxygen consumption. The perceptual measurements include the following: Profile of Mood States (POMS), Exercise Induced Feeling Inventory (EFI), and Rating of Perceived Exertion (RPE).

Two orientation days will be conducted prior to any testing. Each of these sessions should last approximately 30 minutes. On the first day of orientation, you will complete a personal health and information questionnaire (PAR-Q) and an informed consent form. During the orientation days, you will become acquainted with both pieces of exercise equipment and the testing procedure.

After the orientation, you will return for two (2) separate days of testing. Each testing day will last approximately one hour. Prior to exercise, you will complete the POMS and EFI questionnaires. You will then exercise on either the VR or non-VR cycle for 20 minutes at your own pace while the aforementioned physiological and perceptual measurements are being taken. Following successful completion of both testing sessions, you will be mailed an Equipment Comparison Questionnaire and asked to return it within 3 days.
Risks and Discomforts:

With any type of physical activity, there is a certain amount of risk. Though the investigators have attempted 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 researcher.

Inquiries:

You are encouraged to ask any questions you may have concerning the test and 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 investigation 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. 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

_________________________________________  ______________________
Initials                                      Date
APPENDIX C

RATING OF PERCEIVED EXERTION (RPE)
RATING OF PERCEIVED EXERTION (RPE)

6

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

**Explanation of RPE to Subjects**

"Rating of perceived exertion (RPE) is a subjective measure that will indicate how hard you feel you’re working. As you can see by the chart in front of you, the scale ranges from 6 to 20, 6 being what you feel right now as you are sitting and resting. The scale then progresses through to 20 which is the feeling that the work is so hard, you can no longer continue no matter how hard you try. You will be asked to evaluate your RPE throughout the test by pointing to the appropriate number you see on the display monitor. Please be as truthful and as accurate as possible when choosing your RPE value. There is no right or wrong answer, it is simply how you feel at that moment. Do you have any questions?"
APPENDIX D

EXERCISE INDUCED FEELING INVENTORY (EFI)
subject #
pretest / posttest
date:

EXERCISE-INDUCED FEELING INVENTORY

Instructions: 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.

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)

APPENDIX E

FIVE SELECTED ITEMS FROM THE PROFILE OF MOOD STATES (POMS)
5 SELECTED ITEMS FROM THE
PROFILE OF MOOD STATES (POMS) QUESTIONNAIRE

The numbers refer to these phrases.

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

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friendly</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Tense</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Angry</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Worn out</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Unhappy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</table>

APPENDIX F

DATA COLLECTION SHEET
DATA COLLECTION SHEET

TEST 1
VR BIKE / NON VR BIKE
DATE: _________________
SUBJECT #: _______________
HEIGHT (in): _______
WEIGHT (lb): ______ (kg): ______

TEST 2
VR BIKE / NON VR BIKE
DATE: _________________
SUBJECT #: _______________
HEIGHT (in): _______
WEIGHT (lb): ______ (kg): ______

<table>
<thead>
<tr>
<th>TIME</th>
<th>RPE</th>
<th>TIME</th>
<th>RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pretest</td>
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<td>pretest</td>
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<td>20 min</td>
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</table>

COMMENTS: 
APPENDIX G

FOLLOW-UP QUESTIONNAIRE
POSTEXERCISE QUESTIONNAIRE

1. Which exercise did you prefer (circle one)?
   - Virtual Reality (VR) bike
   - Non-Virtual Reality (nonVR) bike

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 Non-Virtual 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
   - Effective
   - Effective
   - Highly Effective

   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
   - Effective
   - Effective
   - Highly Effective

   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 per session)?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Effective</th>
<th>Highly Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 3 4 5 6</td>
<td>7 8 9 10</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Effective</th>
<th>Highly Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 3 4 5 6</td>
<td>7 8 9 10</td>
</tr>
</tbody>
</table>

