1988

Effects of Sex and Social Influence on Perception of Physical Effort During Light to Heavy Work by Elite Athletes.

Michael Francis Sylva

Louisiana State University and Agricultural & Mechanical College

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Effects of sex and social influence on perception of physical effort during light to heavy work by elite athletes

Sylva, Michael Francis, Ph.D.
The Louisiana State University and Agricultural and Mechanical Col., 1988
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UMI
EFFECTS OF SEX AND SOCIAL INFLUENCE ON PERCEPTION OF PHYSICAL EFFORT DURING LIGHT TO HEAVY WORK BY ELITE ATHLETES

A Dissertation
Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

The School of Health, Physical Education, Recreation and Dance

by
Michael Francis Sylva
B.A., University of Maine, Farmington, 1979
M.A., University of Arkansas, 1981
May 1988
ACKNOWLEDGEMENTS

Sincere and very special appreciation is expressed to Dr. Ronald Byrd, my major professor, for his friendship and guidance in scholarship through my doctoral program and this project. Special appreciation is extended to Dr. Arthur Riopelle, my minor professor, for his major contributions towards the completion of this study and attainment of this goal. I also extend my appreciation to the members of my dissertation committee, Drs. Helen Fant, Carl Hill, Amelia Lee, and Michael Mangum, for their expertise in the shaping of this idea.

A special thanks is extended to each of the following: Gabie Church, Floyd Galliano, Cindy Hadden, Allen Kinley, Greg Landry, Lynda Leggett, Mary Lou Roper, Loren Seagrave, and Shouhua Xia, for their assistance in the collection and analysis of the data.

Finally, I thank my Father and my family for their understanding and sustaining love through these years of growth and maturity.
FOREWORD

This dissertation is written in the style approved by the American Psychological Association for submission to scholarly journals. Pages 1-25 constitute the body of the manuscript prepared in the form acceptable for journal submission. The rest of the pages consists of the appendices, which include an additional review on perceived exertion, the laboratory protocol, statistical analyses (ANOVAs), and a pilot study.
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Abstract

This study was designed to investigate the effect of sex and social influence on perception of physical effort during light to heavy work by male and female athletes. Subjects performed three submaximal trials of 27 minutes each on a cycle ergometer at 25, 50 and 70% of maximum oxygen consumption in the presence of a male coactor, a female coactor, and just riding alone. The results indicated that subjects' ratings of perceived exertion (RPE) were similar when performing at all three coactor/alone conditions. No significant sex difference in RPE was found. Thus, highly trained male and female athletes did not differ in their perception of effort during equivalent relative work load on the cycle ergometer. Discrepant findings in similar studies might be a function of the subject population; elite athletes might be significantly different from untrained subjects in perception of effort as affected by same or different sex coactors.
INTRODUCTION

Borg (1962) proposed that the measuring of an athlete's rating of perceived exertion (RPE) as a subjective complement to the determination of the athlete's objective responses during physical exercise represents an individual's integration of various physiological sensations. Several physiological parameters have been designated as the generators of this "effort sense". According to Ekbolm and Goldbarg (1971), the perception of exertion can arise from peripheral factors (rate and force of muscular contraction) and/or central factors (aerobic requirement, HR, VE, \( \dot{V}O_2 \)). This multifactor model is an extension of Borg's (1962) original proposition. However, the validity of these factors as sole determinants of the "effort sense" has been questioned.

Rejeski and Ribisl (1980) have shown that RPE can be affected by psychological variables independent of changes in physiological responses. Subjects lowered their RPE's when they thought they were participating in a 30-minute trial on the treadmill, compared to values during a perceived 20-minute trial. However, the analysis of physiological data--respiratory rate, heart rate and ventilatory minute volume--produced no
significant difference between the two conditions. They concluded that RPE can be influenced by cognitive variables without alterations in physiological responses. They noted that these psychological effects were seemingly confined to the moderate exercise where physiological cues were not well defined.

Rejeski (1981) reported that the relative importance of physiological input to psychological variables increases as the work intensity and/or duration increases. When work is performed at/or near maximal levels, physiological input (internal cues) serves as the dominant source of information. When cycling at submaximal levels, internal cues are not as strong, so there is a greater chance that cognitive factors (external cues) can serve as more salient sources of information for RPE. From this hypothesized relationship, psychological variables would be expected to have their greatest impact on RPE during submaximal levels of work.

Social influence is worth examining in relation to the psychological factors in perception of exertion. Baron and Bryne (1979) defined social influence as "the alteration of one's behavior, feelings or attitudes by what others say or do." A number of researchers have reported that one's perception of objective reality is
definitely affected by social influence (Sherif, 1935; Asch, 1951; Baron & Bryne, 1979). Rejeski (1981, 1985) reported that the self-perception of exertion can be partially a function of social information processes.

Hardy (1983), in his study of the effects of social influence on RPE within a self-presentation paradigm, found that RPE can be moderated by a coactor and the coactor's behavior. This implies that, in addition to sensory input, subjects also used the presence and behavior of a coactor in determining their RPE. Morgan and Pollock (1977) in their research with marathoners suggested that an athlete's perceptions of exertion are less likely to be subject to distortions by social influences (coactors) than are those perceptions of non-athletes.

Hardy (1983) noted that findings from his study were limited to untrained individuals performing at moderate intensities. He further proposed that along with characteristics that might be specific to this population, sex and personality traits might also mediate social influences; he noted that more research is needed to determine the validity of these suggestions. Accordingly, the purpose of the present study was to investigate the effect of sex difference and social influence on perception of physical effort.
across light to heavy work by elite athletes. The term "elite" is used in this study to represent individuals who were on a varsity team and/or running club, and were engaged in a systematic exercise program and competing at a regional and/or national level.

REVIEW OF LITERATURE

Over the last two decades there has been a significant increase in research concerning physical exercise and the rating of perceived exertion (Pandolf, 1983; O'Sullivan, 1984). According to Pandolf (1983), examination of the perception of exertion during exercise has become interdisciplinary in nature. Some physiologists have shown interest in applied psychological issues, while others have been investigating theoretical issues concerning psychophysiology and exercise perception. With respect to RPE, some physiologists have shown much interest in the interplay of multiple sensory input while others have been concerned with identifying the major sensory cue(s) underlying perception of effort. Pandolf (1983) further reported that another group has investigated effort sensation under several forms of exercise and in different exercise conditions involving the interaction of several muscle groups. He also noted that some are interested in the effects of exercise, intensity,
duration and mode on perceived exertion, while others examined the effects of age, gender and physical training on exertional estimates. Finally, Pandolf (1983) reported that in recent years, human factor scientists and clinicians have tried to use the available knowledge relative to perceived exertion for industrial and medical applications.

Morgan (1981), Rejeski (1981), and Rejeski and Ribisl (1980) reported that perceived exertion is to a large extent influenced by cognition. According to Hardy (1983), more support for the interrelationship between physiological and cognitive factors in the subjective "cost" of exercise has come from research on the perception of fatigue. A study by Pennebaker and Lightner (1980) revealed that subjects who heard an amplification of their own respiration during exercise on a treadmill reported more fatigue and fatigue-like symptoms than subjects hearing distracting sounds such as street noises through headphones during exercise. Hardy (1983) further reported that the results of such studies imply complex relationships between perceived exertion, cognitive processes and physiological indicants. However, he also noted that the relationship between a fatigue scale and Borg's (1970) RPE Scale is questionable; taken collectively, such
findings suggest that the perception of internal states during physical exercise is a complex cognitive process. That is when the athlete's attention is directed to external cues, the role of physiological indicants declines. Consequently, motivational, informational, and emotional factors merge to play a very significant role in the subjective assessment of exercise.

