THE RELATIONSHIP BETWEEN CALORIC EXPENDITURE AND EXAM SCORES OF NORTH CAROLINA STATE UNIVERSITY STUDENTS IN HEALTH/FITNESS PHYSICAL EDUCATION CLASSES

By

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The purpose of this investigation was to identify the relationship between average weekly caloric expenditure (kcalavg) via exercise during a three-month period and final written exam scores of college students in health/fitness physical education classes at North Carolina State University. Participants were 166 male and female college students between the ages of 18 and 43 years. Co-variables in the study were gender, age, race, grade point average (GPA), cardiovascular fitness level, year in school, class instructor, body mass index (BMI), percent body fat, grading option (GDO), and the interaction effects of (GDO x GPA), (GDO x BMI), (GDO x kcalavg), and (kcalavg x kcalavg).

Multiple linear regression analyses were conducted on the data from the study in phase I (full model), phase II (reduced model), and phase III (separate regression model). No predictions were made using the models because the major focus of the statistical analysis was upon identification of explanatory variables rather than prediction. Analysis of variance (ANOVA) results indicated a significant ($p < .05$) relationship between kcalavg and final exam scores of male and female participants when gender-separated data sets were analyzed in the phase II model. Results from the phase I model also showed a significant ($p < .05$) relationship between kcalavg and final exam scores for male participants. Statistical analyses in phase I and phase II for all participants combined indicated a significant ($p < .0001$) relationship between class instructor and final written exam scores. Results from analyses for all participants combined (phases I, II, & III)

showed that physical fitness level and final written exam scores were significantly ($p < .01$) related.

Male participants, on average, burned slightly more than 4,300 kcals via exercise per week, while females averaged an expenditure of 2,835 kcals per week. No conclusions could be drawn from the data that support an optimal level of caloric expenditure in relation to final written exam scores.

APPROVAL PAGE

THE RELATIONSHIP BETWEEN CALORIC EXPENDITURE AND EXAM SCORES OF NORTH CAROLINA STATE UNIVERSITY STUDENTS IN HEALTH/FITNESS PHYSICAL EDUCATION CLASSES

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CHAPTER I

INTRODUCTION

Years of examination of exercise research have provided contrasting evidence of a link between exercise and cognitive performance (Bills, 1927; Kirkendall, 1985; Tomporowski & Ellis, 1986; Weingarten, 1973). It is even less clear how exercise affects the cognitive performance in general, or the classroom performance in particular, of a diversified college student population in health/fitness physical education classes. There is also no definitive research that explores how the relationship between exercise and cognitive performance could impact physical education professionals who have endeared themselves to the principles of dualism (the separation of mind and body). According to Kretchmar (1994), Ousterhoudt (1984), and Weiss (1969), many physical education professionals have historically shown little interest in understanding the nature of embodiment and holism (the unity of mind and body). Instead, physical education professionals train the body to an external end with the implication that the physical education profession neglects the whole person. In an attempt to address these issues, the need exists to examine the relationship between exercise and cognitive performance of college students in health/fitness physical education classes.

The American College of Sports Medicine (ACSM, 2000) has indicated that substantial research literature supports the fact that exercise can improve physiological function, enhance psychological well being, and increase physical fitness. A limited amount of research has been conducted to explain how exercise relates to the classroom cognitive performance of college students, and mixed results exist in the exercise/cognitive performance research literature in the few studies that have used college-aged individuals as participants (Gliner, Matsen-Twisdale, Horvath, & Maron, 1979; Kubitz & Mott, 1996; Lybrand, Andrews, & Ross, 1954; Plunk & Bowden, 2001; Sullum, Clark, & King, 2000; Tomporowski, Ellis, & Stephens, 1987; Weingarten & Alexander, 1970). Although research has focused on the relationship between exercise and cognitive performance in general, there has been little investigation specific to the relationship between exercise as measured by caloric expenditure and cognitive performance as measured by class exam scores. More studies are needed to supplement the few that currently exist in an attempt to gain insight into this relationship.

Cognitive performance measurements found in the research literature include memory recall (Bills, 1927), perceptual skills (Young, 1979), and reaction time (Chodzko-Zajko, Soloman, Heinl, & Ellis, 1992). Dillon and Schmeck (1983) defined cognitive performance as a function of critical thinking that requires the processing of information that can be perceived by the individual and placed in memory or retrieved from memory. An associated measure of cognitive performance is academic performance. Cambridge (2001) defines academic performance as the act of studying and thinking at schools, especially colleges and universities, with measures expressed as letter grades or point grades for specific classroom work and grade point averages (GPA) for semester and/or academic year results. The research literature has presented mixed results from the influence of exercise on classroom performance, as some results (Lueptow & Kayser, 1973) have shown no association between these variables, though other research results (Shephard, 1997) indicated that a positive relationship does exist.

Etnier et al. (1997) indicated that the general inconclusiveness of exercise/cognition research is partly because there are many influences on cognitive performance other than exercise and no single, specific variable has been proven to explain the variation in cognitive performance among individuals. Non-exercise variables that have been researched include motivation (Condry & Chambers, 1978), psychosocial behavior (Hawken, Duran, & Kelly, 1991), time management (Britton & Tesser, 1991), class attendance (Van Blerkom, 1992), residential environment (Delucchi, 1993), preparation strategies (Carrell & Menzel, 1997), sleep patterns (Pilcher & Walters, 1997), issues of diversity (Greasley, 1998), and family backgrounds (Betts & Morell, 1999). Research results from each of these non-exercise variables have indicated some measurable influence on cognitive performance, although the extent of that influence is debatable.

Purpose Statement

The purpose of this investigation was to identify the relationship between exercise expressed as caloric expenditure via exercise during a three-month period and cognitive performance expressed as final written exam scores of college students in health/fitness physical education classes at North Carolina State University. Although numerous variables have been identified as having some impact on cognitive performance, the independent co-variables used in this study were selected because of their association with exercise and classroom cognitive performance. This study addressed nine research questions.

Research Questions

1. When statistically controlling for exercise and non-exercise variables, what is the relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores of college students in health/fitness physical education classes?

2. When statistically controlling for exercise and non-exercise variables, what is the relationship between physical fitness level and final written exam scores of college students in health/fitness physical education classes?

3. When statistically controlling for exercise and non-exercise variables, what is the relationship between body composition and final written exam scores of college students in health/fitness physical education classes?

4. When statistically controlling for exercise and non-exercise variables, what is the relationship between gender and final written exam scores of college students in health/fitness physical education classes?

5. When statistically controlling for exercise and non-exercise variables, what is the relationship between class instructor and final written exam scores of college students in health/fitness physical education classes?

6. When statistically controlling for exercise and non-exercise variables, what is the relationship between grade point average (GPA) and final written exam scores of college students in health/fitness physical education classes?

7. When statistically controlling for exercise and non-exercise variables, what is the relationship between grade option and final written exam scores of college students in health/fitness physical education classes?

8. When statistically controlling for exercise and non-exercise variables, what is the relationship between the interaction effect of specific independent variables and final written exam scores of college students in health/fitness physical education classes?

9. What is the relationship between fitness-related variables and superior ("A") final written exam scores of college students in health/fitness physical education classes?

Significance of the Study

The results of this study may have an impact on the physical education profession in several ways. First, a positive relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores may enhance the argument for expanded physical education programs in school-based settings, contrary to a trend showing a decline in required physical education programs at all school levels in the United States (Almond & McGeorge, 1998; Hensley, 2000). If exercise is a variable that contributes to the explanation of cognitive performance, it will help to validate the importance of physical education programs and will support the concept that physical education is a "core" academic subject. Second, a positive relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores may also reduce the impact that dualistic theory has long had upon the physical education profession. Simultaneously, a positive relationship between these variables may help promote the theory of holism, a doctrine that postulates that the thoughtful aspect of people is influenced by body composition, health, and movement, and that the whole person is greater than the sum of his or her parts (Kretchmar, 1994; McCloy, 1966; Williams, 1965). Third, the results of this study may illustrate the influence of diversity (i.e., gender, race, age) on the classroom performance of college students in health/fitness physical education classes. Butler and Walter (1991) studied the importance of recognizing the interaction of racism, sexism, and ethnocentrism at all levels of education and acknowledged the necessity of teachers to adapt to a more multicultural classroom.

Basic Assumptions

1. It was assumed that all participants exerted maximal effort during the Cooper 1.5-mile run to measure cardiovascular fitness levels.
2. It was assumed that the participants gave all self-reported information honestly and completely.

Delimitations

1. All participants in this study were from intact health/fitness (PE 107 run conditioning) classes at North Carolina State University (NCSU).
2. All instruction for participants within the seven health/fitness sections came from three physical education instructors at North Carolina State University.

Limitations

1. All participants were drawn from the same university population. This sampling procedure may potentially limit the ability to generalize the results to young adults being educated in a similar setting.

2. A limited age range (18-43 years) was examined in this study. The results will be generalizable only to persons of similar age.
3. Three physical education instructors, with similar educational backgrounds and teaching credentials, taught the seven health/fitness classes in this study. Differences in personality and teaching style between the three instructors may have potentially limited the homogeneity of instruction.

Definition of Terms

Body mass index. Body density is determined by dividing body weight (kilograms) by height (meters squared) as recommended by the National Heart, Lung, and Blood Institute (1998). Classifications and measurement ranges for all participants were 1) underweight, < 18.5; 2) normal, 18.5-24.9; 3) overweight, 25.0-29.9; 4) class I obesity, 30.0-34.9; 5) class II obesity, 35.0-39.9; and 6) class III obesity, > 40.0.

Caloric expenditure. The amount, duration, and intensity of exercise measured by kilocalories as an indicator of metabolic output (ACSM, 2000). Caloric expenditure via exercise during a three-month period was the independent variable of major interest in this study.

Cognitive performance. A function of critical thinking that requires the processing of information that can be perceived by the individual and placed in memory or retrieved from memory (Dillon & Schmeck, 1983). Final written exam scores for students in the health/fitness classes constituted the measure of cognitive performance. Grade classifications and point values were 1) excellent, 90-100; 2) above average, 80-89; 3) average, 70-79; 4) below average, 60-69; 5) poor, < 60.

Cooper 1.5-mile cardiovascular fitness run. A timed 1.5-mile run as prescribed by the guidelines established at the Cooper Institute for Aerobic Research (Cooper, 1982). Fitness categories for men and women were established for each participant based upon his/her run completion time. Fitness classifications were 1) excellent, 2) above average, 3) average, 4) below average, 5) poor.

Exercise. A subset of physical activity that involves planned, structured, and repetitive bodily movement performed to improve or maintain one or more components of physical fitness (ACSM, 2000). Each participant's exercise volume was measured by determining his/her average weekly energy expenditure in kilocalories (kcals) for a three-month period.

Exercise/activity questionnaire. A modified version of the Aerobics Center Longitudinal Study Physical Activity Questionnaire (Kohl, Blair, Paffenbarger, Macera, & Kronenfeld, 1988) was used in this study to determine exercise participation and caloric expenditure of all participants.

Kilocalorie (kcal). A calorie is a measure of heat used to indicate the energy supplied by food and the energy expended by the body. The term kilocalorie is the main expression of a food's energy-producing value (ACSM, 2000).

Moderate exercise intensity. An exercise intensity (40%-60% of VO_2max) well within the individual's current capability that can be sustained for a prolonged period of time (60 minutes), which has a gradual initiative and progression and is generally non-competitive (ACSM, 2000).

Percent body fat. Skin fold thickness measures are used in prediction equations (Jackson & Pollock, 1985) to estimate body composition. The measurements are taken with calipers at the chest, mid-abdominal, and mid-thigh for males and triceps, iliac crest, and mid-thigh for females.