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

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

!!!!!!!!THANK YOU FOR YOUR PARTICIPATION IN THIS STUDY!!!!!
APPENDIX H

REVIEW OF LITERATURE
REVIEW OF RELATED LITERATURE

Introduction

Despite vast amounts of evidence citing the positive benefits of exercise, many individuals have difficulty initiating and maintaining a regular exercise program. It is therefore important for those in the field of exercise and sport science to understand the physiological and psychological mechanisms behind exercise adherence in addition to the affects that attentional diversions have on perceived exertion. Through understanding of these processes, health and fitness professionals may be able to create exercise programs that can increase adherence. This review of literature discusses factors influencing exercise adherence such as effects of attentional focus on perceived exercise intensity, as well as the questionnaires used to evaluate the psychological effects of exercise: Rating of Perceived Exertion (3), Profile of Mood States (25), and Exercise Induced Feeling Inventory (18).

Exercise Adherence

Many in the fields of exercise science and sport psychology are interested in the physiological and/or psychological factors that influence an individual’s decision to drop out of or continue an exercise program. A number of epidemiological studies (2, 31, 37) have shown physical activity to have positive benefits on overall health and longevity. Therefore, apparently healthy members of the public as well as coronary-risk and cardiac
patients are encouraged to exercise. Despite this recommendation, many of those who would like to be more active or those who might benefit the most from activity are unable to maintain regular exercise schedules or never initiate programs in the first place (39). Studies indicate that approximately half of those who begin an exercise program, whether on their own or in a structured program, drop out of the program within three to six months (12, 29). Low adherence levels have also been found to occur in apparently healthy, coronary-risk, and cardiac rehabilitation populations (6, 8). The majority of dropouts occur within the first three months and are followed by continued deterioration, with attrition leveling off between 50 and 70% after 12 to 24 months (8).

The ability to identify the traits that affect one’s likelihood of maintaining an exercise program, as well as specific programs that retain the greatest number of people, would greatly help our understanding of exercise adherence. Dishman (13) identified two approaches that have been used to investigate the problem of exercise compliance. The first is the practical approach of the exercise program director. This approach involves one-time measurements of factors that correlate with dropout, and is followed by an attempt to change these factors or accommodate them. The second approach is the theoretical approach of the psychologist or health educator. This approach draws on existing theories and techniques for changing behavior and applies them to exercise. Unfortunately, neither of these approaches have proved adequate in predicting one’s adherence to exercise, as they are one-time measurements and cannot account for changes
over time. This is one reason why characteristics that correlate with the initiation of a program or early compliance cannot predict compliance over the long-term.

In an attempt to characterize the general population, many studies have classified individuals into the following categories: “exercise nonparticipant, dropout, poor adherer, and good adherer” (1,14,20,24). Among these groups, Martin (23) has further subdivided the categories associated with exercise participation into the following: Subject Factors, Social/Environmental Factors, and Exercise Program Factors.

Subject Factors

Subject Factors are considered to be an individual’s inherent genetic traits that may influence exercise adherence. Subject Factors include concepts such as attitude toward exercise, self-motivation, and behavioral patterns. Ironically, an individual may have a positive attitude toward exercise, but this trait does not appear to predict participation or later adherence (14). These individual traits may have a strong influence on adherence as “Many personal habits, characteristics, and circumstances that discourage exercise compliance may be unavoidable or as resistant to change as is exercise compliance itself” (13). Examples of these characteristics and habits include smoking, poor use of leisure time, obesity, blue collar employment, and lack of support from the spouse. Although these factors are believed to be associated with compliance, they are not accurate predictors of exercise adherence. Biological factors such as aerobic fitness and body composition are also thought to influence an individual’s attitudes toward and motivation
to exercise. In fact, some research has identified a relationship between high body fat percentage, excess weight, and lower exercise adherence (14,24).

One factor that has consistently been shown to predict exercise adherence however, is self-motivation. Although the term "motivation" is considered a major trait affecting exercise adherence, there is currently little agreement as to the underlying nature and definition of motivation (40). In 1981, Dishman and Ickes (15) created the Self-Motivation Inventory (SMI) in an attempt to provide an objective measure of individual motivation. Low self-motivation as measured by the SMI appears to predict attrition from an exercise program. It has also been suggested that a link exists between the maintenance of self-motivation and the achievement of one's exercise goals. Danielson and Wanzel (11) found that exercisers who failed to attain their exercise goals dropped out approximately twice as fast as those who did attain them.