Morgan and Pollock (1977) reported that perceptions of exertion by trained athletes are not very likely to be subject to distortions by social influence. This is probably due to the ability of the elite athlete to "associate", i.e. to monitor sensory input, and adjust the pace to accurately mirror physiological capabilities. However, non-elite athletes cannot "associate" so precisely; their relative "dissociation" generally results in less than optimal pacing, either too fast or too slow (Morgan and Pollock, 1977). Hardy (1983) suggested that the unique perceptual capabilities of elite athletes might interact with sex and personality traits, further moderating social influences.

Morgan (1973) has shown that at heavy workloads extroverts generally underestimate RPE. Furthermore, Robertson, Hiatt, Gillespie, and Rose (1975) reported
that individuals who are classified as sensory reducers assign lower RPE to a given workload than do sensory augmenters. The findings of these studies seem to imply that the perception of exertion can be influenced by personality trait. To date, however, no studies have been undertaken to investigate the effect of sex and social influences (condition: alone, coactor opposite sex, coactor same sex), on perception of physical effort of highly trained athletes.

METHOD

Subjects

Seventeen elite male and female volunteer athletes (9 males and 8 females), most of whom were from the varsity track team at Louisiana State University, participated in this study. Subjects were middle-distance runners whose best events ranged from 400 meters to 1500 meters and who were familiar with cycle ergometry. Table 1 presents biometric data on selected subject variables.

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Procedures

Prior to the start of this experiment, each subject read and signed an informed consent form.
(Appendix A), and was apprised of all the procedures associated with the experiment. Approval for this study was obtained from the Committee on Humans and Animals as research subjects at LSU prior to data collection.

All subjects were tested on four separate occasions, with at least two days between tests. Subjects were asked to avoid any extensive vigorous activity prior to the laboratory session on each test date.

The first exercise session began with a 3-minute warmup at 50 watts, followed by a test of peak oxygen uptake (\(\dot{V}O_2\) peak). The test began at a workload of 50 watts (at 60 rpm) and increased by fifty watts every minute until the subject was unable to maintain the desired pace. Heart rate (HR), oxygen consumption (\(\dot{V}O_2\)) and respiratory quotient (RQ) were obtained every minute. To determine the attainment of \(\dot{V}O_2\) peak, the criteria of a peak HR equal to or more than 220 minus chronological age, a plateau in \(\dot{V}O_2\), and an RQ greater than 1.0 were used (Astrand & Saltin, 1961a, 1961b). Subjects who failed to meet at least two of the three listed criteria were retested.

The submaximal cycling workloads of the next three sessions were set at 25% (light intensity), 50%
(moderate intensity), and 70% (heavy intensity) of the subject's VO₂ peak. Subjects performed one session alone and the other two sessions with a coactor. To avoid an order effect, odd-numbered subjects (1st, 3rd...) performed alone first and even-numbered subjects (2nd, 4th...) exercised first with a coactor. During each session, the subject performed three consecutive 9-minute trials for each of the calculated workloads, ordered from light to heavy to take advantage of the natural incremental warming-up.

When the subject arrived at the laboratory for the alone condition, he/she was instructed to sit on the cycle ergometer while being outfitted with instrumentation to measure physiological parameters. Each subject was informed that he/she would be performing three consecutive 9-minute bouts at different intensities and that he/she would be required to maintain the appropriate pedalling pace (60 rpm) by coordination with the sound of a metronome. They were also told that periodically during the test, they would be asked to rate their perception of effort (RPE), that is, to approximate how difficult the work felt. This rating was taken during the last 15 seconds of minutes 7 to 9 of each stage by letting the subject point to the appropriate value on an RPE scale. At the same
times, HR and $\dot{V}O_2$ data were being collected.

The procedures for the coaction condition were, in general, similar to the above condition; the only difference was the addition of another performer on the same task, simultaneously, but independently (coactor). The subjects did not know that the coactors (one male and one female) were friends of the experimenter. The subjects were told that by testing two people simultaneously the experiment would be finished quicker. The coactor (same or opposite sex as the subject) was positioned about 2 meters to the right of the subject on a cycle ergometer and was outfitted for HR and $\dot{V}O_2$ data collection the same as the subject. Subjects were shielded from observing the coactors' responses by the location of the instrumentation to be used in the test and the position of the coactor. Each subject was told that both he/she and the coactor would be working at the same intensities. After the testing of all subjects was completed, all participants were debriefed as to the nature of the study and the results obtained.

Instrumentation

The exercise apparatus used in this experiment was a cycle ergometer (Monark). An electronic metronome (Franz model LM.5), was used to set the pedalling
cadence (60 rpm). Both the ergometer and the metronome were calibrated each day prior to testing.

\( \dot{V}O_2 \) was measured using standard open circuit spirometry over one-minute periods. Expired \( O_2 \) and \( CO_2 \) fractions were sampled from a 5-liter mixing chamber by Beckman \( O_2 \) (model OM-11) and \( CO_2 \) (model LB-2) gas analyzers that were calibrated before each test and at minutes 5, 10, and 19 of each submaximal test. The gas fractions and ventilatory minute volumes, obtained by Rayfield dry gas meter, were integrated by an Apple IIe computer program that provided the physiological data output during the exercise session.

Heart rate was monitored by a Hewlett-Packard 1500B electrocardiograph using CMS lead placements. An ECG strip was obtained at rest and during the last 15 seconds of each minute to be evaluated. Borg's (1970) 15-point perceived exertion scale was used to obtain RPE data.

Analysis of Data

Means were calculated for RPE, HR, and \( \dot{V}O_2 \) for each level of work under each submaximal work conditions. The data were analyzed using a 2 (sex: male, female) x 3 (condition: alone, coactor opposite sex, coactor same sex) x 3 (intensity level: light,
moderate, heavy) within subject design. Univariate ANOVA techniques were used on the dependent variables: RPE, HR and \( \dot{V}O_2 \). Significant effects were further examined through non-orthogonal planned comparison procedures. Alpha was set at 0.05 for main effects and at 0.025 for the non-orthogonal planned comparisons. Due to high relationships among the dependent variables, a multivariate analysis was considered inappropriate because of the probability of multicolinearity.

Results and Discussion

Physiological data-\( \dot{V}O_2 \) (ml/min/kg)

For \( \dot{V}O_2 \), the ANOVA revealed a significant main effect for level \((F(2, 30) = 561.97)\). These findings reflect the additional metabolic cost as exercise intensity level increased. Also, a significant main effect for sex (across intensity level and condition) was found \((F(1, 15) = 42.21)\), and a significant level x sex interaction was revealed \((F(2, 30) = 25.85)\).

The significant intensity level and the sex x level interaction simply show that \( \dot{V}O_2 \) changed differently for each sex across coactor/alone condition and level (intensity). Non-orthogonal comparisons revealed significant difference between males and females for
increments between successive levels. In both cases, (level 1 vs 2 difference and level 2 vs 3 difference), males showed a higher \( \dot{V}O_2 \) difference than females. Least Square Means for the interactions were plotted and the significant non-orthogonal planned comparisons were examined. In examining the graph of the Least Square Means for the \( \dot{V}O_2 \) variable for level x sex interaction, one finds that although males and females increase in \( \dot{V}O_2 \) at each successive level, the gap between the sexes widens at each progressive level of intensity. Males experienced a greater absolute increase in \( \dot{V}O_2 \) at each level of intensity (Figure 1), simply a mathematical relationship dictated by the higher \( \dot{V}O_2 \) maximum of male subjects. There was also a nonsignificant, yet suggestive, main effect for \( \dot{V}O_2 \) by condition \( (F (2, 30) = 3.26) \). This implied that something happened across the three conditions, but the specifics could not be elucidated.