Physical fitness. The ability to perform daily activities without undue stress or fatigue. The components of physical fitness, which are objective and measurable, are 1) flexibility, 2) cardiovascular endurance, 3) muscular strength, 4) muscular endurance and 5) body composition (ACSM, 2000). Cardiovascular fitness in this study was defined by each participant's performance in a timed 1.5-mile run as prescribed by the guidelines established at the Cooper Institute for Aerobic Research (Cooper, 1982).

Vigorous exercise intensity. An exercise intensity (> 60% VO_2max) that sufficiently represents a substantial cardiovascular challenge, or if that intensity results in fatigue within 20 minutes (ACSM, 2000).

CHAPTER II

REVIEW OF LITERATURE

The purpose of this literature review is to provide information about, and evidence of, the relationship between exercise and cognitive performance. The literature review is divided into nine sections that are related to research in this area. The nine topics in each section are 1) definitions of exercise, cognitive performance, and academic (class) performance, 2) physiological and psychological benefits of exercise, 3) trends of daily exercise participation in society and physical education, 4) dualism and holism as related to physical education, 5) animal and human research related to exercise and cognitive performance, 6) exercise and cognitive research in specific age groups, 7) physiological effects of exercise on cognitive performance, 8) non-exercise variables that influence cognitive performance, and 9) summary.

Exercise, Cognitive Performance, and Academic (Class) Performance Defined

Exercise. The American College of Sports Medicine (ACSM) defines physical activity as bodily movement produced by the contraction of striated muscle that substantially increases energy expenditure (ACSM, 2000). According to the ACSM, exercise is defined as a subset of physical activity that involves planned, structured, and repetitive bodily movement performed to improve or maintain one or more components of physical fitness. The components of physical fitness, which are objective and measurable, are 1) flexibility, 2) cardiovascular endurance, 3) muscular strength, 4) muscular endurance and 5) body composition. Exercise can thus be considered a method of achieving physical fitness.

Cognitive and academic (class) performance. Dillon and Schmeck (1983) defined cognitive performance as a function of critical thinking that requires the processing of information that can be perceived by the individual and placed in memory or retrieved from memory. Cambridge (2001) states that a more specific measure of cognitive performance is academic performance, which is defined as the act of studying and thinking at schools, especially colleges and universities, with measures expressed as letter or point grades for specific class work, and grade point averages (GPA) for semester and academic year results. Although research has explored the possibility of a relationship between exercise and class performance, the mechanisms by which regular exercise may improve this measure of cognition are not well understood.

Measurements of cognitive performance include memory recall (Bills, 1927), perceptual skill (Krus, Wapner, & Werner, 1958; Weingarten, 1973; Young, 1979), reaction time (Chodzko-Zajko et al., 1992; Madden, Blumenthal, Allen, & Emery, 1989), and class performance (Sallis et al., 1999; Shephard & Lavallee, 1994). Research has shown that exercise has also been associated with changes in other psychological parameters such as a decrease in stress (Brown, 1991; Dua & Hargreaves, 1992; Kagan & Berg, 1988), and an increase in self-esteem (Daley & Buchanan, 1999; Walters and Martin, 2000). Wilmore and Costill (1999) reported that a cause-and-effect relationship exists between consistent, moderate exercise and physiological variables, and that structured and consistent physical exercise also has numerous psychological effects on the human body.

Physiological and Psychological Benefits of Exercise

Physiological benefits of exercise. Wilmore and Costill (1999) reported that exercise options are considered to be either aerobic in nature, which are sustained, submaximal routines that emphasize dynamic, large muscle movements that utilize oxygen for energy production, or anaerobic in nature, which are short, intense bouts of exercise that emphasize strength/speed movements that use non-oxygen dependent sources of energy. The ACSM (2000) states that exercise can be performed in different ways to bring about particular physical adaptations through fitness training. The five components of physical fitness can be trained individually (i.e., high intensity weight training for improved muscular strength) or as a group (i.e., swimming laps to promote fitness gains in all components of fitness).

Blair et al. (1989) provided an example of the influence that exercise has on the overall health of the human body by utilizing over 13,000 men and women participants in a longitudinal study. Participants were given a treadmill exercise test and were assigned to one of five physical fitness categories. All participants were tracked for eight years and death rates were calculated for each fitness category. A relative risk of death was computed by taking into consideration family history of heart disease, smoking, cholesterol, blood pressure, and blood sugar levels. The results showed a strong, inverse relationship between physical fitness and death. In the higher fitness categories, heart disease and cancer death rates were lower.

The ACSM (2000) states that when activity begins, the body is required to move from a resting position to an altered state of homeostasis. The most obvious changes that occur during and immediately after exercise are physiological (i.e., increased heart rate, ventilation, blood pressure, etc.) to adjust to the greater demands placed on the body. In healthy individuals, these changes involve minimal risk (e.g., increased chance of sudden death). Research shows that consistent training over time leads to long-term health improvements as is evidenced by the following studies. Miller (1995) showed that weight-bearing exercises, such as running, have a positive effect on bone mineral density in men and women. Zelasko (1995) reported that exercise expends energy (kilocalories) and can play an important part in weight loss programs. Laughlin (1999) indicated that moderate intensity, endurance-based exercise can result in significant positive changes in the variables that effect oxygen consumption, such as stroke volume, heart rate, and atrial-venous oxygen difference. Fagard (2001) reported that exercising three to five times per week at moderate intensity levels for 30-60 minutes results in significant blood pressure reductions for individuals who are hypertensive and, to a lesser extent, will reduce blood pressure in normo-tensive individuals. Thompson et al. (2001) showed that muscle hypertrophy and muscle function are positively impacted by chronic exercise. Roecker et al. (2002) reported that adding heart rate maximum values to heart rate prescription models could enhance cardiovascular training designed to improve physiological function.

Psychological benefits of exercise. Barabasz (1991) reported a positive influence from exercise on mood state in a study that tested 24 university student volunteers. Each participant exercised aerobically (mode choice by student) for 45 minutes. When compared to baseline scores, results from a mood state questionnaire given to each participant immediately after the exercise showed reduced total mood disturbance and reduced tension-anxiety. Dua and Hargreaves (1992) performed a study that supports the theory of improved psychological well being from exercise participation. This study used three sets of participants (15 long-term, chronic exercisers; 14 short-term, sporadic exercisers; 18 nonexercisers) to analyze negative and positive affects associated with thoughts and day-to-day experiences. A questionnaire was completed by participants in each group; this questionnaire also included a rating of overall general stress. Long-term exercisers reported more positive affect associated with their thoughts and day-to-day experiences than the non-exercisers. Long-term exercisers also reported less overall stress than did the non-exercisers. The authors concluded that chronic exercise could be useful in controlling stress and reducing depression.

Stein and Motta (1992) studied the relationship between exercise and psychological well being of college-aged participants. This study required 89 undergraduate students to participate in an aerobic (swimming) exercise group, a non-aerobic (weight training) exercise group, or a non-exercise (control) group to measure the effects of exercise on depression and self-concept. Depression and self-concept questionnaires, along with a fitness swim test, were used as dependent measures for this pretest-posttest study. Results showed that the non-aerobic group was superior to the aerobic group for enhancing self-concept. Most previous studies of similar methodology had shown a greater positive influence on participants' self-concept when they engaged in aerobic exercise rather than non-aerobic exercise. The authors concluded that this study supported the theory of improved psychological benefits through participation in non-aerobic exercise and promoted the notion that various modes/types of exercise may bring forth psychological benefits.

Blinde and Taub (1999) conducted a study that showed the benefits of exercise towards personal empowerment for individuals with physical and sensory disabilities. Tape-recorded interviews with 28 male college students with physical or sensory disabilities were conducted to ascertain the participants' involvement in sport and physical fitness activities and empowerment levels. Results showed that those who participated in sport and physical fitness activity had an enhanced perception of effectiveness in social settings that provided a greater sense of control in life. The authors concluded that exercise could be beneficial to individuals of all physical abilities.

Mack, Huddleston, Dutler, & Bian (2000) performed a study that utilized 74 students who were enrolled in a seven-week physical activity class. During each week of the course, each student completed a questionnaire that assessed happiness and sadness. Repeated-measures analysis of variance showed no change in average mood state scores, though it was reported that students' scores remained in the "happy" category throughout the course. Female participants did show significantly higher "happy" scores as compared to the male participants. The authors theorized that the high mood state baseline scores at the beginning of the course did not allow for a significant increase in scores even if the exercise had a positive effect on students' psychological well-being. Thus, the participants were considered to be non-responders.

Walters and Martin (2000) presented research results that demonstrated no improvement on psychological profile scores from exercise. The purpose of their study was to examine the link between aerobic exercise, self-esteem, and problem behavior in children. Participants were 67 children in grades 3-5 who took part in a 13-week intensive aerobic exercise program, while 80 children received a low-intensity aerobic exercise program. A self-perception questionnaire was given to both groups before and after the 13-week program. Results from statistical analysis (analysis of variance) showed that the intensive exercise group did not have significant improvement in any of the questionnaire scores as compared to the control group, nor did it diminish the level of problem behaviors in that group. The authors postulated that both groups began and ended the 13-week training session with scores that were well above average, which did not allow for any significant improvement in test scores.

Trends of Daily Exercise Participation

Trends in society. Pate, Heath, Dowda, and Trost (1996) conducted the Youth Risk Behavior Survey of 11,631 high school students that provided information on exercise and other health behaviors, such as diet and substance use. A subset of 2,652 highly active students and a subset of 1,641 low-activity students were used to examine the relationship between exercise and other health behaviors. Logistic regression analysis results showed that low exercise levels were associated with cigarette smoking, marijuana use, lower fruit and vegetable consumption, greater television watching, and low perception of academic performance. The authors concluded that low exercise level was linked to several negative health behaviors and that interventions to increase exercise participation may be effective in reducing such behaviors.

According to Mokdad et al. (1999), obesity (defined as being over 30% above ideal body weight) in the overall population of the United States increased from 12% in 1991 to 18% in 1998. The greatest increase occurred between the ages of 18 to 29 years. By region, the largest increases in weight were seen in the South with a 67% increase in the number of obese people. The North Carolina Institute of Medicine (1999) reported that, in North Carolina, children and adults rank among the least physically fit of all states (49th overall) and the state received a D+ grade on physical activity in 1998. The North Carolina Institute of Medicine also reported that, based on 1999 data from a national health initiative called Healthy People 2000, only 29% percent of students in grades 9-12 participated in daily physical education, down from 42% in 1991.

Statistics from the National Center for Health Statistics (2000) show that participation in regular physical exercise is not as prevalent as in the past, especially in school-aged individuals. Nearly half of all young people in the United States (12-21 years) are not vigorously active on a regular basis and the number of overweight children has more than doubled in the past decade. The United States Department of Health and Human Services (2000) reported that physical exercise is listed as one of the 10 leading health indicators for Healthy People 2010, a continuation of Healthy People 2000 directed by U.S. Surgeon General David Satcher. In an attempt to slow the decline of

America's physical health, physical inactivity has been placed as the second national priority for public health concerns in the new millennium. The Surgeon General has established a target goal of 85% of adolescents in grades 9-12 that engage in 20 minutes of vigorous exercise three or more days per week, up from the present level of 65%. Currently, only 15% of adults aged 18 years and older engage in 30 minutes of moderate physical exercise five or more days per week. Healthy People 2010 has a goal target of 30% for this age group.

Trends in physical education. Hanson and McKenzie (1989) reported that public school systems in the United States have often viewed physical education from a negative standpoint so that physical educators are forced to fight to preserve the existing curricular investment in physical education. Godin and Shephard (1990) stated that the likelihood of sustaining a regular exercise program during adult life depends, in part, on the individual's past experience of physical exercise and that the importance of conveying the benefits of regular exercise is paramount during a person's formative years.