Individuals have many reasons for choosing to exercise. Some of the primary motives for exercising have been identified as: health and fitness, a means to improve appearance, enjoyment, social experience, and psychological benefits (40). Conversely, many reasons have been given for why one does not participate in a regular exercise program. The most popular of these are: lack of time, fatigue, inaccessible program location, lack of knowledge about fitness, lack of willpower, and spousal support (7,13). Lack of time appears to be the most popular reason for not exercising, however, lack of time is not the real issue for most people. Individuals can often find or make time for activities they enjoy such as going to a movie, watching television, and other pastimes.
It is therefore important for health professionals to recognize this fact and attempt to offer programs that not only bestow health benefits, but also provide enjoyment and personal satisfaction.

Reinforcement from spouses or family has also been consistently related to increased exercise adherence. Heinzelmann and Bagley (20) found that those who complied with preventative exercise programs were twice as likely to have spouses with positive attitudes toward exercise. Another investigation looking at rehabilitation programs concluded that cardiac patients without spousal support were three times more likely to drop out than those with spousal support (1).

It should be noted that even though many reasons to not exercise are rationalizations and misperceptions of barriers, studies have shown that from 10 to 40% of nonmedical barriers are unavoidable (13). Dropout, therefore, is not always a behavioral problem and may not always respond to behavioral interventions. Compliance interventions should thus differ depending on whether a barrier is real or perceived, or is only a rationalization or excuse for noncompliance.

Social/Environmental Factors

Many people begin an exercise program for social reasons, ranging from time spent with friends, to meeting new people, to fighting loneliness. Individuals who regularly exercise with others express that the experience is more enjoyable than exercising on their own. Heinzelmann and Bagley (20) found that almost 90% of their 195 program participants preferred exercising with someone else or with a group rather
than exercising alone. Massie and Shepard (24) showed that adherence was only 47% for participants who aerobically exercised individually, whereas adherence was 82% for those who participated in group exercise. In an attempt to further comprehend exercise adherence and motivational factors, Winkel (39) interviewed continuing participants and dropouts from an employee fitness program. It was found that continuing participants scored higher than dropouts on the goals to develop recreational skills, to go out with friends, to satisfy curiosity, to release competitive drive, and to develop social relationships. They also reported a greater increase in positive reactions toward the program over time compared to those who dropped out. Thus, it appears that the social aspect is an important factor contributing to exercise adherence and that continuing exercise perpetuates positive attitudes toward activity.

**Exercise Program Factors**

Adherence is also influenced by factors such as the location of the facility and exercise prescription. Poor adherence was often found in individuals who believed their exercise program to be inconveniently located (1,24). Attrition rates were shown to be lower for unsupervised exercise groups compared to supervised groups, thus suggesting that designing an exercise program at a convenient location near the home may have some advantage over a fixed location (1,24). Appropriate exercise prescription is also an important factor, as it has been found that adherence tends to drop off with increased exercise intensity (33).
Attentional Focus

Attentional focus is defined as the internal or external events an individual concentrates on during a given exercise session (18). Oftentimes, novice exercisers will focus their attention on the physiological changes of their body, such as increased ventilation, sweating, and fatigue (internal focus). More experienced exercisers tend to disassociate their attention from these physiological occurrences and focus on factors not related to their body’s internal responses to exercise (external focus). Many studies have investigated the effects of attentional manipulation on perceptions of exercise intensity and have found that there appears to be a relationship between attentional focus and perceived exertion (5,10,17,19,32,34,41).

Pennebaker and Lightner (32) presented two studies investigating the effects of external foci of attention on perceptions of fatigue. The first experiment held exercise constant and compared the external stimulus of street sounds with the internal stimulus of one’s own breathing. Subjects heard one of these stimuli through headphones while walking at a set pace on a treadmill. Results indicated that those who listened to the external distraction of street sounds had decreased perceptions of fatigue, whereas those who were forced to pay attention to their body by listening to an amplification of their own breathing increased their perceptions of fatigue.