---

Insert Figure 1 about here

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Physiological data - HR

A significant main effect for level (on the dependent variable HR) was found \( (F (2, 30) = 465.57) \), reflecting the increment in cardiac output
generally associated with increased metabolic cost of incremented work. A nonsignificant, but suggestive, level x sex interaction was noted (F (2, 30) = 3.31).

The plot of Least Square Means revealed a slightly different trend than for $\dot{V}O_2$. Females had a slightly higher mean HR at the light (25%) level of intensity, while the means for males were higher at the 50% and 70% $\dot{V}O_2$ max levels (Figure 2).

Contrasts between the differences by sex for levels 1 and 2 were significantly different (F (1, 15) = 335.17). Also, a significant difference (F (1, 15) =367.72) was found between males and females from levels 2 to 3.

Non-orthogonal polynomial comparisons showed a significant linear response (F (1, 15) = 555.05 and F (1, 15) = 9.03, respectively, for males and females). Females also showed a quadratic response.

Psychological data - RPE

The ANOVA for the ratings of perceived exertion revealed no significant main effect for coactor/alone condition (F (2,30) = 1.14) or sex (F (1, 15) = 0.57), and no significant interaction was found. However, a
significant main effect was found for level (F (2, 30) = 241.31).

The finding of a significant intensity level effect was neither surprising nor of great interest. This indicates that a subjective response such as RPE increases as the level of intensity and associated cardiovascular and metabolic demands increase. The finding of a nonsignificant condition effect and a sex effect were of importance. For condition, this suggests that the simultaneous performance of another male or female does not affect his/her rating of perceived exertion. For sex, this suggests that trained male and female athletes do not differ in their perception of effort at similar power outputs on the cycle ergometer.

The finding of no difference in condition or sex for RPE was inconsistent with the results of Hardy (1983), who found that an individual's perceived exertion was subject to social influence, particularly at low and moderate levels of work intensity. This disagreement is apparently a function of the fact that Hardy's results were with untrained subjects, while elite athletes served in the present study. In support of this concept, Morgan and Pollock (1977) had noted that athletes who performed similar tasks with others...
(coactors) did not suppress their rating of perceived exertion at any level of work. They hypothesized that athletes were better able to "associate"; that is, they monitored sensory input and body functions, and adjusted pace to accurately mirror physiological capabilities better than nonathletes. Nonathletes' relative "dissociation" led to less than optimal pacing, performing either too slow or too fast. It was concluded that an athlete's perceptions of effort were less likely to be affected by coactors (social influences), than were those perceptions of nonathletes. Whether this is a characteristic that first contributes to success in sport or one that is developed through participation in sport would be worthy of investigation.

While it can be accepted that, in the conditions imposed in this experiment, the presence of a coactor had no effect, certainly the competitor—coactor in real-life athletic events influences performance. To what degree RPE in competitive scenarios is affected is problematic. Consider track competition, where runners often run as a group (especially in long distance races), but where sometimes an individual sprints out at considerable anaerobic cost in order to "shake off"
some of the other runners (more apparent in short distance races). This is a form of mental strategy to determine who is tough enough to keep up the pace of the race or to disguise true feelings of fatigue to discourage other runners.

Another practical application of these results relates to the use of the ratings of perceived exertion in clinical settings. According to Noble (1982), a significant number of cardiac rehabilitation programs are at present using the ratings of perceived exertion to control the level of exercise intensity. Hardy's (1983) findings that nonathletes' RPEs are significantly affected by coactors would appear to undermine the validity of using RPE for beginners in cardiac rehabilitation programs. The danger to high-risk patients is clear. On the other hand, the present study and that of Morgan and Pollock (1977) might be used to infer less danger to patients who have been in rehabilitation for a long enough period that they might be better able to associate their sensory input to realistic performance levels.

In summary, the results of this current study support the thesis that both female and male highly trained athletes were relatively unaffected by the presence of a coactor of either sex. The importance
of psychological factors on RPE seems more apparent when dealing with untrained subjects in the presence of other performers. Whether the same psychological interactions occurred in the trained athletes, or whether they have learned from experiences in training and competition simply to focus more effectively on their physiological state cannot be determined from the present data.
References

Asch, S.E. (1951). "Effects of group pressure upon the modification and distortion of judgment." In H. Guetzkow (Ed.), Groups, leadership, and men (pp. 177-190). Pittsburgh: Carnegie.


Figure Captions

1. Level x Sex Interaction for Mean $\dot{V}O_2$ Scores
2. Level x Sex Interaction for Mean HR Scores
Figure 1. Level x Sex Interaction for Mean \( \dot{\text{VO}_2} \) Scores
Figure 2. Level x Sex Interaction for Mean HR Scores
Table 1
Group Biometric Data

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<th>Variable</th>
<th>Male (N=9)</th>
<th>Female (N=8)</th>
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<tr>
<td>Age (yrs)</td>
<td>22.22 ± 2.48</td>
<td>23.75 ± 8.02</td>
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<tr>
<td>Height (meters)</td>
<td>1.76 ± 0.07</td>
<td>1.63 ± 0.10</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.00 ± 7.72</td>
<td>55.19 ± 5.98</td>
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<tr>
<td>(\dot{V}O_2) max (l/min)</td>
<td>3.84 ± 0.46</td>
<td>2.26 ± 0.19</td>
</tr>
<tr>
<td>(\dot{V}O_2) max (ml/kg/min)</td>
<td>60.00 ± 8.23</td>
<td>40.95 ± 3.63</td>
</tr>
</tbody>
</table>
APPENDIX A

Informed Consent
EXPERIMENT SIGN-UP FORM

My signature, on this sheet, by which I volunteer to participate in the experiment on __________________________
conducted by

Experimenter

indicates that I understand that all subjects in the project are volunteers, that I can withdraw at any time from the experiment, that I have been or will be informed as to the nature of the experiment, that the data I provide will be anonymous and my identity will not be revealed without my permission, and that my performance in this experiment may be used for additional approved projects. Finally, I shall be given an opportunity to ask questions prior to the start of the experiment and after my participation is complete.

Subject’s Signature
APPENDIX B

Instructions for Rating the Perception of Effort
You are about to participate in the exercise test. You will be riding a cycle ergometer while we will be taking measurements of some physiological parameters. During the cycling we want you to give us an estimate of how hard you feel the work is; this means that we want to know your rating of perceived exertion. Perceived exertion means the overall amount of effort and physical fatigue, together with all feelings and sensations of physical exertion and stress. We want you to focus on the total inner sensations and feelings of exertion, do not just concern yourself with one factor such as shortness of breath or leg fatigue. At various times during the exercise test you will be asked to give your rating of perceived exertion. When appropriate, a rating scale will be available and we will request that you indicate your perception of effort by pointing to the corresponding value.

(A slight modification of Hardy’s, 1983)
APPENDIX C

Rating of Perceived Exertion (RPE) Scale
6
7  VERY, VERY LIGHT
8
9  VERY LIGHT
10
11  FAIRLY LIGHT
12
13  MODERATELY HARD
14
15  HARD
16
17  VERY HARD
18
19  VERY, VERY HARD
20

(A slight modification of Borg's 1970 scale)
Appendix D

Statistical Tables
Table 2
RPE ANOVA

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<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>F</th>
<th>Pr &gt; F</th>
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<th>H - F</th>
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<tr>
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<td>7.02</td>
<td>0.57</td>
<td>0.4602</td>
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</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>183.15</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Condit</td>
<td>2</td>
<td>3.65</td>
<td>1.14</td>
<td>.3321</td>
<td>0.3271</td>
<td>0.3321</td>
</tr>
<tr>
<td>Condit*Sex</td>
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<td>5.11</td>
<td>1.60</td>
<td>.2181</td>
<td>0.2217</td>
<td>0.2181</td>
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<tr>
<td>Error(condit)</td>
<td>30</td>
<td>47.82</td>
<td></td>
<td></td>
<td></td>
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Greenhouse-Geisser Epsilon = 0.8631
Huynh-Feldt Epsilon = 1.0301