Almond and McGeorge (1998) reported that within the past 30 years in the United States, required physical education participation from grade school through college has been reduced in an attempt to streamline curriculums and save money. Hensley (2000) surveyed 600 four-year colleges and universities in the United States to determine how many schools had a required basic instruction program (BIP) in physical education for all students. Results from 386 schools (64% return rate) showed that 63% had a BIP in physical education, with a two-hour requirement being the most common. Hensley noted that the BIP in physical education requirement for four-year colleges and universities was over 90% prior to 1960.

Daily physical education. Shephard and Lavallee (1994) directed the Quebec Trois Rivieres study, a longitudinal experiment that involved 546 primary school students in grades one through six. The study compared experiment participants who received an additional hour per day of physical education taught by a physical education specialist (for a total of one hour and forty minutes) to control participants who received only the standard 40-minute physical education program, taught by a non-specialist. This curricular discrepancy allowed the control subjects 13% to 14% more academic instruction time than the experimental group. Each participant's cognitive performance in five areas (French, English, mathematics, natural science and conduct) was computed. Repeated measures analysis of variance results showed that experimental students outperformed the control participants by significant levels in grades two, three, five and six. The authors concluded that cognitive performance is maintained or enhanced by an increase in a student's level of physical activity even when accompanied by a reduction in curricular time for the study of academic material.

Dwyer, Blizzard, and Dean (1996) used fifth grade students as participants in a study designed to examine the relationship of exercise and cognitive performance. Three activity groups (control, skill, or fitness) participated in a 14-week intervention. The control group exercised for a half hour three times per week in physical education class; the skill group had similar content as the control group but exercised for 75 minutes daily; the fitness group followed the same routine as the skill group but exercised at higher intensities. Results showed that cognitive performance was similar in the three groups despite less classroom time in the two exercise groups. The authors suggested that these results indicate indirect support for the beneficial role of exercise on cognitive performance.

Sallis et al. (1999) conducted a two-year study of fourth and fifth grade students in a single public school district (12 schools) in Southern California to examine the relationship of exercise and cognitive achievement. Participating schools were randomly assigned to one of three conditions. In the specialist condition, certified physical education specialists implemented the Sports, Play, and Active Recreation for Kids (SPARK) program (Sallis et al., 1997). In the experimental condition, classroom teachers were trained by research staff to implement the SPARK program. In the control condition, classroom teachers implemented the usual physical education program. Results showed that achievement test scores for students involved in the SPARK program greatly exceeded the national average at baseline. The authors concluded that these results reinforced previous findings (Shephard, 1997) that spending more time on physical education does not interfere with cognitive performance.

Dualism and Holism as Related to Physical Education

Kretchmar (1983), Malcolm (1971), Meier (1979), Merleau-Ponty (1963), and Weiss (1969) are philosophers and researchers who have addressed different theories of dualism and the influence each theory has on sport and physical education. Foster (1991) defined dualism as a doctrine centered on mental and physical realms and the relationship between the mind and body. Jensen (1998) noted that the earliest ideals of dualism originated from Greek philosophers (Plato, Socrates) during the fourth and fifth centuries, B.C.E., and other philosophers have since promoted these ideals, most notably the sixteenth century French mathematician Rene' Descartes.

Dualism. Weiss (1969) described the mind and body as two substances linked by emotions that are simultaneously unifications of the mind and body. According to Descartes' theory (i.e., Cartesian dualism), mind-knowing is superior to body-knowing, and the mind is thus held in higher esteem as it controls the inferior body. Thus, Cartesian dualism establishes a hierarchical concept of man that emphasizes mind over body and defines man as *possessing* a body rather than *being* a body. Morgan and Meier (1988) stated that proponents of dualism support the notion that man is composed of two distinct substances that are independent of each other, the mind and the body. According to the theory, the mind is an indivisible, conscious, and free substance possessing no qualities of extension and thus is not susceptible to mechanical laws; the body is an unthinking, extended, and material substance that acts as an unconscious machine.

Weiss (1969) reported that the physical education profession has shown little interest in understanding the nature of embodiment (the unity of mind-body) and has instead embraced the dualistic doctrine of disembodiment (separation of mind-body and the view of the body as an inferior object to the mind). Kretchmar (1983), who attempted to develop categories of dualism that practitioners could understand, defined four types of dualism (object, value, behavior, language) and related each to sport and physical education. Object dualism refers to tending the body, and not the mind, by coaching, teaching, and training, with the implication that physical educators neglect the whole person. Value dualism promotes the Platonic theory that mind, thinking, and mental activities are superior to the body, with the implication that non-physical education disciplines are superior, which is evident when physical education departments change titles to include terms such as "sports science" and "exercise science." Behavior dualism dictates that all action must be preceded by thinking, which implies that the body is a machine and must have a "pilot" in order to perform. Language dualism suggests that verbal symbols are superior to other types of symbols, which in turn diminishes the significance of movement as a form of expression and communication.

Osterhoudt (1984) wrote that the philosophic basis of modern physical education is derived from the doctrines of dualism and empiricism, which together form empiricist dualism. Empiricism supports the influence of experience rooted in bodily senses, rather than reason, as being the source of knowledge. Thus, empiricist dualism defines the body as being one objective, concrete thing among other objective, concrete things and that the experiences of bodily sensations determines further knowledge. Though empiricist dualism promotes physical education in extrinsic terms, it concurrently raises intellectual doubt against physical education as a discipline. Osterhoudt concludes that empiricist dualism tends to interpret physical education as an exercise modality that uses the body to an external end, but severs physical education from its humanistic possibilities.

Holism. McCloy (1966) and Williams (1965), prominent physical educators of the 20^{th} century, advanced the doctrine of holism, which describes individuals in non-dualistic terms. The doctrine of holism promotes the notion that the physical aspect of people is influenced by thought, while body composition, health, and movement influence the thoughtful aspect of people. Thus, the whole person is greater than the sum of his or her parts. Williams described the person as a whole being and suggested that the physical education profession should "educate through the physical" by teaching social and moral lessons through dance, exercise, and sport. McCloy, who also described people as whole beings, postulated that the physical education profession should promote "education of the physical" by improving cardiovascular fitness, muscular fitness, and flexibility while also enhancing thought and attitudes.

Wilson (1979) argued that Cartesian dualism lacks objective evidence to support its theory. Wilson wrote that Descartes and his successors made the mind and body so different that their interaction could not be explained. Grayling (2001) stated that this unexplained interaction is evidenced in Descartes' attempt to reason how one substance mysteriously interacts with the other by asserting that the mind exercises its influence over the body in one specific part of the brain, the pineal gland. Wilson and Grayling postulated that the holistic view (that there is only one substance) was the conceptual opposite of dualism and that holism was a plausible alternative to Cartesian dualism. According to the doctrine of holism, the mind and body are distinct participants in the organic union of life that are not qualitatively opposed to one another. Thus, holism posits the existence of a single fundamental reality. Wilson noted that this materialist, identity theory approach asserts that mental states are identical with processes in the brain and that biophysical systems are endowed with a very high degree of systemic integration.

According to Kretchmar (1994), five holistic principles can be advanced that could cease the physical education profession's placement of mind over body. He postulates that 1) physical influences are always working to shape all that people are and all that people do, 2) the influences of consciousness are always at work, 3) consciousness and embodiment have no complete independence from one another, 4) there are different levels of behavioral intelligence (impressive and unimpressive), and 5) there are different types of activity (motor-active or motor-passive). Gardner (1985) lends support to Kretchmar's fourth holistic principle (intelligence levels) by describing the theory of the eight elements of multiple intelligence (linguistic, mathematic, spatial, musical, kinesthetic, interpersonal, intrapersonal, and naturalistic). Gardner argues that the measure of intelligence is situational specific, thus the "intelligent" physics professor who can solve complex quantitative problems may not be considered intelligent when tested in tasks outside his or her specialty, such as musical or kinesthetic abilities.

Animal and Human Research Related to Exercise and Cognitive Performance

Animal research. A study by Brown et al. (1979) was designed to determine the role of endurance training and a high-fat diet on two neurotransmitters (norepinephrine and serotonin) in the female rat brain. Forty adult female rats (75 days old) were divided into an exercise training group and a sedentary group. Each was further divided into normal or high-fat diet groups. The exercise group trained 30 minutes per day, five days per week for eight weeks, on a treadmill. At the end of eight weeks, the rats were sacrificed and the brains were weighed and sectioned into three areas: The cerebral cortex, cerebellum, and midbrain. In most brain areas, norepinephrine and serotonin levels were significantly higher in exercise/normal diet rats and exercise/high-fat diet groups as compared to both non-exercise groups. The authors suggested that increased levels of serotonin in the midbrain may be the neurotransmittal adaptation responsible for decreased appetite and enhanced weight loss following chronic endurance exercise.

Neeper, Gomez-Pinilla, Chol, and Cotman, (1995) studied rats to investigate the effect of exercise on brain-derived neurotrophic factor (BDNF), a growth factor of the neurotrophin family that supports the function and survival of numerous neurons. Nuclease protection assays were used to measure BDNF messenger ribonucleic acid (mRNA), a sub-measure of BDNF content, in distinct brain structures of adult rats following zero (control), two, four or seven nights of free wheel running by the rats. The authors found a significant, positive correlation between mean distance run per night and BDNF mRNA in specific brain structures in all exercise groups. Additionally, one rat in the two-night exercise group did not run and had BDNF mRNA measurements equal to control levels. The authors postulated that exercise-induced upregulation of BDNF could help increase the brain's resistance to damage and degeneration through support of neuronal growth, function, and survival.

Radak et al. (2001) utilized different-aged rats to analyze the effect of exercise on cognitive function. This animal study randomly assigned young (four-week old) and middle-aged (14-month old) rats to exercise (swimming) or non-exercise (control) groups in order to investigate cognitive function in relation to exercise. A conditioned pole-jumping avoidance ability, tested via memory, was the measure of cognitive function.

Results from passive avoidance tests showed that pole-jumping avoidance learning was improved markedly in both age groups following exercise. The middle-aged exercised rats had significantly better short-term (24 hours) and long-term (72 hours) memory than aged-matched control rats. The authors concluded that exercise could increase cognitive function in rats.

Human research. Weingarten (1973) reviewed exercise and cognition studies and concluded that exercise has a positive influence on the performance of complex cognitive tasks but not on the performance of simple cognitive tasks. He qualified his conclusions based upon the complexity of the cognitive task. Gruber (1975) examined the association between cognitive performance and exercise and based his conclusions on the nature of the exercise. His review concluded that exercise benefits cognitive function only if the exercise involves coordinated movements that require thought before execution. Kirkendall (1985) conducted a review of research that was reported during 1950-1970 on the relationship between exercise and intellectual development. Although Kirkendall reported that many of the studies were not designed to test the cause and effect relationship between exercise and cognition, he noted that there is a modest association between improved motor performance and cognitive performance, especially in those activities involving coordination and balance. Kirkendall stated that this link is most evident during the early stages of development and gradually declines with age.

Tomporowski and Ellis (1986) reviewed 27 experimental studies that tested the effects of exercise on cognition. The authors noted that these previous studies had been evaluated with respect to five factors of major importance to their interpretation. The first factor was the extent to which the investigators attempted to measure the physical fitness of participants prior to an exercise intervention. The second factor was the intensity and duration of the exercise intervention used in each study. The third factor was the cognitive task selected by the investigators. The fourth factor was the time at which the cognitive test was administered to the participants (i.e., during or after the exercise intervention). The final factor the authors noted was whether the exercise intervention had a facilitating, debilitating, or no effect on cognitive function. The studies reviewed included exercise interventions that were grouped by intensity level and exercise duration; this included a range of exercise between brief, intense anaerobic work and long-duration, low-intensity aerobic exertion. Though the results were generally inconclusive, the authors noted that exercise of short duration and moderate intensity led to modest improvement in cognitive function. The authors also concluded that the mixed findings may be explained by variations in the participant's fitness level, the mode of exercise intervention, and the nature of the cognitive task.