A second experiment from the same laboratory (32) required subjects to alternately jog on a cross-country course that required constant monitoring of the external environment, and on a repetitious lap course that required very little external focus. This
investigation found that although both groups of subjects reported similar levels of fatigue, the group on the cross country course ran faster than on the lap course. This led the authors to suggest that factors promoting attention to the external environment also serve to partially reduce awareness of internal sensations.

Others have studied the effects of two different forms of external foci (active vs. passive) on perceptions of exercise intensity. In one investigation (21), subjects were asked to perform 5 minutes of work at either 60 or 90% of VO$_2$ max. During the work, they were required to solve arithmetic problems (active attentional manipulation), listen to asynchronous music (passive attentional manipulation), or do neither (control). The results indicated that active attentional manipulation (arithmetic problems) was more effective than passive attentional manipulation in lowering subjective symptoms of fatigue at the higher work intensity.

Although previous examples have shown external stimuli to decrease one's feelings of fatigue thereby increasing time to exhaustion, external stimuli can also have the opposite effect. Viteri (38) found that an external stimulus such as television viewing actually decreased the subjects' preferred intensity of exercise. Subjects who watched television had a 5% decrease in energy expenditure compared to those who exercised without watching television.

Effects of Music

Attentional focus may also be manipulated by auditory stimulus such as music. Boutcher and Trenske (5) investigated the effects of sensory deprivation and music on
perceived exertion and affect. Subjects performed three, 18-minute sessions on a cycle ergometer at light, moderate, and heavy workloads. All subjects participated in a control, deprivation, and music condition. RPE was significantly lower during the music compared to the deprived condition at the low workload, and RPE was significantly lower in the music compared to the control condition during the moderate workload. Music also appeared to elicit significantly greater levels of affect during the moderate and heavy workloads. The researchers therefore concluded that the influence of music and deprivation on perceived exertion and affect was load dependent.

Copeland and Franks (10) investigated the effect of different types of music on the physiological and psychological responses to exercise. Subjects were required to walk/run to exhaustion on a treadmill while listening to loud, fast, exciting, popular music (Type A); soft, slow, easy-listening, popular music (Type B); and no music (Control). Time to exhaustion was longer during the Type B condition compared to the Control condition. whereas RPE was lower for Type B music than for Control at submaximal workloads. Thus, the authors concluded that certain types of music may result in reduced physiological and psychological arousal during submaximal exercise and therefore may lead to increases in endurance performance.

**Rating of Perceived Exertion**

**Theoretical Basis**

Investigators often use Borg’s RPE scale (3) to measure subjective feelings of exercise intensity which may, in turn, be converted into objective findings. This method of
quantifying subjective symptoms was designed so that it would be applicable to most people regardless of gender, age, circumstances, and national origin (4). The overall perceived exertion rating integrates various information including the many signals elicited from the peripheral working muscles and joints, central cardiovascular and respiratory systems, and from the central nervous system. All of these signals, perceptions, and experiences are integrated into a configuration or "Gestalt" of perceived exertion (4).

The Borg scale is based upon a "ratio-scaling model" where methods of rating exertion levels have the same metric qualities as methods used in physics and physiology, (i.e., methods with an absolute zero and with the same distance between all scale values) (4). Because the perceived exertion determined by ratio-scaling methods grew with an exponent of about 1.6, it was concluded by Borg (4) that an integration of central factors such as heart rates and peripheral factors such as blood lactates with an exponent of about 2, would better "explain" the psychophysical variation than a single physiological variable.

The scale ranges from 6 to 20 and can be used to denote heart rates ranging from 60-200 beats per minute (4). This format was intended to make the scale easier to use because a certain value on the scale (e.g., 12 would correspond to an approximate heart rate of 120 beats per minute for 30-50 year old subjects). This, however, is a loose relationship, because factors such as age, type of exercise, environment, anxiety, and others, may influence the accuracy of heart rate as an indicator of strain.
Validity and Reliability of the RPE Scale

Extensive research has been performed investigating the validity and efficacy of measuring perception of exertion in a clinical setting. Ceci and Hassmen (9) studied the RPE scale as a means of regulating exercise intensity by comparing running performance on a treadmill with performance in a field situation. It was found that after a 4 week testing period, subjects could accurately reproduce a particular velocity using RPE, however, prediction was more accurate during the field condition than the treadmill condition. They also discovered there was a high internal consistency by test-retest reliability between velocity, heart rate, and an RPE of 11. Therefore, in this situation, RPE was an accurate means of monitoring exercise intensity.