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Greenhouse-Geisser Epsilon = 0.6150
Huynh-Feldt Epsilon = 0.6867

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Greenhouse-Geisser Epsilon = 0.7741
Huynh-Feldt Epsilon = 1.0634

Level. N Represents the Nth Successive Difference in Level
Contrast Variable: Level.1

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Contrast Variable: Level.2

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Level.N Represents the Nth Degree Polynomial Contrast for Level

Contrast Variable: Level.1

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Contrast Variable: Level.2

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Table 3

\[ \dot{V}_{O2} \text{ ANOVA} \]

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<td>0.1557</td>
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</tr>
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Greenhouse-Geisser Epsilon = 0.9994  
Huynh-Feldt Epsilon = 1.2298

| Level          | 2  | 12285.98| 561.97| 0.0001 | 0.0001| 0.0001|
| Level*Sex      | 2  | 565.11  | 25.85 | 0.0001 | 0.0001| 0.0001|
| Error(Level)    | 30 | 327.93  |       |        |       |       |

Greenhouse-Geisser Epsilon = 0.5907  
Huynh-Feldt Epsilon = 0.6544

| Condit*Level   | 4  | 2.89   | 0.87  | 0.4863 | 0.4508| 0.4731|
| Condit*Level*S | 4  | 4.31   | 1.30  | 0.2801 | 0.2873| 0.2838|
| Error(C*L)     | 60 | 49.72  |       |        |       |       |

Greenhouse-Geisser Epsilon = 0.6495  
Huynh-Feldt Epsilon = 0.8500

Level.N Represents the Nth Successive Difference in Level Contrasts Variable: Level.1

| Mean           | 1  | 21066.07| 990.26| 0.0001 |
| Sex           | 1  | 1116.47 | 52.48 | 0.0001 |
| Error         | 15 | 319.10  |       |        |
Contrast Variable: Level.2

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<td>Error</td>
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Level.N Represents the Nth Degree Polynomial Contrast for Level

Contrast Variable: Level.1

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<tbody>
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Contrast Variable: Level.2

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Table 4

HR ANOVA

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<tr>
<td>Sex</td>
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</tr>
</tbody>
</table>

Greenhouse-Geisser Epsilon = 0.7928
Huynh-Feldt Epsilon = 0.9301

| Level      | 2  | 90459.98 | 465.57 | 0.0001 | 0.0001 0.0001   |
| Lev*Sex    | 2  | 642.25  | 3.31  | 0.0504 | 0.0721 0.0645   |
| Err(Lev)   | 30 | 2914.48 |       |        |                 |

Greenhouse-Geisser Epsilon = 0.6883
Huynh-Feldt Epsilon = 0.7855

| Con*Lev    | 4  | 142.77 | 1.24  | 0.3019 | 0.3050 0.3025   |
| Co*Le*Sex  | 4  | 52.96  | 0.46  | 0.7636 | 0.7026 0.7574   |
| Er(Co*Le)  | 60 | 1721.01 |      |        |                 |

Greenhouse-Geisser Epsilon = 0.7190
Huynh-Feldt Epsilon = 0.9669

Level.N Represents the Nth Successive Difference in Level
Contrast Variable: Level.1

| Mean       | 1  | 139306.67 | 335.17 | 0.0001 |
| Sex        | 1  | 2213.49  | 5.33   | 0.0357 |
| Error      | 15 | 6234.39 |        |        |
Contrast Variable: Level.2

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<th>F</th>
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Level.N Represents the Nth Degree Polynomial Contrast for Level

Contrast Variable: Level.1

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Contrast Variable: Level.2

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TABLE 5
Means for the Experiment

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<th>RPE</th>
<th>VO(_2) (ml/kg/min)</th>
<th>HR</th>
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<td>19.67</td>
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### Table 6

Standard Deviation for the Experiment

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<tr>
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<th>RPE</th>
<th>$\dot{V}O_2$ (ml/kg/min)</th>
<th>HR</th>
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<td>Light</td>
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<td>3.67</td>
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<td>7.31</td>
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<td></td>
<td></td>
<td></td>
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<tr>
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<td>Light</td>
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<td>1.83</td>
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<td>1.13</td>
<td>3.28</td>
<td>16.00</td>
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<td>Light</td>
<td>0.83</td>
<td>1.05</td>
<td>10.81</td>
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</table>
APPENDIX E

Rating of Perceived Exertion (RPE): A Review
Rating of Perceived Exertion (RPE) : A Review

Over the last 15 years, clinical application of the perception of effort during work in patients with different forms of ailments has become increasingly popular (Pandolf, 1983). The surge of interest in physical conditioning for preventative and rehabilitative reasons has caused an increased awareness of the need for understanding the physiological stresses, psychological factors, and perceptions associated with exercise (O'Sullivan, 1984).

According to Borg (1982), a person's perception of work is a very appropriate way of assessing the degree of strain, has potential for helping us understand physical performance, and has applications in physical therapy. Early after its development, many cardiologists and physiologists were suspicious of Borg's RPE Scale --"Cardboard Technology"--(Noble, 1982). At present, many exercise laboratories in the United States display the 'cardboard' scale on a wall in front of the cycle ergometer or treadmill. RPE during exercise has definitely been and continues to be useful to clinicians. However, because of its
practical value and simplicity, the Borg scale has been used sometimes in clinical settings where another instrument might have been more appropriate (Noble, 1982).

Perception of Exertion

Perceived exertion is generally defined as an individual's rating of the intensity of physical work (O'Sullivan, 1984; Morgan, 1973). Many researchers have examined the physiological and non-physiological factors at the root of the rating of perceived exertion. Carton and Rhodes (1985) reported that at low levels of work, physical perception in the exercising muscles seems to be the key stimulus for the perception of exertion. However, when exercise intensity goes beyond the lactate (anaerobic) threshold, increased accumulation of blood lactate complements local input from neuromuscular mechanisms. Central (HR, VO₂ and respiration rate) cues also contribute to this 'effort sense' at this point (Carton and Rhodes, 1985). From the above discussion, it seems appropriate that a theoretical framework based upon a multidimensional model—physiological and psychological considerations—is needed to support the concept of changes in perception of effort caused by training. In support for this model, Pandolf (1983),
Borg and Noble (1974), and Ekblom and Goldbarg (1971), have proposed that the overall perception of effort should be regarded as a 'gestalt' of many sensations, including the feelings of stress and strain in the exercising muscles, and psychological feelings associated with cardiopulmonary function.

Borg's RPE Scale

Various scales (ratio and categorical) have been developed to measure perceived exertion during exercise (O'Sullivan, 1984; Asfour, Ayoub, Mital, and Bethea, 1983; Mihevic, 1981). The most popular is probably the psychophysical category scale developed by Borg (1970). According to Pandolf (1978), early researchers who used Borg's RPE scale were interested in its reliability and validity for various kinds of physical work. In recent years, investigators have focussed more on the evaluation of the relative importance of different physiological signals in the rating of exertion. After several revisions, Borg developed a fifteen-point graded subdivision scale which used numbers from 6 to 20, where odd numbers were followed by verbal descriptors such as "very very light" at 7 to "very very hard" at 19 (O'Sullivan, 1984; Asfour et al., 1983; Borg, 1973). These numbers were selected to be as close as possible to one-tenth of the matching mean.
heart rate. The RPE scale has been validated for exercising with the cycle ergometer and has been proven valid and reliable in repeated tests of increasing work load (Allen and Pandolf, 1977; Arstila and Wendelin, 1974; Borg, 1973). Also, the 15-point RPE scale is so simplified and easy to use that the average person is able to rate the subjective "cost" of physical activity with accuracy, consistency, and great precision (Morgan, 1981). Unlike his earlier scales, Borg's 15-point RPE scale made possible immediate interindividual comparisons of the intensity of perception (Pandolf, 1983).