Chodzko-Zajko et al. (1992) reported that the relationship between exercise and cognitive performance in older adults (aged 65-88 years) is task specific with exercise benefits more often observed in events requiring rapid processing but less evident in self-paced tasks. Etnier et al. (1997) reported mixed results after conducting a meta-analysis of over 200 studies that examined what effect acute or chronic exercise had on cognition. To determine effect sizes, studies were coded as acute, chronic, or mixed acute/chronic exercise. Study designs were coded as either quasi-experimental or true experimental. Cognitive measures included 106 different tests that were classified as being memory, mathematical ability, verbal ability, reasoning, creativity, academic performance, mental age, intelligence quotient, reaction time, motor skills, or perception. In 134 of these studies, there was a small positive effect of exercise (acute and chronic) on cognition. The meta-analysis results indicated that exercise may not have a meaningful impact on cognition when it is administered in acute bouts, but chronic exercise that produces fitness gains may be a useful intervention for enhancing cognitive function. However, the quasi-experimental designs of these cross-section and correlation studies give question to the results. The authors summarized that exercise is only one of many variables that may influence cognitive performance and more research is warranted to analyze its association in this process.

Exercise and Cognitive Performance in Specific Age Groups

Adolescents. Daley and Buchanan (1999) examined changes in self-perception related to participation in extracurricular aerobics. Females aged 15 to 16 years from a single-sex secondary school in southeast England were recruited into either an aerobics plus physical education group (n = 43) or a physical education only group (n = 70). The physical education only group took part in compulsory class activity once per week for one hour and did not participate in any form of aerobics throughout the duration of the study. Participants in the aerobics group took part in compulsory class activity and additionally attended an aerobics class once per week after school for five weeks. All participants completed a physical self-perception questionnaire one week prior to commencing the aerobics intervention and again five weeks later. All participants also completed a physical activity participation questionnaire at the conclusion of the study. A series of 2 x 2 analyses of variance (ANOVA) with repeated measures for time were conducted. Results showed significant changes in adolescent girls' physical self-perceptions as a result of participation in five weeks of aerobics in addition to a one-hour physical education class.

Daley and Ryan (2000) examined the cognitive performance of adolescent boys and girls attending a mixed Catholic comprehensive school in southwest England. Three classes were randomly selected from each of grades 8, 9, 10 and 11. Each class consisted of 21 to 25 pupils for a total of 232 participants between the ages of 13 and 16 years. Previous examination results for common core topics (English, mathematics, and science) were used as measures of cognitive performance and each grade was rated as follows: A=5, B=4, C=3, D=2, E=1, F=0. Participants completed a modified version of a physical activity participation questionnaire and were asked to list all sports-based physical activities normally participated in during a typical week and to indicate the frequency and duration of each activity. Correlations between exercise participation and cognitive performance were not statistically significant. The authors suggested that external factors, such as age and family background, may influence the exercise/cognitive performance relationship.

College-aged adults. Lybrand et al. (1954) used college students to measure the effects on perceptual organization after a five-mile march while carrying a 40-pound backpack. Cognitive scores for participants were higher than both non-exercisers and subjects in sleep-deprived conditions. Weingarten and Alexander (1970) studied the effects of exercise on cognitive performance of college males of different physical fitness level. Two cognitive tests of odd and even-numbered matrices were given to physically "fit" (n = 13) and "less fit" (n = 9) male participants. During test one, all participants performed a physiologically moderate work level on a treadmill (zero grade) with speed kept constant at 3.5 mph for 10 minutes, plus the time added to complete the cognitive matrices. During test two, given five days later, all participants performed a physiologically heavy work level with speed kept constant at 3.5 mph but with grade levels beginning at 5% for the first four minutes, 10% for the next four minutes, and 15% for minutes 8-10. The "less fit" group showed a significantly higher cardiovascular exertion level during test two. No differences were seen between test scores and time taken for test completion on test one for either group, though in test two the "fit" group scored higher and took a longer completion time than the "less fit" group. The authors speculated that the "less fit" participants completed test two in less time (as compared to test one) in an effort to escape physical pain from an increased workload and thus rushed their answers and consequently made more errors.

Gliner et al. (1979) gave college-aged adult men detection tasks for several hours after a marathon race. When compared to pre-test results, fewer false-positive responses suggested that participants' cognitive sensitivity increased as a result of endurance exercise. Counter to these findings are results from a study by Tomporowski et al. (1987) which compared 12 elite college-aged track athletes (mean VO_2max = 66.09 ml / kg / min) to 12 average-fit participants (mean VO_2max = 41.11 ml / kg /min). Participants were given a test of cardiovascular fitness approximately five weeks prior to attending a laboratory test session in which they performed free-recall test of memory. During the laboratory session, each participant ran on the treadmill at 80% VO_2 max until voluntary exhaustion or until a total treadmill run time of 50 minutes elapsed. The free-recall test of memory was administered immediately upon completion of the run. The authors hypothesized that highly trained runners would be able to withstand the physical stress of the exercise intervention more efficiently than average fitness group participants and would consequently perform better on the free-recall memory task. Although none of the high-fitness participants reported the exercise demands to be fatiguing, suggesting that the treadmill run produced different physiological effects on the two groups of participants, no significant differences on free-recall cognitive memory tasks were reported between groups.

Kubitz and Mott (1996) had 34 Kansas State University students participate in an experiment designed to determine the effect of aerobic exercise on brain function measured by electroencephalographic (EEG) monitoring during and after exercise. A group of 14 women and 20 men participated as exercisers (n = 18) or as controls (n = 16). Those in the exercise group exercised on a cycle ergometer for three 5-minute stages while wearing an electrode cap to monitor EEG readings. Those in the control group followed the same protocol (without the exercise) and watched a 15-minute fitness video. Results showed that aerobic exercise decreased the alpha level of EEG activity and increased the beta level in the exercise group participants. This reaction was an indicator of increased brain activity, although the level of activation returned to its normal state after exercise. The non-exercise group that watched videotapes showed EEG responses that indicated a deactivation of brain activity.

Herholz et al. (1987) suggested that a plausible explanation for the varied results in endurance-type exercise studies may be derived from theory that long-duration aerobic exercise causes an arousal of the central nervous system (CNS) that may have an effect on cognition. However, Tomporowski et al. (1987) argued that endurance-type exercise also causes physical fatigue of the musculoskeletal system and that these changes may increase or decrease cognitive performance depending on when the subject is tested and the physical fitness level of the participant.

Sullum et al. (2000) utilized college-aged participants to measure the processes of change for exercise, self-efficacy, and decision-making ability. Undergraduate male and female students (n = 52) participated in a semester-length aerobic conditioning class. Questionnaires were given in an eight-week follow-up to identify those who continued to exercise and those who had stopped (relapsers). Results showed that relapsers had lower self-efficacy scores and higher perceived negative views of exercise as compared to non-relapsers. The authors concluded that continuous exercise routines have more enduring value as compared to intermittent exercise routines and that consistent exercise may promote cognitive success in college students.

Plunk and Bowden (2001) determined the physical fitness level of college-aged males (n = 28) and females (n = 47) by using the Cooper 1.5-mile run and compared scores to grade point average. Each participant's estimated submaximal oxygen uptake was determined by his/her time on the 1.5-mile run. These values were used to place each participant into one of five categories of fitness (1 = poor; 2 = fair; 3 = average; 4 = good; 5 = excellent). An insignificant correlation coefficient (r = .28) was reported for all participants; males had a correlation coefficient of (r = .14) and females had a correlation coefficient of (r = .46). The authors suggested that the discrepancy in the correlation coefficients between males and females may be because the GPA of college-aged females were positively affected by physical fitness as compared to males. However, it is more likely that these differences were seen as a result of performing statistical analysis on a relatively small and uneven population size.

Older adults. Bills (1927) measured the effect of high muscle tension (grip strength) on a cognitive task of addition and perception memory that was given during the performance of the hand dynamometer strength test. Results showed that participants performing mental tasks during conditions of increased muscular tension demonstrated more rapid acquisition and recall of nonsense syllables, faster learning of a paired-associate memorization task, greater accuracy on simple mathematical problems, and superior efficiency on a color-naming perception test than those participants who performed the same tasks under normal conditions. A different result was seen in a study by Krus et al. (1958). Participants performed 20-second upper body isometric contractions followed by a test of perceptual sensitivity. Results showed a decreased performance in pre-post sensitivity tests among participants. This study suggested that individuals' psychological functioning immediately after anaerobic exercise may be different from their ability to process information during anaerobic exercise. These anaerobic muscle-tension exercise studies were done to test the inverted-U theory of arousal, which states that as physical arousal increases, performance will increase up to a point and will then decrease as further arousal continues (Martens, 1974). Data from such studies indicate that moderate levels of muscular exertion may elicit the greatest performance increase as compared to extremely low or high levels of muscular tension.

Blomquist and Danner (1987) reported mixed results after investigating changes in information-processing efficiency that occur when exercise improves physical fitness. Adult volunteers (n = 66) between the ages of 18 – 48 years were recruited as study participants from adult fitness programs, educational classes, and the community. Predicted maximum oxygen uptake (VO_2max) via bicycle ergometry was used as the measure of physical fitness. Participants were divided into two groups based on an increase in predicted VO_2max from pretest to posttest; a 15% improvement was the criterion for participant inclusion into the Improved Group and improvement of less than 5% placed participants into the Stable Group. Twelve participants whose physiological change was 5% to 15% were eliminated from the study. Four information-processing measures (memory-scan task, same-different name retrieval task, timed pictoral subtest, word list memory) were given individually to each participant at the beginning and end of the 12-week study period. A significant interaction was found for the Posner name retrieval task (Posner & Mitchell, 1967) as the time required to access letter names from long-term memory decreased more from pretest to posttest in the Improved Group than in the Stable Group. The time required to scan immediate memory for numbers tended to become shorter for Improvement Group participants as compared to Stable Group participants, but the difference was nonsignificant. Timed pictoral subtests and word list memory tasks showed improvement for both groups without a significant difference between groups. The authors noted that although improvements in information-processing were not dramatic, these changes did occur in healthy adults who made modest gains in physical fitness.

Madden et al. (1989) conducted a study at Duke University that showed no improvement in cognitive performance on reaction time and attention tests. A group of 85 older adults (age 65+) were randomly assigned to either an aerobic exercise group, a non-aerobic exercise group (yoga), or a control group. Baseline fitness levels were measured as were baseline reaction-times. After 16 weeks of training, there was improvement in aerobic capacity in the exercise group, but there was no improvement on the reaction-time tests. The authors concluded that improvements in such cognitive tests are independent of improved aerobic capacity. By comparison, Van Boxtel et al. (1997) examined aerobic fitness and its interaction with age to predict cognitive performance on measures known to be affected by chronological age. Participants (males and females, 24-76 years of age) were subjected to submaximal bicycle ergometry tests and extensive neurocognitive examinations (tests of intellect, memory, simple and complex cognitive speed). Results showed that aerobic capacity accounted for up to five percent of the variance in the examination scores. The authors concluded that aerobic fitness may selectively and age-dependently act on attentional cognitive processes.