Skinner, Hustler, Bergsteinova and Buskirk (35) investigated the validity of Borg’s RPE scale with individuals of different body sizes. Eight lean and eight obese subjects were presented with varying cycle workloads in random order, and were asked to determine their RPE accordingly. This RPE was compared to RPE values obtained during a progressive exercise test. The results showed that there were no significant differences in any of the psychological and perceptual variables between the two protocols and that the coefficients of reliability for both procedures were high.

Psychological Factors Influencing RPE

Perceived exertion is not only influenced by physiological mechanisms, but is also affected by psychological variables. For example, on any given day, one may run at a
heart rate of 150 and RPE of 13, whereas on another day, the same workload may elicit an RPE value of 17 due to certain physical or emotional factors.

Quite often, individuals who are neurotic, anxious, or depressed seem to have difficulty in their perceptual processing of work intensity. It appears that extroverts tend to underrate work intensity at heavier loads, and their stated work preference is higher for prolonged work than it is for introverted subjects (26). In one experiment (26), 75 subjects were tested on a bicycle ergometer with progressing work loads. Results indicated that 67 of the subjects’ judgments of RPE were consistent with expectations based upon actual loads, while eight of the subjects appeared to have errors in their perception of exercise difficulty. The psychometric characteristics of these eight subjects were examined and findings showed that seven of them were either neurotic or anxious. In other words, the ability to accurately rate perceived exertion was dependent in part upon the psychological characteristics of the rater. It is therefore implied that anxiety neurotics and depressives may lack the ability to interpret subjective sensations accurately. It has been further theorized that the inability probably reflects the autonomic arousal which characterizes such states.

It has also been theorized that an individual’s states and traits may influence perceived exertion. In an experiment by Morgan (26), nine male subjects exercised on a bicycle ergometer at 50 rpm and resistances of 300, 600, 900, 1200, and 1500 kpm for one-minute periods. The correlations of the RPE at each of these workloads and traits such as extraversion, neuroticism, anxiety, depression, and somatic perception were
examine. Extraversion was found to correlate inversely with perceived exertion at 900 kpm (-.62), 1200 kpm (-.69), and 1500 kpm (-.71), thus implying that those who were classified as more extroverted had lower RPE ratings than those who were not. Subjects were also asked to indicate a workload at which they would prefer to work at for 30 minutes. This stated work preference was also correlated (+.70) with extroversion, indicating that the extroverted subjects chose to work at a higher workload than did introverted subjects.

It would appear that somatic perception, anxiety, neuroticism, and extroversion are interactive variables in the perceptual processing of information. This position is supported by research (28) investigating the effects of hypnotic suggestion on perceived exertion. In this study, work load was held constant while the subject's perception was altered by means of hypnotic suggestion. While under hypnosis, subjects were told that they were cycling up a steep grade, on level terrain, or coasting downhill, when in fact they were working at 600 kpm in all conditions. The subject's perceived exertion as well as physiological changes in heart rate corresponded to the heavier and lighter workloads suggested by hypnosis. It is also interesting to note that heart rate at the end of the workload was about 15 beats higher when the subjects were told that they were cycling up a grade. These findings strongly support the view that psychological processes have an important influence not only on perceived exertion, but also to physiological responses to exercise.
Profile of Mood States (POMS)

The Profile of Mood States (POMS) has been widely used to measure mood states in psychiatric outpatients and as a method for assessing changes in such patients (25). Lately, it has also been used in sport and exercise science to assess athletes’ moods in relation to competition or training. The POMS consists of a 65 five-point adjective rating scale that represents the refinement of a total of 100 different adjective scales by means of repeated factor analyses. The POMS, for the most part, can be understood by persons with at least a 7th grade education.