Physiological Mechanisms and Perception of Effort

Some of the physiological processes thought to be associated with central signals of exertion include HR, ventilatory minute-volume (V), respiratory rate (RR) and $\dot{V}O_2$ (Robertson, 1982). Rated exertion has been reported to show linear correlations with HR, work intensity, V, relative $\dot{V}O_2$, and RR [correlation coefficients between 0.8 and 0.9] (O'Sullivan, 1984; Stamford, 1976; Borg and Noble, 1974; Borg, 1973; Gamberale, 1972). Ekblom and Goldbarg (1971) proposed the use of a two-factor model
to evaluate the perception of physical effort (Figure 2). This model consists of (1) Local factors--force and rate of muscle contraction--involving sensations of strain and stress in exercising muscles, and (2) Central factors--HR, VE, $\dot{V}O_2$, RR--involving feelings of tachycardia [increase in HR], tachypnea [increased rate of breathing] and dyspnea [difficulty in breathing] (Pandolf, 1978). Pandolf (1982), has also reported that this multifactor model might allow for a better comprehension of these physiological factors as compared to a single undifferentiated rating of perceived exertion. This multifactor model is an expansion of Borg's original research that dealt with short-term exercise, work in which the focus

was on perceptions of exertion that originate in the muscles, joints, and skin; to the contrary, during long-term work, sensations in the organs of respiration and circulation are important (dominant). Peripheral factors are presumed to generate the primary sensory cues whereas central factors serve as an "enlarger" that intensifies peripheral input in relation to the aerobic metabolic demand (Robertson, 1982). Central factors start their potentiating stimulus at about 30
to 180 seconds after the beginning of exercise.

Sensory monitoring of local and central cues takes place on both conscious and unconscious levels (Robertson, 1982). For example, feelings of discomfort during respiration are consciously monitored. On the contrary, during physical work sensory cues associated with tissue oxidation and heart rate are usually unconsciously monitored. In summary, the mechanisms for controlling perceptual cues are not well understood but do involve a multifactor model that might involve cues from: (1) baroreceptors, chemoreceptors and mechanoreceptors; (2) other specific physiological responses to exercise; and/or (3) corollary responses dealing with central nervous system regulation or a combination of various physiological adjustments to exercise (Robertson, 1982). It has also been hypothesized that physiological processes that include \( V_o \), HR and the relative \( \dot{V}O_2 \) generate central factor input that influences the perception of exertion during different levels of dynamic exercise (Robertson, 1982).

Factors that Mediate RPE

According to Hardy (1983), the focus on a primary signal does not consider the mediating influence that differences between individuals, both psychological and physiological, could play in the overall perception of
effort. It has also been reported that cognition, sex, personality traits, and physical attributes might also affect perceived exertion (Morgan, 1981; Rejeski, 1981; and Rejeski and Ribisl, 1980). Related to the latter point, perception of work effort decreases with physical training (Ekblom and Goldbarg, 1971).

In studying marathoners, Morgan and Pollock (1977) suggested that an athlete's perception of effort is less likely to be distorted by social influence (coactors) than are those perceptions by nonathletes. This is presumably due to the ability of athletes to monitor their sensory input better than nonathletes. Also, it has been reported that the rating of perceived exertion was significantly lower in sensory reducers as compared to sensory augmenters for an absolute work level (Robertson, Hiatt, Gillespie, and Rose, 1975). In summary, it is apparent that the perception of effort can be mediated by both psychological and physiological individual difference variables and also by cognition.

Motivation

As coaches exhaust their knowledge of the physical readiness of athletes, they generally turn to the fundamentals of motivation (Howe, 1986). Motivation deals with the explanations behind an individual's
observable behavior and is measurable only by imperfect devices (Howe, 1986; Maehr, 1978; Hall, 1961). Thus, the study of motivation is the search for reasons behind some of the most perplexing unknowns of man’s behaviors in life (Harter, 1981; Birch & Veroff, 1966). According to Birch and Veroff (1966), the selection, intensity, and duration of behavior lie within the scope of motivation, and observation of resultant activity is the basic tool for establishing the theories of motivation. This has led to the assumptions that: (1) an organism’s behavior is a sequence of activities, (2) such activities can be coded reliably, and (3) these activities have contemporaneous psychological determinants.

The early concepts of motivational theory were not without criticisms and challenges. White (1959), discredited the traditional drive reduction theory and psychoanalytic instinct theory of Hull (1943) and Freud (1920) respectively. White reported that both theories, which are very similar, are appealingly simplified and have had much criticism, but such criticism has not lent itself to a clarification. He therefore attempted a conceptualization that gathers some of the key elements omitted by the drive reduction theory and the psychoanalytic instinct theory. For his
new concept of motivation White chose the word "competence", intended in a broad biological sense to refer to the capacity of the organism to interact with its surrounding (Atkinson, 1978; White, 1959). White's main argument was that the motivation required to reach competence cannot be totally generated from sources of energy which were conceptualized as instincts and drives.

In voicing his dissatisfaction with the drive theories, White (1959) presented much information implying that behaviors such as curiosity, exploration, mastery, play and an individual's attempt to deal competently with one's surrounding could not be fully explained by the reduction in motivation, by anxiety reduction, or by secondary reinforcements (Harter, 1981, 1978). According to Harter (1981), White's challenge to the drive theory was not satisfactory. Harter (1981) has reconceptualized parts of White's original model. According to Weiss and Bredemeier (1983), the underlying principle for Harter's competence motivation theory highlights individual differences, developmental changes, and a combination of other factors. This makes her model different from other motivational models (e.g. drive reduction theory), and is very well suited for the
examination of youth sport participation.

According to Weiss, Bredemeier and Shewchuck (1985), the relationships among extrinsic/intrinsic motivational direction, perceived control, physical competence, and an individual’s actual achievement are of great interest to sport psychologists. They favored using Harter’s (1981) definition of motivational orientation as the motivational stance one takes in reference to a particular achievement domain. For example: intrinsic orientation concerning sport participation also gives a measure of the main reasons why one engages in specific achievement-related behaviors. The using of Harter’s model is an advantage in that the causal relationships among these factors could be determined empirically with sensitivity to individual and developmental differences (Weiss et al., 1985). The model by Harter is in agreement with Deci’s (1975) conceptualization of intrinsic motivation as the need to feel self-determining and competent in dealing with one’s environment. Also, the motivational dimensions given by Harter are congruous with other factors that are often integral to sport: curiosity, challenge, judgement, mastery and criteria (Weiss, et al., 1985).

Over the last ten years, motivational construct
has played a pervasive role in the psychology of sport (Weiss, et al, 1985). Motivation in sport has been intensely researched from both practical and theoretical perspectives. The nature of motivation in participation (Alderman and Wood, 1976), the effects of competition and external rewards on intrinsic motivation, and the anxiety/arousal-producing factors experienced in sport participation have been examined by Scanlan and Passer, (1979) and by Simon and Martens (1979).

Howe (1986) presented a 3-component model for coaches that is useful in explaining performance. First is the Actual Performance, limited by psychological factors. Next is the Maximal Performance which is the highest possible performance for a team or individual, limited only by physical and physiological parameters. This is rarely reached by most competitors. Finally, there is the Ultimate Performance level which is theoretically an attainment level for any sport activity that has not yet been reached. Ultimate Performance is perhaps closest to being reached in the sprint events of track and field. These three levels can be used to make an athlete
overcome relatively limited physiological preparation. By using motivation, the coach plans to bring the first level close to the second level by generating a willingness in the athlete to approximate his/her Maximal Performance through good practice and effort during competition. Training and other preparations are affected by motivation also.