Park and Schwarz (2000) reported that if participants aged 20 to 75 are given a cognitive task to perform, reasons for the differing results can be partitioned into categories. Some of the variance will be attributed to the participants' education level, their experience with the cognitive task, and their age. Park and Schwarz identified four mechanisms that have been hypothesized to account for age differences in cognitive functioning. These mechanisms are 1) the speed at which information is processed, 2) working memory function, 3) inhibitory function (i.e., inhibiting attention to irrelevant material), and 4) sensory function (i.e., visual/auditory acuity).

Physiological Effects of Exercise on Cognitive Performance

Dustman, Emmerson, and Shearer (1994) reported that although neuropsychological research examining the physiological changes in human brain structure is limited because of the cost and invasiveness of the techniques, results show that 1) exercise may cause changes in the brain or its environment, and 2) these changes may have a positive influence on the brain's performance capabilities. Hollmann and Struder (1996) stated that the human brain represents the most complicated structure known to man, yet it is the least researched organ in the body. According to Stipp (2001), research shows that by late middle age, humans will lose about 1% of brain volume each year, and that by age 55 most humans will have about 75% of the learning and recall ability that existed at age 25. Stipp noted that the possibility of a direct influence of exercise on the brain, and thus cognitive performance, could be associated with cerebral blood flow, hormonal changes, and neural activity in the brain during and/or after exercise.

Cerebral blood flow. An investigation by Herholz et al. (1987) was performed to measure the influence of cycle ergometer (dynamic) exertion on regional blood flow of the adult brain. A significant median blood circulation increase of 14% was shown at a workload of 25 watts; an increase of 25% was seen at 100 watts, which was significantly higher than the blood circulation increase at the 25-watt level. The authors interpreted the cerebral blood flow increase as a combined effect of elevated systemic blood pressure and functionally activated brain metabolism. In contrast, Rogers, Schroeder, Secher, and Mitchell (1990) conducted a study that utilized isometric (static) exercise that showed no increase in brain blood flow. Regional blood flow was measured in adult participants at rest and after four consecutive unilateral static contractions of leg extensor muscles. The work intensity was equivalent to 8%, 16%, 24% and 32% of the participant's maximal leg strength. Systolic blood pressure rose to an average of 124 mm Hg at the highest work intensity, but no difference was seen in regional brain blood circulation when compared with values at rest. The authors suggested that although a direct association between cerebral blood flow and cognitive function remains unclear, the findings from these studies indicate that static and dynamic exercises are associated with different degrees of brain activation as indicated by changes in cerebral blood flow. The authors further hypothesized that an observable regional blood flow increase during dynamic exercise could be explained by the influence of the body's mechanoreceptors because the motor cortex of the brain is activated by movement but is not activated by sustained isometric contractions.

Hormonal changes. Tan (1990) examined the relationship between serum testosterone level and nonverbal intelligence in right-handed young adults with regard to handedness. Participants were 29 male and 17 female right-handed students from Ataturk

University in Erzurum, Turkey. Hand skill was measured by a peg moving task and nonverbal intelligence was measured by Cattell's Culture Fair Intelligence Test (Tan, 1988). In men with right-hand preference, intelligence quotient (IQ) was positively linearly related to serum testosterone. In females with consistent right-handedness, there was a negative linear correlation between IQ and serum testosterone. The author concluded that testosterone has a positive effect on the development of the left-hemisphere motor skills in men and that there are sex-related differences in hormonal influences on brain development. This theory is in support of a study by Jacklin (1989), which suggested that a particular hormone is often related to behavior in different ways for males and females. Jacklin reported that the behavior effect from a specific hormone can be positive for one sex but negative for the other sex.

Neural activity. Blusztajn and Wurtman (1983) reported that neurotransmitters such as acetylcholine, catecholamine, and serotonin influence an individual's ability to exercise by promoting activity in the peripheral and central nervous systems. Acetylcholine, in particular, transmits signals for motor fibers as well as for neurons in the central nervous system that involve memory, awareness, and mood. Conlay et al. (1986) showed that during exercise, a reduction in choline has been associated with a reduction in acetylcholine and a corresponding slowing in transmission of the contraction-generating impulse across muscle. A study by Conlay, Sabounjian, and Wurtman (1992) utilized trained, qualified runners of the Boston Marathon to examine the effects of exercise on neurotransmitters. Blood was collected before and after the race to assay the plasma content of choline, a dietary constituent that is also a precursor to the neurotransmitter acetylcholine. Results showed that choline content in the plasma was reduced by approximately 40% from resting levels after runners completed the 26.2 mile run. The authors hypothesized that supplemental dietary choline may improve performance by increasing acetylcholine release, improving signal transmission, or by enhancing the athlete's thought processes.

Hughes, Smith, and Kosterlitz (1975) reported that the amino acid tryptophan is the preliminary stage of the neurotransmitter serotonin, a central nervous system opioid peptide that has a biochemical influence on the human psyche. Hollmann and Studer (1996) reported that exercise performed below the anaerobic threshold (~ 70% of maximal oxygen uptake) and lasting longer than 30-60 minutes results in a significant increase in plasma free fatty acids, which in turn enhances the level of tryptophan at the blood-brain barrier. If the intensity of exercise is sufficient to elevate arterial blood lactic acid above 3-4 mmol/L, or if the exercise lasts longer than 60 minutes, endogenous opioid peptides are released. This rise in exercise-induced opioid peptides suggests that performance athletes may be able to tolerate higher levels of lactate acidosis and psychic pain; that is, pain sensitivity is suppressed while a positive mood (e.g., "runner's high") is triggered (Hollmann & Studer).

Pert (1997) reported that each neuron in the human brain has hundreds of thousands of protein receptors. As more receptors are discovered in the brain, more are also found in other systems of the body. The human brain's ability to generate new cells accounts for its ability to continue to learn, and exercise can enhance optimal learning states. Pert concluded that the mind-body connection is actually physical. Weiss (2001) reported that each human being has approximately 100 billion neurons, each of which has 1,000 to 100,000 connections that constantly change, and that exercise will generate a greater number of connections between neurons. Simple tasks such as brushing one's teeth with the non-dominant hand can provide sufficient stimulus to increase neural connections.

Ratey (2001) reported that stimulation leads to an increase in neurons and their connections. According to Ratey, two natural brain chemicals, nerve growth factor (NGF) and brain-derived neurotropic factor (BDNF) act as "Miracle Gro for the brain" and are released when the brain is active. The primary motor cortex, basal ganglia, and cerebellum coordinate physical movement and also coordinate the movement of thought. Fundamental motions such as walking and running trigger the neural firing patterns in these brain regions. Weiss (2001) reported that the brain is the hungriest organ in the human body, consuming 25% of all the glucose and oxygen in the body, and that these nutrients are supplied to the brain via blood flow, which is increased during exercise.

Non-Exercise Variables that Influence Cognitive Performance

Class attendance. Van Blerkom (1992) examined attendance in 17 undergraduate psychology classes and found that attendance dropped as the semester progressed, and this change showed moderate correlations with grade point average. He also noted that students reported that they missed classes most often because of time conflicts with other course work, illness, boring classwork, and because the classes interfered with social activities. Trice, Holland and Gagne (2000) performed a survey study of 120 undergraduate students to explore the association of class absences and grade point averages. The authors found that students who voluntarily cut class with no reason had a lower mean GPA as compared to students who reported no voluntary absences. It was also reported that students who had not visited families in the previous month had a higher GPA than those who had visited families.

Family background. Call, Beer, and Beer (1994) administered general anxiety, test anxiety, and shyness questionnaires to 116 boys and girls in grades four, five, and six at an Iowa elementary school. Grade point averages and normal curve equivalents from the previous year were obtained for each child to make a statistical comparison to the anxiety tests. Results of this study showed that children of divorced parents (n = 31) had lower grade point averages than children of non-divorced parents (n = 85). Betts and Morell (1999) utilized more than 5,000 undergraduates at the University of California, San Diego, to be participants in a study designed to measure the effects of family background on cognitive performance. Results showed a significant difference in grade point average among students with different personal backgrounds (i.e., socioeconomic status, type of school attended, family members' education level). This same difference in GPA was seen among students with different academic backgrounds. The authors suggested that these disparities in grade point average reflected variations in the preparation of freshmen undergraduates. No link with grade point average emerged for the variables of teacher-pupil ratio or teacher's level of education. Zalaquett (1999) analyzed the retention characteristics of college students whose parents never attended college (n = 202), students whose parents had some college experience (n = 244), and students whose parents graduated from college (n = 394). No significant differences were found between the grade point averages and retention rates of first-generation students and those of the other two groups.

Issues of diversity: Race, gender, ethnicity, and age. Card, Moran, and Newell (1983) reported that learning is a change in behavior and knowledge that arises as a consequence of some internal or external stimulus that involves the internal development of physio-cognitive structures. The external stimuli usually take the form of pedagogic and experiential activities. Sleeter and Grant (1987) reported that, in the arena of diversity, the pedagogical components of multicultural teaching have been woven from many different strands – ethnic studies, feminist pedagogy, liberatory education, and interactive/experiential learning methods. Butler and Walter (1991) studied the impact of multicultural diversity on educational outcomes and wrote of the importance of recognizing the connectedness of racism, sexism, and ethnocentrism at all levels of education. The authors acknowledged that because of a shift to a more multicultural classroom, it is necessary to implement a transformed curriculum through new pedagogy, texts, and administrative practice. This classroom shift was evident when Barringer (1993) reported that the wave of immigration absorbed by the United States during the 1980's was its largest in 70 years and that at least one of every seven people will grow up speaking a first language other than English. Drake (1993) reported that 27% of all school students in the United States represent minorities. Foster (1997) reported that although African Americans comprised 16.2% of children in U.S. public schools in 1986, only 6.9% of all teachers were African American. Latino children represented 9.1% of the school population, though only 1.9% of all teachers were Latinos.

Schoem, Frankel, Zuniga, and Lewis (1993) suggested that the idea of a multicultural university is threatening to many faculty members because it forces them to acknowledge that their insights and knowledge are limited. Wlodkowski and Ginsberg (1995) reported that because of student diversity in classrooms, what seems to have once worked for teachers may now be inadequate, whether in the area of encouraging motivation, initiating humor, or helping people to learn effectively. The authors emphasized the need for a motivational framework for culturally responsive teaching that consists of the ability to

1) *Establish inclusion* – all teachers and learners feel respected and connected.
2) *Develop attitude* – a favorable disposition among learners and teachers toward a learning goal.
3) *Enhance meaning* – an increased complexity of what is learned to increase critical consciousness.
4) *Engender competence* – knowing how to be effective in learning something of personal value.

Diller, Houston, Morgan, and Ayim (1996) studied the role of gender in education and identified reasons for and against integrating males and females in physical education. Pro-integration arguments were that 1) the abilities of females will never be realized until gender integration leads to similar expectations for both sexes, 2) the physiological differences between the sexes deserve little attention in physical education because of a lack of high-level competition, and 3) integration offers females a better opportunity to reach their potential. Anti-integration arguments were that 1) males dominate coeducational interactions in ways that limit female participation that will lead to a greater loss of opportunity for girls, 2) coeducational programs will be shaped in a masculine mold, and 3) segregated classes will preserve diversity.

Greasley (1998) studied the affect of gender on students' approaches to learning. Three types of learning approaches defined were 1) the surface learning approach, in which the student attempts to perform the minimal amount of work necessary to pass the course, 2) the deep learning approach, in which the student is intrinsically motivated to develop competency in the course material, and 3) the achievement learning approach, in which the student works to get the highest grade possible in order to enhance self-esteem. Male and female business students (n = 300) were given the 64-item Approaches to Studying Inventory (ASI). Results showed that fear of failure was higher in females than males; females also were categorized as surface learners when compared to males. The heightened fear of failure was attributed to anxiety over course workloads, poor exams, and an aversion to speaking in class tutorials. Greasley postulated that females became surface learners as a result of their heightened fear of failure. Males were reported to be more prone to deep learning approaches than females and were more extrinsically motivated than females. Greasley concluded that educational departments that promote a fear of failure and surface learning would discourage the full learning potential of all students, but of females students in particular.