The POMS scale is broken down into six factors: Tension-Anxiety (T), Depression-Dejection (D), Anger-Hostility (A), Vigor-Activity (V), Fatigue-Inertia (F), and Confusion-Bewilderment (C). Factor T is defined by adjective scales descriptive of heightened musculoskeletal tension. Factor D represents a mood of depression accompanied by a sense of personal inadequacy. Factor A represents a mood of anger and anticipation toward others. Factor V is defined by adjectives suggesting a mood of vigorousness, ebullience, and high energy. Factor F represents a mood of weariness, inertia, and low energy level, and Factor C is characterized by bewilderment and muddleheadedness. The Total POMS score (Total) is determined by summing Factors T, D, A, F, C, subtracting Factor V, and adding 100 to this value.

Validity and internal consistency of the scale have been well established and it has been found that the extent to which the individual items within the six mood scales
measure the same factor are near .90 and above (25,30). Test-retest reliability of the POMS ranges from .65 for Vigor to .74 for Depression (23).

Use of POMS in Sports and Exercise Science

The use of the POMS in sports and exercise science is due in large part to the work of W. P. Morgan. In 1980, Morgan (27) presented the “Iceberg Profile,” which is the typical athlete profile. The “Iceberg Profile” is defined by scores that fall below the 50th T score on Tension, Depression, Fatigue, and Confusion, and above the 50th T score on Vigor in comparison with published norms for individuals of comparable age and educational background.

Morgan (27) has also found that athletes differ from nonathletes on a variety of psychological states. Athletes tend to have lower scores on Tension, Depression, Fatigue, and Confusion, and higher scores on Vigor than nonathletes. It has also been suggested that exercise lowers the levels of Depression, Anxiety, Tension, and Confusion (25). In a study conducted by Maroulakis and Zervas (22), it was found that aerobic exercise (consisting of a 60 minute aerobics dance class) elicited a significant beneficial effect on all POMS mood factors, and that 24 hours later, mood scores had not fully regressed to preexercise levels. The control group’s (no exercise) overall mood profile was poorer and their responses remained basically unaltered across administrations.

The POMS has also been used in research investigating mood states and their relationship to “exercise addiction” (16,36). One study (16) investigated whether experienced distance runners would increase plasma levels of B-endorphins/B-lipotropin
(BN-EP/BN-LPH) immunoreactivity at 60 and 80% of their maximum potential. The POMS was used to determine whether or not any changes in mood states after running were related to this change in BN-EP/BN-LPH immunoreactivity. The results indicated that mood states improved about 50% in both the 60 and 80% running conditions, corresponding also to increased levels of BN-EP/BN-LPH after running. It was thereby suggested that the “increase in endogenous opiates in those who train regularly might cause a desire or additional running or ‘addiction’” (16).

Thaxton (36) also investigated the psychological effects of short-term exercise addiction on habitual runners (greater than five times per week for at least a year). The runners were randomly assigned to four groups. Two groups ran on the day of testing and two did not. All groups completed the POMS. The authors found that the POMS was able to detect shifts in mood and that even minor changes in routine (i.e., not running) had a negative affect on mood in these habitual runners.

Environment and Exercise-Induced Emotional Change

In addition to the belief that exercise environment can affect an individual’s perception of physical symptoms (32), it has also been theorized that the exercise environment can influence mood (19). A recent investigation by Harte and Eifert (19) examined the psychoneuroendocrine effects of different exercise environments on emotional experiences. It was hypothesized that running would elicit both a positive mood change and related increase in catecholamine and cortisol activity. It was also
expected that the emotional effects of running would be affected by perceived exertion, attentional focus, and environmental setting.

Trained runners were tested during an outdoor condition, two indoor conditions, and a control condition. The outdoor condition consisted of a 12 km run. The two indoor conditions required the subjects to run on a motorized treadmill. During one of these sessions (indoor-external), subjects listened to external environmental sounds (i.e., wind, cars, people talking, and bird sounds) via headphones, and during the other session (indoor-internal) they listened to an amplification of their own breathing. The investigators measured mood via the POMS and Recent Life Events Questionnaires. An attentional checklist was used to measure the subjects’ direction of attention during exercise. Urinary catecholamines and cortisol were also measured after each exercise session.