According to Howe (1986), a coach trying to motivate an athlete in an effective way faces a major problem of trying to determine an appropriate theoretical base for motivation. He further reported that currently over twenty theories gain support from psychologists, but he believed that only three are relevant for sport. Achievement Motivation is the theory most commonly described. This theory explains behavior as the result of an individual's need to achieve a standard of excellence judged against the performance of others. This also incorporates the concept of "fear of failure" which is widely accepted in sports. Atkinson (1978), the premier psychologist associated with this theory, generated a complex formula to predict behavior based on the two aspects of the theory (Howe, 1986).

A second and more controversial theory requires explanation of motivation via the use of reinforcement.
This suggests that changes in behavior result from the reinforcements that are applied. This theory, though not highly popular in the research setting, has been unconsciously used by coaches (Howe, 1986).

Finally, the Incentive Motivation theory of Birch and Veroff (1966) has found support with some sport psychologists. To them, action is the result of these four effects: expectation of success, a good chance to succeed, motives considered of more generalized need that act to change the strength of the incentive, and the values of the incentives which the person applies to the action. According to Alderman and Wood (1976), "Incentive Motivation is the incentive value that an individual attaches to the possible outcomes of actions which he chooses to engage in will, in fact, partially determine the courses of actions he actually chooses". In the field of sports, this would imply that the nature of the physical activity and the way in which the person perceived this nature, in part determines whether or not the individual will be motivated to engage in such activity. From the coach's perception, he/she must attempt to provide the availability of success, manage the expectancy for success, and to consider the incentives for action that may be different from one athlete to the next (Howe, 1986).
Howe further reported that all three theories include the principle that motivation will be most effective if considered to be a long term process.

It is quite clear that knowing an athlete well enough will give the coach the scope to generate a full scale motivational program which will lead to success rather than failure (Howe, 1986). Understanding the reasons for participation, recognizing those more prone to anxiety, and identifying those easiest to stimulate will make it probable that a proper and successful model for motivation is chosen (Howe, 1986). This will provide better athletes who are more able to handle the inescapable ups and downs of competitive sports (Howe, 1986).

Coaches and sport psychologists need to help athletes broaden the view of what success and failure means. It should be made clear to athletes that achievement and success are more than just winning. This should also apply to coaches who believe that winning is everything. The winner in most sport is greatly honored while the loser is looked down upon. This leads us to the concept of goal setting. Athletes and coaches need to set short-term, intermediate, and long-term individual and team goals. These goals must take into consideration the psychological and
biological readiness of the athlete. It is also important that coaches give athletes adequate feedback about their performances, and that the task to be performed should not be very hard or too easy. Goals should be monitored and reevaluated often and adjustments be made if necessary.

Deci, Sheinman, Schwartz and Ryan (1981) proposed that the characteristics of the rewarder or communicator (often the coach), are among the factors that may determine whether the controlling components will be noticeable. That is, if at any given time the intent of the communicator or rewarder was to generate a certain behavioral outcome, it would be likely that the controlling aspect of the reward or communication would be very noticeable.

According to Howe (1986), the field of reinforcement theory gives a useful model for adjusting athletic behavior via "shaping". This is defined as setting shorter, smaller, and carefully graduated goals, promoting a continuous high level of motivation as successes are achieved. It is important to recognize that since these goals are not very large, setbacks are not seen to be permanent and are less damaging.

In conclusion, coaches still have a great
responsibility for motivating athletes, and this includes communicating and working with some athletes prior to competition. During this time, the interaction between athletes that takes place in team sports should be monitored with care. Coaches who know the athletes well are able to detect problems very quickly and are able to help relax and guide the athletes. The motivation process should be constantly monitored (even after a major victory) as new information is gained through games and practices. Results should be placed in the proper context so that failure and success are realistically viewed by the athlete. The ultimate goal is to create athletes who are capable of motivating themselves to perform, and to be able to accept the results of the effects of their own skill and effort (Howe, 1986). Total dependence on coaches and psychologists could be detrimental (creating poorer performances) in the long run.

Social Influence

Social influence needs to be evaluated in relation to psychological factors in perception of effort. According to Baron and Bryne (1979a), social influence is defined as "the alteration of one's behavior, feelings or attitudes by what others say or do". Therefore, social influence occurs whenever feelings,
attitudes or behaviors are changed by the words or actions of other persons (Baron and Bryne, 1979a, 1979b; Baron and Liebert, 1971). These feelings, thoughts and behaviors are diverted from what they would have been in the absence of such influence.

As is generally known, social influence takes many different forms. Some of the most important ones are conformity, compliance, and obedience (Baron and Bryne, 1979a, 1979b; Baron and Liebert, 1971). According to Baron (1983) and Baron and Bryne (1979a), conformity refers to situations in which individuals change their behavior or attitudes so as to agree with widely accepted standards or rules of conduct—i.e. social norms. In contrast, compliance refers to situations in which individuals change their behavior because of direct requests from others. Finally, obedience involves situations where changes in behavior are produced by direct commands from others (Baron and Bryne 1979a, 1979b; and Baron and Liebert, 1971). A fourth major type of social influence is modelling. Modelling occurs in instances in which the behavior of one or more persons is altered via observations of the actions of at least one other person. This is very different from conformity, compliance, and obedience in that it represents a kind of unintentional social
influence. In this case, the individuals (models) who affect others do not necessarily intend to cause such effects. Interestingly, these models might not even know that they are being observed by others (Baron and Bryne, 1979b).

Asch (1951) conducted various studies concerning an individual's reaction when confronted by a group that unanimously and incorrectly agrees on a particular judgement. Asch reported that groups can be so powerful that they can cause individuals to shift their decision in just about any direction. Group pressure can cause people to call true what they yesterday deemed false. The results of Asch's study showed the powerful effect of an incorrect majority on the response of a person.

Baron and Bryne (1979a), reported that in Asch's experiments, subjects probably responded mainly to informational social influence because they wanted to execute the task in a correct manner and were seeking signals from others to know what to do. However, in many social situations, conformity is likely to involve normative social influence in that humans generally want to be liked and so tend to do what is expected by others. In many instances, we are most likely affected by both types of social influence.
Summary

Many physiological and neuromuscular mechanisms have been suggested as the primary and secondary signals underlying the perception of effort. However, Rejeski and Ribisl (1980) reported that RPE can be affected by psychological factors independent of alterations in physiological responses. In that same study, it was concluded that RPE can be influenced by cognitive factors without changes in physiological response. Viewing the perception of exertion only on the basis of local and central factors represents a very simplistic answer to a highly complex issue of physical exercise. Social influence is worth examining in relation to the psychological factors in perception, since it has been reported that an individual's perception of objective reality is definitely affected by social influence (Baron and Byrne, 1979b; Asch, 1951; and Sherif, 1935). The concept of motivation is important for sports performance since the ultimate goal in sport and athletics for coaches is to develop athletes who are capable of motivating themselves and who are able to accept the results of their own skill and effort. Since the overall perception of effort has been regarded as a 'gestalt' of many sensations or
integration of total psychological, physiological and
cognitive input, cognitive research scholars now
maintain that RPE should best be viewed in the context
of a socio-psychophysiological integration model
(Morgan, 1981). This is true since factors that affect
RPE seem to involve variables such as physiological,
psychological, cognitive, social influence and
environment, and the motivational level of the athlete.
Such a multidimensional model does challenge coaches
and sport psychologists to widen their horizons when
examining the factors that affect sport performance and
RPE.
References


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of perceived exertion during work." Ergonomics. 19, 53-61.