Magee, Baldwin, Newstead, and Fullerton (1998) studied the issue of age and its effect on educational outcomes as measured by preferred approaches to learning (i.e., surface, deep, or achievement). First-year male and female undergraduates were given 42 open-ended questions from the Biggs Study Process Questionnaire (SPQ) to assess students' attitudes and approaches to studying the last time they were in formal education. Students between the ages of 18-20 years were classified as the immature group (n = 497); students age 21 years and over were classified as the mature group (n = 103). Results showed that the mature group was more achievement-oriented and deep learning-oriented than the immature group. The authors suggested that the mature group was more intrinsically motivated because of more lifetime experience and a greater appreciation for the application of learning.

Motivation. Research by Condry and Chambers (1978) found that students with an intrinsic orientation used more information-gathering and decision-making strategies than did students who were extrinsically oriented. The authors concluded that extrinsically oriented students are inclined to offer the minimal effort necessary to get the maximal reward. Lepper (1988) noted that students who are intrinsically motivated will participate in a class for the learning and enjoyment that it provides while an extrinsically motivated student will participate in order to obtain some reward or avoid some punishment that is external to the class itself.

Brown, Armstrong, and Thompson (1998) reported that motivation in higher education 1) describes the amount of effort put into an activity and its goal; 2) has some consistency, but can also change; 3) affects, but is also affected by, the level of performance; and 4) in its current form and level is a reaction to circumstances, but is also dependent on the past personal history, thought habits, and study habits of that person. Well-motivated students have always succeeded in higher education and will continue to do so. Thus, the challenge has been to stimulate, engender, and enhance the motivation of those students whose enthusiasm for learning cannot be taken for granted. The authors concluded that students often are bored by uninspired teaching or are disenchanted by badly taught material that often can be traced to university lecturers who are untrained in the art of communication. Simmons, Van Rheenen, and Covington (1999) reported that motivation to learn is acquired through modeling, communication of expectations, and direct socialization by significant others such as parents and teachers.

Preparation strategies. Carrell and Menzel (1997) analyzed final exam preparation strategies by students in a speech course (n = 245) at a midwestern university. Results showed that overall grade point average correlated positively with final exam scores when students followed two preparation strategies: reviewing the concepts delineated on the study guide and reading class notes. Collins (1999) initiated an informal questionnaire to assess what test preparation strategies were most successful for radiologic technologists who were preparing for national certification examinations. The author cited four variables that were considered to be vital to successful test preparation: time management, physical health, mental preparation, and study habits. The study habits were subdivided into six areas of emphasis: being informed about the test, anticipating questions to be asked, summarizing notes, reviewing notes the night prior to the exam, forming a study group, and taking time for recreation.

Psychosocial behavior. Hawken et al. (1991) examined the influence of communication competence, roommate rapport, and loneliness on cognitive performance of college students. Results indicated that communication competence was positively related to grade point average and negatively related to loneliness. A study by Wentzel (1993) examined the relationships of prosocial and antisocial classroom behavior to cognitive achievement. The results from multiple regression analyses, based on 423 students in sixth and seventh grade, prompted the authors to suggest that significant correlations between social behavior and cognitive outcomes could be explained, in part, by the relationships between social and academic behavior. Niebuhr and Niebuhr (1999) studied the degree of association between student-peer relationships, student-teacher relationships, and student cognitive performance of 241 ninth-grade high school students. Student-peer relationships and student-teacher relationships were measured by a questionnaire while achievement was measured by grade point average. Both relationships were positively correlated to student cognitive performance as measured by grade point average.

Residence. Delucchi (1993) investigated the cognitive performance of 471 students attending a large, four-year public institution on the West Coast of the United States. The study was designed to determine whether apartment, commuter, and residence hall students differ in cognitive performance. Participants were selected by random sampling and completed a questionnaire with items examining background characteristics and various attitudes, behaviors, and college experiences. Results of multiple regression analyses for academic performance showed that eleven independent variables accounted for 27% of the variance in GPA. After controlling for several background characteristics, being a commuter student positively influenced grade point average in comparison to living in an apartment adjacent to campus. The effect of dormitory residence on GPA was also positive, though it was not statistically different from the effect of apartment housing.

Sleep patterns. Pilcher and Walters (1997) examined the effects of sleep deprivation on cognitive performance in 44 college students. Participants were 26 women and 18 men who were enrolled in an undergraduate psychology class. Cognitive performance was measured by a critical thinking appraisal that was completed by each participant after either 24 hours of sleep deprivation or approximately eight hours of sleep. Participants also completed two questionnaires to assess self-perceived estimated performance and off-task cognitions. Cognitive performance results showed that sleep deprived participants performed significantly worse that the non-deprived participants. Ironically, the sleep deprived participants rated estimated performance and concentration significantly higher than the non-deprived participants. The authors concluded that college students may not be aware of the extent to which sleep deprivation is inversely related to cognitive performance. Trockel, Barnes, and Egget (2000) analyzed the effect of several health-related variables (exercise, diet, sleep habits, mood states, perceived stress, time management, social support, hours worked per week, religious habits, gender, and age) on grade point averages of 200 students living on-campus at a large private university. Sleep habits, especially wake-up times, accounted for the largest amount of variance in GPA (later wake-up times were associated with lower GPA). Kelly, Kelly, and Clanton (2001) examined the effects of sleep patterns on cognitive performance using 148 undergraduate students enrolled in introductory psychology classes. Participants were classified as short sleepers (six or fewer hours of sleep per night), average sleepers (seven to eight hours per night), or long sleepers (nine or more hours per night). Long sleepers reported significantly higher grade point averages than short sleepers. Average sleepers were not significantly different from long or short sleepers. It was theorized by the authors that the lower grade point averages of short sleepers may have been the result of a decreased ability to focus on education-related activities.

Time management. Macan, Shahani, Dipboye, and Phillips (1990) surveyed 165 students to assess time management behaviors and the relationship to attitude, stress, and cognitive performance. Results showed that students who perceived they had control of time reported significantly greater evaluations of performance as compared to those who did not feel they had control of time. Britton and Tesser (1991) performed a study in which 90 college students submitted their Scholastic Aptitude Test (SAT) scores and completed a time management questionnaire. Four years later, each student's cumulative grade point average was obtained from college records. Regression analysis showed that time management components were significant predictors of cumulative grade point average. The authors concluded that time management practices may influence college achievement.

A related time management issue exists on whether time spent on intercollegiate athletic participation affects scholarly success. In a study by Maloney and McCormick (1993), data were obtained for all 12,000 undergraduate students at Clemson University.

a Division I-A school. This student population included 574 athletes who participated in a National Collegiate Athletic Association (NCAA) team sport (e.g., football, baseball) or individual sport (e.g., cross-country, golf). The authors further classified the athletes as being in a revenue sport (football, basketball) or non-revenue sport (all others). Multiple regression analyses results showed that the overall mean course grade was lower for athletes as compared to non-athletes. The authors contended that background factors explained this underperformance because many athletes came to school with lower SAT scores and less high school preparation than non-athletes. However, players in the two revenue sports had even lower course grades while still accounting for the discrepancies in backgrounds. The authors concluded that these results were a "seasonal phenomenon" related to time demands and that athletes were being exploited as players and as students.

A similar study was performed by Robst and Keil (2000). Athletes' grades and graduation rates at Binghamton (NY) University, a Division III school, were examined. When compared to non-athletes, the grades of athletes were similar. The graduation rates were actually higher for athletes than for non-athletes. The authors concluded that the time spent on athletic participation does not impair students' cognitive performance at Division III schools.

Summary

The literature is inconclusive on how exercise may affect cognitive performance. Studies vary by design issues, subject selection, performance measures, and timing of tests that make it difficult to link one particular independent variable to a specific cognitive result. It is even less clear how exercise could improve classroom cognitive performance of college students in health/fitness physical education classes. The literature reflects a gap in the research that is specific to exercise and cognitive performance, especially of college-aged individuals.

CHAPTER III

METHODOLOGY

Procedures

Data collection for this study occurred during the 2002 spring semester in the Department of Physical Education at North Carolina State University in Raleigh, North Carolina. Institutional Review Board (IRB) approval was obtained from North Carolina State University (see Appendix A) and Middle Tennessee State University (see Appendix B). Participants were 166 male and female students enrolled in regularly scheduled health/fitness physical education classes (PE 107, run conditioning). Classes began on January 7, 2002, and concluded on May 3, 2002. Classes were conducted over a 16-week period with each of the seven sections meeting twice weekly for a total of 30 class meetings. Class days were divided into one orientation/informed consent day, four health lectures, two 1.5-mile cardiovascular fitness run test days, one written exam day, and 22 exercise sessions. The exercise sessions consisted of cardiovascular training (via running) with calisthenics and weight training included on specific class days.

Data, in the form of physical measures and written components, were collected and recorded by class instructors in a Monday/Tuesday or Wednesday/Thursday format, according to the class schedule, throughout the 16-week semester (see Appendix C). Three physical education faculty members taught the seven health/fitness classes in their usual format as part of their regular teaching assignment. Each faculty member was trained by the investigator to administer the modified Aerobics Center Longitudinal Study Physical Activity Questionnaire (Kohl et al., 1988). This exercise/activity questionnaire provided data that were used to calculate each participant's average weekly caloric expenditure via exercise over a three-month period. Other than responding to the questionnaire, students were not required to perform any activities in or out of class that were different from previous PE 107 classes.

In addition to regular class activities, a study orientation session was conducted for participants during the first week of classes that included the distribution and explanation of the informed consent forms (see Appendix D). The first 1.5-mile cardiovascular fitness run test was performed during the second week of classes. Body weight and body height were recorded for each participant during the sixth week of classes, with body weight data used for the exercise/activity questionnaire kilocalorie calculations. The first administration of the exercise/activity questionnaire (see Appendix E) was administered during the seventh week of classes. Instructors also verified grade point averages and grade options (letter grade or credit only) during the seventh week of classes. The second questionnaire was administered during the 11th week of classes. Skin fold measures were taken during the 14th week of classes and were used to determine body composition. The second 1.5-mile cardiovascular fitness run test and the third administration of the exercise/activity questionnaire were performed during the 15th week of classes. The final measure taken was the comprehensive final written exam, which was given during the 16th week of classes.

Participants

Participants consisted of students enrolled in seven health/fitness physical education classes (PE 107, run conditioning) at North Carolina State University in Raleigh, North Carolina, during the 2002 spring semester. Participants represented all classifications (year in school) with a division among males (n = 130) and females (n = 36). Age range of the participants was 18 –43 years. Participants received no compensation for involvement in this study.

Instrumentation

The four physical measures obtained during this investigation were body height and body weight for body mass index (BMI) calculation, percent body fat, and 1.5-mile cardiovascular fitness run times. The six written components obtained during this investigation were informed consent, grade option, grade point average, self-reported information (age, race, gender, year classification), exercise/activity questionnaire responses, and comprehensive final written exam results. A copy of the data collection sheet is given in Appendix F.

Physical Measures

Body height. Participants had height measured while standing barefoot with heels together and weight evenly distributed on both feet. A Detecto D-339 physician scale with height rod that measures 30 to 78 inches was used. The instructor recorded height to the nearest quarter-inch.

Body weight. Participants had body weight measured by standing motionless on a Chatillon weight scale. The Chatillon scale, model # BP15 – 400T type 15, was calibrated prior to the start of the semester. Participants were clothed in shorts and tee shirts, without shoes. The instructor recorded weight to the nearest quarter-pound.