Analysis of the POMS showed that following the outdoor run, subjects tended to feel less anxious, less depressed, less angry and hostile, less fatigued, and more invigorated than at pretest. The significant finding for the indoor-external focus condition was that subjects felt more fatigued after the run. However, after the indoor-internal focus run, subjects felt more tense, more depressed, angrier, more hostile, and more fatigued than at pretest. RPE was also higher during the indoor-internal focus run than during either the indoor-external focus or outdoor runs.

In this investigation, outdoor running was primarily associated with an external, environmental focus of attention, whereas the two indoor running conditions were
associated with an internal focus of attention. It was also found that increases in adrenaline secretions were similar over conditions, however noradrenaline and cortisol secretions were higher during the internal run and condition.

Overall, it appears that vigorous exercise has a positive effect on mood, however the environment in which it occurs and attentional focus seem to exert a mediating effect. It also appears that when an environmental setting is lacking in stimulation or is perceived as tedious, subjects experience some physical and emotional stress as shown by increased RPE and mood profiles. The implication of these findings is that “the activity of exercising is not automatically beneficial, but exercisers need positive environmental stimulation to gain the full beneficial effects from their activity” (19). Thus, positive environmental stimulation may be an important determining factor in exercise compliance and adherence for those individuals who lack motivation.

**Exercise Induced Feeling Inventory (EFI)**

The Exercise Induced Feeling Inventory was developed in 1993 in an attempt to identify the subjective feeling states that occur during and following an activity (18). It is believed that these subjective feeling states may play a role in the prediction of exercise initiation and adherence (12,18). The questionnaire includes 12 items that attempt to identify four distinct feeling states: Revitalization, Tranquility, Positive Engagement, and Physical Exhaustion.

A major assumption in the development of the EFI is that the stimulus properties of physical activity are capable of producing several distinct feeling states and that “the
arousal created by physical activity can lead to a variety of feelings, good or bad, depending upon the cognitive label assigned to events" (18). Content validity of the EFI was measured by a survey of 77 college students who were regular exercisers (18). The survey attempted to determine how well the students thought each of the feelings described by 145 chosen adjectives were relevant to the effects that preceded or followed either low-intensity or high-intensity exercise. These adjectives were then classified into homogenous categories and further reduced to the final questionnaire, with 12 adjectives representing the four feeling states mentioned above. It was found that over one-half of the college students surveyed endorsed these adjectives as states that corresponded to those felt with either high or low-intensity exercise and for nine of the items, this proportion exceeded 75%.

The authors also tested the concurrent and discriminant validity of the EFI by comparing it to the Positive Affect Negative Affect Schedule (PANAS) and the Activation Deactivation Adjective Check List (AD-ACL) (18). Results showed that the Revitalization, Tranquility, and Positive Engagement subscales of the EFI correlated positively with the Positive Affect subscale of the PANAS and that none of the EFI subscales correlated with the Negative Affect subscale of the PANAS. The Revitalization subscale of the EFI correlated with the Energy subscale of the AD-ACL. Both the Physical Exhaustion and Revitalization subscales of the EFI correlated with the Tiredness subscales of the AD-ACL. These data appears to indicate that the EFI subscales have good concurrent and discriminant validity with current measures of mood and affect.
There is little information available regarding use of the EFI. However, measurement of affect is important in the promotion of exercise motivation and adherence. The EFI provides a much needed tool to measure the resulting effects of acute bouts of exercise. Knowledge of feeling states induced by exercise may prove to be an invaluable tool in exercise prescription.

**Summary**

Despite the overwhelming evidence in support of exercise's beneficial effects on health and psychological well-being, 25% of the U.S. population is considered to be sedentary (37). It is, therefore, of vital importance to understand the complex psychological, social, and physical factors that contribute to exercise motivation and adherence. A better understanding of these factors may enable health professionals to promote physical activity programs more successfully, thus improving the health status of the general population.
REFERENCES