Figure Captions

1. Number of published citations on Perceived Exertion.

2. Relative Contribution and time course of Central and Local signals of exertion.

3. Levels of performance.
Fig. 1. Number of Published Citations on Perceived Exertion (from Pandolf [1983]).
Fig. 2. Relative Contribution and Time Course of Central and Local Signals of Exertion (from Robertson [1982]).
Fig. 3. Levels of Performance (from Howe [1986]).
APPENDIX F

Pilot Study
SEX DIFFERENCES IN ELITE ATHLETES' PERCEPTION OF PHYSICAL EFFORT

A Pilot Study

Michael F. Sylva

Spring 1986
Abstract

This study was designed to examine sex differences of elite athletes in perception of physical effort. Nine trained middle distance runners, 6 males and 3 females, from 17 to 26 years of age, performed maximal and submaximal exercise. The maximal test consisted of graded cycle ergometer work to exhaustion. The submaximal test was comprised of exercise on a cycle ergometer at 25, 50, and 70% of the subjects' maximal oxygen consumption (max \( \dot{VO}_2 \)). \( \dot{VO}_2 \), HR, and perceived exertion rating measures were obtained during each test. Perceptions of pain were also recorded after each exercise. A 2-by-3 Factorial Anova with repeated measures on the factor level was used to analyze the data. In addition, preplanned comparisons were also conducted. Results showed no significant difference between sexes in their perception of effort or pain at 25 or 50% of max \( \dot{VO}_2 \). However, there was a significant difference by sex at the 70% level.
Introduction

Over the last twenty-five years there has been a significant increase in research concerning physical exercise and rating of perceived exertion (RPE) (Pandolf, Billings, Drolet, Pimental, & Sawka, 1984; Pandolf, 1983; O'Sullivan, 1984). Borg (1962) first proposed the measuring of an athlete's RPE as a subjective complement to the measuring of objective responses during physical exercise.

RPE, although an individual's subjective view of the intensity of work, is highly correlated with selected objective physiological parameters. Heart rate (HR) is linearly related to RPE. This correlation underlies the use of RPE in the exercise prescriptions for cardiac patients (Borg, 1982) and has been validated for running on a treadmill as well as for exercise on a cycle ergometer (Stamford, 1976; Borg, 1973; Gamberale, 1972).

The RPE scale has fifteen graded subdivisions using numbers from 6 to 20. Within this scale, odd numbers are followed by verbal descriptors. For example, seven is considered "very light" and nineteen is considered "very, very hard"
(Borg, 1973). These RPE values were selected to be as close to one-tenth of the matching heart-rate as possible. However, Borg and Linderholm (1967) found that the relationship between HR and RPE changes with age. They reported that younger subjects gave lower ratings of exertion in relation to heart rate than did older subjects.

The rating of perceived exertion represents an individual's integration of various physiological sensations (Pandolf, 1983). It was proposed that the main sensory information comes from the feelings of soreness and/or pain in the joints and muscles during exercise and from feelings associated with the cardio-pulmonary system (Ekblom & Goldbarg, 1971; Pandolf, 1983, 1978). Also, Pandolf, Burse, and Goldman (1975) and Morgan (1981) have reported that some psychometric parameters which result in changes of emotional state could have an impact on the overall cognitive processing of sensory information in the perception of effort during physical work.

According to Pandolf (1983), examination of the perception of exertion during exercise has become interdisciplinary in nature. Certain psychologists have shown interest in applied psychological issues, while others have been investigating theoretical issues
concerning psychophysiology and exercise perception. In addition, some physiologists have shown much interest on the interplay of multiple sensory input, while others have been concerned with identifying the major sensory cue(s) underlying perception of effort. Another group of physiologists has investigated effort sensations under several forms of exercise or different exercise conditions involving the interaction of several muscle groups. Finally, others have been interested in the effects of exercise intensity, duration and mode on perceived exertion as well as the effects of age, sex and physical training on exertional estimates. Morgan (1981) and Rejeski (1981) contended that perceived exertion is to a large extent influenced by cognition (thoughts). According to Hardy (1983), more support for the interrelationship between physiological and cognitive factors in the subjective "cost" of exercise comes from research on the perception of fatigue. A study by Pennebaker and Lightner (1980) revealed that subjects who heard an amplification of their own respiration rates during exercise on a treadmill reported more fatigue and fatigue-like symptoms than subjects hearing unrelated distraction sounds, such as street sounds, through headphones during exercise. Hardy (1983) further
reported that the results of such studies gave the implication that a complex relationship exists among perceived exertion, thought cognitive processes and physiological indicants. However, he also noted that it is questionable whether a fatigue scale is equal to Borg's (1962) RPE Scale. Taken collectively, such findings suggest that the perception of internal states during physical exercise can be influenced by cognitive processes. When external information is available to the athlete, the role of physiological indicants declines. Consequently, motivational, informational and emotional factors emerge to play a very significant role in the subjective assessment of exercise (Hardy, 1983).

Rejeski (1981) reported that the relative importance of physiological input to psychological variables changes with the duration of exercise and/or intensity, not from an empirical level of analysis, but from a conceptual one. At submaximal exercise, there is a great chance that psychological factors could act as cues in the subjective perceived exertion. This relationship is weak when work has physiological demands at or near VO\(_{2}\) max. From these relationships, physiological variables would be expected to influence perception of effort more at or near maximal levels of
exercise (Hardy, 1983).

Scott and Gigsbers (1981), in a study of perception of pain in competitive swimmers, found that intense athletic activity associated with pain was found to increase pain tolerance level. It was suggested that knowing more about athletes' response to pain could enable better predictions to be made concerning an athlete's ability to exert himself through the pain barrier. They further suggested that a better comprehension of the psychological factors that regulate the willingness of athletes to withstand pain would be quite helpful in defining the limits to which people with chronic pain, perhaps related to a disease process, could be reasonably encouraged in the acceptance of their pain. This is a questionable generalization, since their subject population was limited to competitive swimmers.

Hogan and Fleishman (1979), focusing on sex differences in perception of pain, observed that no significant difference in RPE between male and female has been reported. Sex differences of elite (highly trained) athletes in perception of physical effort have not been examined. Therefore, this study was designed to investigate sex differences in trained athletes' perception of physical effort and of pain...
METHOD

Subjects and test schedules

Six male and three female (N=9) highly trained, competitive middle distance runners, ranging in age from 17 to 26 years, were studied. All subjects, Louisiana State University students, were briefed on the nature of the study and gave written consent. Every subject was judged to be physically fit (they reported running more than 20 miles per week). Two experimental protocols were used—maximal and submaximal exercise tests. The tests were performed in a normal constant-temperature laboratory setting on two test-days. The tests were performed at about the same time of the day to control for diurnal variation. The first day of testing was for familiarizing subjects with the equipment and for establishing the maximal capacity for exercise. The athletes participated in a submaximal exercise test on the second day of testing.

Procedure

Subjects were tested on two different days with at least a day apart. Seat height was adjusted for each athlete and the frequency of pedalling was set at 60 revolutions per minute (RPM) with the help of an audiovisual metronome.
The maximal test consisted of 50 watt/min increments every two minutes to voluntary exhaustion, beginning at a no-load condition. HR was determined by ECG and \( \dot{V}O_2 \) by standard open circuit spirometry during the last 30-sec period of each load (Beckman OM-11 \( \dot{O}_2 \) analyzer). Beckman LB2 \( CO_2 \) analyzers, and Rayfield dry gas meter were all calibrated prior to and after each test. Subjects were required to achieve at least two of the three following criteria: (1) RQ > 1; (2) HR > 220 minus age in years, and; (3) no increase in \( \dot{VO}_2 \) despite an increase in work-load. During the submaximal test, the athlete was given a three-minute rest during which time he/she sat on the cycle with mouthpiece inserted. During this period, electrodes for heart rate measurements were attached and gas analysis equipment was calibrated. HR measures were taken 15 seconds before the end of the second and third minutes of rest. At the end of the third minute, the subject began exercising and the load was set to 25% of the athlete's \( \dot{V}O_2 \) max. The gas analysis equipment was again calibrated during the first two minutes, with \( \dot{V}O_2 \), HR, and RPE measures being taken during each of the last three minutes (6, 7, & 8). At the end of the eighth minute, the second work load (50% of \( \dot{V}O_2 \) max) was set
and the same procedures as during the 25% \( \dot{V}O_2 \) max work load were followed. At the end of the sixteenth minute, the third workload was set and the same measurement procedures were repeated again (minute 16-24).