BMI calculation. Height and weight measurements were taken to determine each student's body mass index by using the calculation formula recommended by the National Heart, Lung and Blood Institute. The formula required that each participant's weight (kilograms) be divided by height (meters squared). BMI was calculated by using a conversion table (pounds and inches into kilograms and meters) provided by the National Heart, Lung and Blood Institute. BMI was a control variable for this study. BMI classifications (National Heart, Lung and Blood Institute, 2000) are as follows:

BMI Score	Classification
< 18.5	underweight
18.5 - 24.9	normal weight
25.0 - 29.9	overweight
30.0 - 34.9	class I obesity
35.0 - 39.9	class II obesity
> 40.0	class III obesity

Percent body fat. Skin fold thickness measures were taken for each participant with Lange skin fold calipers at the chest, mid-abdominal, and mid-thigh for males and triceps, iliac crest, and mid-thigh for females. All measurements were taken on the right side of the body. Measurements were taken twice at each site in sequential order. A third measure was taken at any site where variation in skin fold thickness between the first two skin fold measures was greater than one millimeter (ACSM, 2000). The Jackson/Pollock (1985) prediction equations were used to estimate percent body fat. Percent body fat was a control variable for this study. Percent body fat classifications (ACSM, 2000) for adults are as follows:

Percent Fat (Males)	Percent Fat (Females)	Classification
2.4 - 9.4	5.4 - 17.0	Superior
9.5 - 14.0	17.1 - 20.5	Excellent
14.1 - 17.4	20.6 - 23.6	Good
17.5 - 22.3	23.7 - 27.6	Fair
22.4 - 29.0	27.7 - 35.3	Poor
> 29.0	> 35.4	Very Poor

1.5-mile cardiovascular fitness run. Each participant had his/her cardiovascular fitness level established by completing a 1.5-mile run test as prescribed by the Cooper Institute of Aerobic Research. The Cooper 1.5-mile run test is recognized as a leading field test for aerobic physical fitness assessment (Cooper, 1982). After a brief warm-up of jogging and stretching, each participant ran the prescribed distance on the university's outdoor track (2,414 meters, approximately 6 laps). In the event of adverse weather, the alternate test site for the 1.5-mile run was the university's indoor track (2,414 meters, approximately 10 laps). Instructors used a Seiko Model SO51 stopwatch to hand-time all participants. Participants performed a 10-minute cool-down after completing the test. Finishing times for the 1.5-mile run were recorded for each participant. Each participant was placed in a fitness category based upon his/her finishing time. The 1.5-mile fitness run was a control variable for this study. Fitness classification scales (Cooper, 1982) for males and females between the ages of 13-49 years are given in Appendix G.

Written Components

Informed consent. A standardized informed consent form provided by North Carolina State University was used to acquire participation permissions for this study. The purpose of the study was explained to all participants, as were all procedures and potential risks and/or benefits.

Grade options. Participants had the option to register for the PE 107 class for letter or credit-only grading. All course requirements were equal for all participants with the exception that letter-grade participants received grades of A, B, C, D, or F, based on a 10-point scale, and credit-only participants received grades of "pass" (credit) or "fail." Credit-only participants needed an overall class grade ≥ 70 to receive class credit. Grade option was a control variable for this study.

Grade point average. Each participant had a cumulative grade point average from previous course work upon enrolling in this health/fitness class. GPA was obtained by reviewing university records provided by the North Carolina State University Office of Records and Registration. GPA was a control variable for this study.

GPA is computed by using the following formula. Each hour of course credit is assigned a "quality point" based upon the letter grade assigned (A = 4 quality points, B =

3 quality points, etc.). A student finishing a three-hour course with a grade of "A" will have his/her grade point average determined by multiplying each credit hour (3) times the quality point value (4) for a total of 12 quality points. Quality points (12) are divided by the total number of credit hours attempted (3) to determine the grade point average [12 ÷ 3 = 4]. Thus, this student would have a GPA of 4.0 for that course. All cumulative quality points will be divided by all hours attempted to obtain a student's cumulative GPA.

Self-reported information. Each participant provided the class instructors with descriptive information (age, race, gender, year classification) that was included in the original statistical (phase I) model. Instructors received this information during the first week of classes at the orientation/informed consent session.

Exercise/activity questionnaire. Each participant completed the modified Aerobics Center Longitudinal Study Physical Activity Questionnaire (Kohl et al., 1988) to determine average weekly caloric expenditure during a three-month period. The questionnaire was administered on three separate occasions (mid-February, mid-March, and mid-April) to ensure an accurate exercise recall by the participants. The exercise amount included in-class and out-of-class activity. Measurements were taken in metabolic equivalents (METs) in which one MET equals the resting metabolic rate of approximately 3.5 ml O_2 / kg / minute. MET values will vary according to exercise type and intensity (Wilmore & Costill, 1999). The questionnaire was supplemented with a table of MET values (see Appendix H). MET values were converted into kilocalories (kcals)/minute as shown in the formula and example below (ACSM, 2000).

$$\text{METs} \times 3.5 \times (\text{body weight in kg} \div 200) = \text{kcals/min}$$

61 kg male running @ 8.5 mph (assigned MET value of 12.0)

$$12 \times 3.5 \times .305 = 12.8 \text{ kcals/min}$$

Estimated caloric cost per week was calculated by multiplying the number of exercise minutes per week times the number of kcals per minute.

3 sessions/week, 30 minutes/session

$$3 \times 30 = 90 \text{ minutes/week}$$

$$90 \times 12.8 = 1{,}153 \text{ kcals/week}$$

Participants 1) recorded the most physically demanding exercise routines in which they regularly participate, 2) recorded how many sessions per week that they participate in each activity, 3) recorded how many minutes they spend in each exercise session, and 4) recorded the intensity level of each exercise (Ainsworth et al., 2000). Each participant's average kcal total per week during the previous three months was the independent variable of interest for this study. Reliability and validity for this questionnaire were established by validation studies (Kohl et al., 1988).

Final written exam. Each participant took a comprehensive final written exam as a measure of his/her cognitive performance in the health/fitness class. All participants took an identical, standardized exam that was constructed from questions obtained from the physical education department's health/fitness test bank. Test bank questions were measured for content (face) validity by prior course examinations (Morrow, Jackson, Disch, & Mood, 2000). The comprehensive final written exam was given during the final week of classes. Scores were based upon a 100-point grading scale. Final written exam scores were the dependent variable in this study. A copy of the comprehensive final exam is given in Appendix I.

Data Analysis

Data screening. Data were screened for outliers by observation and by calculating ranges, standard deviations, and means. If there were a rational reason for an unusual reading, various options were considered, including omission of the very extreme readings if there were a physical explanation for the aberration.

Descriptive statistics. Descriptive statistics were used to identify the basic features of the data in this study and to provide a simple summary of the sample and its measures. Means and standard deviations were calculated for each of the continuous variables. In addition, a matrix of correlation coefficients for all possible pairs of continuous variables was calculated. An explanation of statistical terms and procedures is given in Appendix F.

Multiple regression analysis. The study design was a quasi-experimental, cross-sectional model. A multiple linear regression analysis was conducted on the collected data in three separate procedures (phase I, phase II, and phase III). The model for the multiple linear regression analysis is given in Appendix J. Of the 15 independent variables in the model, each participant's average weekly kilocalorie expenditure via exercise for the prior three months was the variable of major interest. The other independent variables were considered to be co-variables, meaning that they also were expected to share in the explanation of variation in the dependent variable. Data from the phase I (full model) analysis that did not support the significant contribution of any of the covariables in the explanation of the dependent variable resulted in those variables being dropped from the model. All remaining variables were used in the phase II (reduced model) data analysis. Separate multiple regressions were conducted in phase III to explore the relationship between fitness-related variables and extreme final written exam scores (≥ 90 and ≤ 69).

The statistical package, SAS, was used to perform the statistical analyses mentioned above. PROC MEANS of SAS was used for calculating means and standard deviations. PROC CORR was used for obtaining the matrix of correlation coefficients for all bivariate pairs of variables. PROC GLM (general linear models) was used for obtaining the multiple regression analysis. The output from the procedure provided tests of significance of the contribution of each of the variables adjusted for the others. The regression coefficients and their standard errors, as well as the analysis of variance (ANOVA) for regression, were also obtained as part of the output. PROC FREQ was used for obtaining frequencies for each variable.

CHAPTER IV

RESULTS

The purpose of this chapter is to report statistical testing results that identify the significant independent variables related to final written exam scores of college students in health/fitness physical education classes at North Carolina State University. The results given in this chapter are presented to address the nine research questions given in chapter one.

Statistical analyses were performed to 1) calculate means and standard deviations (descriptive statistics) of each continuous variable, 2) obtain the matrix of correlation coefficients for all bivariate pairs of variables, 3) identify variables that were associated with variability in the dependent variable, and 4) test for statistical significance of each variable's contribution when adjusting for all other variables. The analysis of variance of regression was performed in three phases. The full regression model (i.e. all 15 independent variables were included) was used in phase I. A reduced regression model in which non-contributing variables from phase I were omitted was used in phase II. A separate regression model that analyzed fitness-related variables and extreme ($\geq$ 90 and $\leq$ 69) final written exam scores was used in phase III. A legend that identifies all variable abbreviations in the tables of this chapter is given in Table 1.

Table 1

Legend for Variable Abbreviations.

Abbreviation	Variable
Age	Age of participants in years
BMI	Body Mass Index; measure of body composition
FX	Final exam score; dependent variable
Gender	Sex of participants; male / female
GPA	Grade Point Average; scale of 0.0 to 4.0
GDO	Grade Option; letter grade or credit only
Instructor	Class instructor for specific class section
Kcalavg	Participant's average weekly kilocalorie expenditure via exercise for 3-month period
Race	Participant's race; Caucasian; African American; American Indian; Asian American; Hispanic American; Other
Year	Participant's year in school; freshman, sophomore, junior, senior, graduate school
% Fat	Percent body fat; measure of body composition
1.5 Run	1.5-mile fitness run finishing time; measure of physical (cardiovascular) fitness level

Descriptive Statistics

Descriptive statistics were used to identify the basic features of the data in this study and to provide a simple summary of the sample and its measures. Means and standard deviations were calculated for each of the continuous independent variables (Table 2). The participant total (n = 166) was divided by gender (male = 130; female = 36). Age of participants ranged from 18 to 43 years. Grade point averages ranged from 1.5 to 4.0. Body composition values were within the normal scale for BMI and were within the excellent scale for percent fat for both male and female participants. Average weekly caloric expenditure via exercise during a three-month period ranged from 894 kcals to 14,433 kcals for all participants. Finishing times for the 1.5-mile cardiovascular fitness run ranged from 7 minutes, 25 seconds (7.43 minutes) to 13 minutes, 07 seconds (13.11 minutes) for males; and from 9 minutes, 49 seconds (9.81 minutes) to 14 minutes, 57 seconds (14.95 minutes) for females.

Final written exam scores (dependent variable) for all participants ranged from 42 to 100 on a 100-point scale. Values between 78 and 86 accounted for 43.4% of all final written exam scores. Male participants showed an average score of 80.1; female participants had an average score of 78.9. Final written exam scores averaged 80.3 for Caucasian students (n = 152) and 74.7 for minority students (n = 14). Average scores varied between classes with different instructors. Participants' average scores were 82.8 for instructor one (n = 66), 87.4 for instructor two (n = 28), and 74.4 for instructor three (n = 72). Results showed that of the 31 participants who scored ≥ 90 on the final exam, 55% were from instructor one's classes, 39% were from instructor two's classes, and 6% were from instructor three's classes. Participants opting to take the class for a letter grade (n = 58) showed an average final written exam score of 80.5; participants taking the class for credit only (n = 108) had an average score of 79.5. Based on the fact that there was no sizable difference between the mean final exam scores for participants taking the class for a letter grade compared to those taking the class for credit only, it was decided to combine these two groups of data into one data set upon which the multiple regression analysis was run.