The RPE scale was mounted on a wall in front of the subject and the subject indicated his/her rating by pointing to one of the numbers on the scale. At the end of each test, subjects were asked to rate their degree of discomfort using the Simple Descriptive Pain Scale.

**Analysis of Data**

The independent variables were sex and work rates (at 25, 50 and at 70% of \( \dot{V}O_2 \) max). The dependent variables were the rating of perceived exertion and perception of pain. The design used was a 2-by-3 Factorial Anova with repeated measures on the factor level (25, 50 and 70% \( \dot{V}O_2 \) max). Non-orthogonal polynomial comparisons were conducted as follow-up.

**RESULTS AND DISCUSSION**

Inspection of the group (sex) Least Square Means (Table 1) indicated that there was no significant difference between sexes in their pain perception at any level or in perception of effort at 25 or 50% of \( \dot{V}O_2 \) max. A significant sex difference for RPE

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Insert Table 1 about here

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was found at 70% of $\dot{V}O_2$ max (Figure 1), with the RPE for males being higher than that for females.

A univariate test using the Huynh-Feldt Epsilon (Huynh & Feldt, 1976) resulted in a significant difference in the perception of pain at different levels of exercise. The emergent value for the three levels taken together in this statistical test was $F(2,14) = 142.33 < 0.0001$. The F Value for level by sex interaction was $F(2,14) = 0.47 > 0.6385$.

Preplanned non-orthogonal comparison of levels for both the perception of work and pain showed linear trends for male and female, for females only, and for males only, denoting significant differences between the levels and supporting the earlier findings by the Huynh-Feldt Statistics (Tables 2 and 3). No quadratic trend for level was found. The Huynh-Feldt Epsilon = 1.0005, so the study met the assumption of compound symmetry.

Insert Tables 2 and 3 about here
As expected, all subjects reported higher RPEs and pain perceptions with greater work loads. The mean RPE for males was significantly higher than that for females at the 70% max $\dot{V}O_2$ level (Figure 1). Rejeski's (1981) similar findings were tentatively attributed to women's having less experience with symptoms of fatigue that appear in demanding work. That concept is subject to serious question, for both males and females in this study were highly trained competitive runners who, one could conclude, have had extensive experience with fatigue. Rejeski's secondary explanation that men are more ego-involved and might thus "suppress their actual fatigue" is also questionable. On the basis of male ego involvement, one might expect lower, rather than higher, ratings of perceived exertion. Perhaps this point could be addressed in an experiment using male and/or female coactors. While the present study can be criticized for the small and unequal sample sizes, it offers support for previous findings. We conclude that previously revealed sex differences in RPE in untrained subjects can be extrapolated generally to a population of highly trained athletes and recommend further
research seeking explanations for these differences.
REFERENCES


APPENDICES

(For Pilot Study)
APPENDIX F1

Group Least Squares Means
## Table 1

**Group LS Means for Psychological Variables**

<table>
<thead>
<tr>
<th>Gender</th>
<th>%</th>
<th>RPE LS Means</th>
<th>SD</th>
<th>Pain Perception LS Means</th>
<th>SD</th>
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<tr>
<td>Male</td>
<td>25</td>
<td>7.50</td>
<td>0.55</td>
<td>0.17</td>
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<tr>
<td></td>
<td>50</td>
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<td>0.55</td>
<td>2.50</td>
<td>0.20</td>
</tr>
<tr>
<td>Female</td>
<td>25</td>
<td>6.67</td>
<td>0.78</td>
<td>0.33</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>10.00</td>
<td>0.78</td>
<td>1.33</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>12.67</td>
<td>0.78</td>
<td>2.33</td>
<td>0.29</td>
</tr>
</tbody>
</table>
APPENDIX F2

RPE values plotted as a function of $\%\dot{V}O_2\text{ max}$
Fig. 1. Increase in RPE plotted as a function of % \( \dot{V}O_2 \) max.
APPENDIX F3

Contrasts
Table 2

General Linear Models Procedure
Dependent Variable: Pain

<table>
<thead>
<tr>
<th>Contrast</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>P R DF</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level Lin (L)</td>
<td>1</td>
<td>18.77</td>
<td>118.30</td>
<td>0.0001</td>
<td>0.92</td>
</tr>
<tr>
<td>Level Quad (Q)</td>
<td>1</td>
<td>0.037</td>
<td>0.23</td>
<td>0.6365</td>
<td></td>
</tr>
<tr>
<td>Level (L) Male</td>
<td>1</td>
<td>16.33</td>
<td>102.90</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Level (Q) Male</td>
<td>1</td>
<td>0.11</td>
<td>0.70</td>
<td>0.4168</td>
<td></td>
</tr>
<tr>
<td>Level (L) Fem</td>
<td>1</td>
<td>6.00</td>
<td>37.80</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Level (Q) Fem</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>14</td>
<td>2.22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3

General Linear Models Procedure
Dependent Variable: RPE

<table>
<thead>
<tr>
<th>Contrast</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>PRDF</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level Lin (L)</td>
<td>1</td>
<td>182.25</td>
<td>283.50</td>
<td>0.0001</td>
<td>0.97</td>
</tr>
<tr>
<td>Level Quad (Q)</td>
<td>1</td>
<td>0.75</td>
<td>1.17</td>
<td>0.2983</td>
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</tr>
<tr>
<td>Level (L) Male</td>
<td>1</td>
<td>168.75</td>
<td>262.50</td>
<td>0.0001</td>
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</tr>
<tr>
<td>Level (Q) Male</td>
<td>1</td>
<td>0.69</td>
<td>1.08</td>
<td>0.3163</td>
<td></td>
</tr>
<tr>
<td>Level (L) Fem</td>
<td>1</td>
<td>54.00</td>
<td>84.00</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Level (Q) Fem</td>
<td>1</td>
<td>0.22</td>
<td>0.35</td>
<td>0.5659</td>
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</tr>
<tr>
<td>Error</td>
<td>14</td>
<td>9.0</td>
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<td></td>
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</tr>
</tbody>
</table>
Michael Francis Sylva was born on June 12, 1955. He is the son of Mr. & Mrs. Zaccheus Michelle Sylva. He attended elementary school in Bathurst (Banjul), The Gambia and graduated from high school in June, 1974. From 1973 to 1976, he was player, coach and manager for a soccer club. Sylva came to the United States of America in August, 1976 and entered the University of Maine, (Farmington, Maine), that September. After three years, he received a Bachelor of Arts degree in Geography in May, 1979. From August 1979 to May 1981, he studied at the University of Arkansas, at Fayetteville, Arkansas, where he obtained a Master of Arts degree in Geography. Michael came to Louisiana State University in 1982 and pursued a Doctor of Philosophy in physical education, with an emphasis in Psychophysiology. He received the doctoral degree in May 1988.
Candidate: Michael Francis Sylva

Major Field: Physical Education (Psychophysiology)

Title of Dissertation: Effects of Sex and Social Influence on Perception of Physical Effort During Light to Heavy Work by Elite Athletes

Approved:

[Signature]
Major Professor and Chairman

[Signature]
Dean of the Graduate School

EXAMINING COMMITTEE:

[Signature]

[Signature]

[Signature]

[Signature]

Date of Examination:

November 12, 1987