Table 2

Means and Standard Deviations for Continuous Variables.

Variable	N	M	SD
Age	166	20.20	3.25
Male	130	20.11	2.90
Female	36	20.50	4.40
GPA	166	3.15	0.61
Male	130	3.13	0.62
Female	36	3.24	0.60
BMI	166	22.76	2.87
Male	130	23.07	2.96
Female	36	21.61	2.21
% Fat	166	12.85	6.13
Male	130	10.70	4.55
Female	36	20.60	4.68
Kcalavg	166	3995.62	2560.91
Male	130	4316.99	2688.03
Females	36	2835.11	1586.64
FX	166	79.83	11.34
Male	130	80.10	11.69
Female	36	78.86	10.06
1.5 Run	166	10.49	1.36
Male	130	10.05	1.02
Female	36	12.07	1.28

Correlations

Bivariate pairs of correlations were run as background information prior to the multiple regression analysis and the results are reported in Table 3. Significance levels of the correlation coefficients are marked after the correlation coefficients (the test is of the hypothesis that the correlation coefficient is equal to zero). The significance level for the correlation coefficient of .10 was used in order to identify all of the important variables for the general linear model. The significance level of .05 was the standard used in the analysis of variance tests of significance.

Results show that some of the fitness-related variables (BMI, percent body fat, physical fitness level) were correlated with age at the .10 level. Final written exam score was correlated with GPA at the .01 level. BMI was correlated with percent fat and weekly kilocalorie expenditure at the .001 level. Percent fat and cardiovascular fitness levels were correlated at the .001 level.

Table 3

Pearson Correlation Coefficients.

	Age	GPA	BMI	%Fat	1.5 Run	Kcal	FX
Age	1.000	-0.037	0.131**	0.134*	0.138*	-0.003	-0.015
		0.636	0.093	0.086	0.075	0.966	0.850
GPA		1.000	-0.104	-0.109	-0.049	-0.094	0.279****
			0.181	0.160	0.534	0.277	0.003
BMI			1.000	0.321****	0.119	0.335****	0.075
				<.001	0.125	<.001	0.334
% Fat				1.000	0.687****	-0.173*	0.061
					<.001	0.026	0.432
1.5 Run					1.000	-0.305****	-0.125
						<.001	0.110
Kcal						1.000	-0.024
							0.766
FX							1.000

Note. Upper number reported is the correlation coefficient; lower number is the probability of a greater *r* value.

*p < .10. **p < .05. ***p < .01. ****p < .001.

General Linear Model

A multiple linear regression analysis was conducted on the data during phase I of the statistical analysis. The model fitted is given in Table 4. This analysis identifies variables that are associated with variability in the dependent variable (final written exam score). The same analysis, minus the independent variable of gender, was used to determine the model for male and female participants. The regression coefficients (b_i) are in different units, so it is important to also report their standard errors. The *t*–tests for the b_i are not reported in Table 4 because the equivalent F–values are given in subsequent tables (for the 1 degree of freedom sources of variation, t = square root of F). The regression coefficients for categorical variables (e.g., instructor) are the differences between the mean of each level of that variable and the mean of the highest level.

Table 4

General Linear Model for the Regression of Final Exam Score on the Independent Variables.

Parameter	b_i	Standard Error (s_{bi})
Intercept	122.11	20.14
Kcalavg	0.00	0.00
Year 1 (fr)	-10.46	9.88
Year 2 (so)	-10.32	9.93
Year 3 (jr)	-6.60	10.09
Year 4 (sr)	-6.12	10.11
Year 5 (grad)	0.00	
Instructor 1	8.95	1.83
Instructor 2	14.06	2.37
Instructor 3	0.00	
Race 1 (Caucasian)	-4.76	6.82
Race 2 (Afr. American)	-13.72	8.43
Race 3 (Asian American)	-13.22	8.09
Race 4 (Hisp American)	-11.14	8.83
Race 5 (other)	0.00	
Gender (female)	2.98	3.48
Gender (male)	0.00	
Age	-0.17	0.29
GPA	-4.53	4.93
1.5 Run	-2.40	0.91
BMI	-1.77	1.00
% Fat	0.25	0.25
GDO (credit)	-47.71	15.89
GDO (letter)	0.00	
GPA * GDO	5.50	2.79
BMI * GDO	1.43	0.58
Kcalavg * GDO	0.00	0.00
Kcalavg * Kcalavg	0.00	0.00

Phase I Analysis of Variance

An analysis of variance (ANOVA) of regression was performed to test for statistical significance of the contribution of each of the variables when adjusted for all other variables. The ANOVA procedure was performed for male participants (n = 130), female participants (n = 36), and all participants (n = 166). The mean squares (type III) for the independent variables as well as the F-values are reported. No predictions were made using the model because the major focus was upon identification of explanatory variables rather than prediction. Probability values associated with those F-values are also reported. Phase I results for male participants, female participants, and all participants combined are reported in relation to eight of the nine research questions given in chapter one. Results of these procedures from the phase I analysis are given in Tables 5, 6, and 7.

Research Questions and Results

1. When statistically controlling for exercise and non-exercise variables, what is the relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores of college students in health/fitness physical education classes?

Results for male participants (Table 5) showed that the independent variable of interest, average weekly caloric expenditure, was significantly ($p < .05$) related to final written exam scores. Caloric expenditure was not significantly related to final written exam scores for female participants or for all participants combined.

2. When statistically controlling for exercise and non-exercise variables, what is the relationship between gender and final written exam scores of college students in health/fitness physical education classes?

There was no significant relationship between gender and final written exam scores of all participants.

3. When statistically controlling for exercise and non-exercise variables, what is the relationship between physical fitness level and final written exam scores of college students in health/fitness physical education classes?

Physical fitness level (i.e., 1.5-mile run time) and final written exam scores for male participants (Table 5) and all participants (Table 7) were significantly ($p < .01$) related. Physical fitness level was not significantly related to final written exam scores for female participants.

4. When statistically controlling for exercise and non-exercise variables, what is the relationship between class instructor and final written exam scores of college students in health/fitness physical education classes?

Class instructor and final written exam scores for male participants (Table 5) and all participants (Table 7) were significantly ($p < .0001$) related. Female participants also showed a significant ($p < .05$) relationship between these variables (Table 6).

5. When statistically controlling for exercise and non-exercise variables, what is the relationship between grade point average and final written exam scores of college students in health/fitness physical education classes?

GPA was significantly ($p < .05$) related to final written exam scores for male participants (Table 5). Female participants and all participants combined showed no significant relationship between GPA and final written exam scores.

6. When statistically controlling for exercise and non-exercise variables, what is the relationship between grade option and final written exam scores of college students in health/fitness physical education classes?

Grade option was significantly related to final written exam scores for male participants ($p < .05$) and for all participants ($p < .01$) as represented in Table 5 and Table 7, respectively. Female participants showed no significant relationship between grade option and final exam scores.

7. When statistically controlling for exercise and non-exercise variables, what is the relationship between body composition and final written exam scores of college students in health/fitness physical education classes?

There was no significant relationship between body composition (BMI or percent body fat) and final written exam scores for male participants, female participants, or all participants combined.

8. When statistically controlling for exercise and non-exercise variables, what is the relationship between the interaction effect of specific independent variables and final written exam scores of college students in health/fitness physical education classes?

The interaction effect of (BMI x GDO), (kcalavg x GDO), and (kcalavg x kcalavg) was significantly ($p < .05$) related to final written exam scores for male participants (Table 5). The interaction effect of (BMI x GDO) was significantly ($p < .05$)

related to final written exam scores for all participants combined (Table 7). There was no significant relationship between interaction effect and final written exam scores for female participants.

Table 5

Phase I ANOVA for Male Participants.

Source	*df*	F- value	Type III MS	Prob > F
Regression	21	4.3	379.9	< .0001
Kcalavg	1	5.6*	502.0	0.0200
Year	4	2.0	730.1	0.0900
Instructor	2	18.7***	1674.8	< .0001
Race	4	0.8	71.9	0.5200
Age	1	2.1	183.9	0.1500
GPA	1	6.3*	562.3	0.0100
1.5 Run	1	12.5**	1119.6	0.0010
BMI	1	0.9	85.4	0.3300
% Fat	1	2.1	188.1	0.1500
GDO	1	5.8*	518.8	0.0200
GPA x GDO	1	1.8	156.6	0.1900
BMI x GDO	1	6.1*	548.6	0.0100
Kcalavg x GDO	1	5.0*	447.1	0.0300
Kcalavg x Kcalavg	1	5.2*	464.2	0.0200
Error	108		89.4	

Note. $R^2 = .452$. Coefficient of variation = 11.8%. Final exam score mean = 80.1.
*p < .05. **p < .01. ***p < .0001.

Table 6

Phase I ANOVA for Female Participants.

Source	*df*	F- value	Type III MS	Prob > F
Regression	20	1.90	127.7	0.09
Kcalavg	1	1.90	124.5	0.19
Year	4	0.60	38.3	0.64
Instructor	2	6.20*	407.9	0.01
Race	4	0.90	61.5	0.47
Age	1	1.90	128.8	0.18
GPA	1	0.80	50.6	0.39
1.5 Run	1	3.40	224.2	0.09
BMI	1	0.02	1.1	0.90
% Fat	1	0.02	1.9	0.90
GDO	1	0.03	1.7	0.87
GPA x GDO	1	1.50	96.7	0.25
BMI x GDO	1	1.00	66.5	0.33
Kcalavg x GDO	1	0.20	15.5	0.63
Kcalavg x Kcalavg	1	1.30	85.5	0.27
Error	15	66.10		

Note. R^2 = .719. Coefficient of variation = 10.3%. Final exam score mean = 78.9.
*$p < .05$.

Table 7

Phase I ANOVA for All Participants.

Source	*df*	F- value	Type III MS	Prob > F
Regression	22	4.4	390.4	< .0001
Kcalavg	1	0.3	23.4	0.6100
Year	4	1.1	97.3	0.3600
Instructor	2	22.2***	1957.4	< .0001
Race	4	2.1	181.8	0.0900
Gender	1	0.7	64.5	0.3900
Age	1	0.4	31.2	0.5500
GPA	1	0.8	74.4	0.3600
1.5 Run	1	6.9**	611.8	0.0090
BMI	1	3.2	278.8	0.0800
% Fat	1	1.0	84.9	0.3300
GDO	1	9.0**	796.6	0.0030
GPA x GDO	1	3.4	341.9	0.0500
BMI x GDO	1	6.1*	538.6	0.0200
Kcalavg x GDO	1	1.8	160.7	0.1800
Kcalavg x Kcalavg	1	3.1	277.1	0.0800
Error	143		88.4	

Note. R^2 = .405. Coefficient of variation = 11.8%. Final exam score mean = 79.8.
*p < .05. **p < .01. ***p < .0001.

Phase II Analysis of Variance

All variables in the general linear model regression procedure were analyzed for their contributions to the explanation of variation of final written exam scores. Variables that did not share in the explanation of variation in final exam scores were eliminated from the full model (phase I) so that a reduced model (phase II) could be obtained. The five non-contributing variables that were dropped from the full model were year, race, gender, age, and (kcalavg x grade option); ten variables remained in the reduced model.

The ANOVA procedure in phase II was performed for male participants (n = 130), female participants (n = 36), and all participants (n = 166). The mean squares (type III) for the independent variables as well as the F-values are reported. Probability values associated with those F-values are also reported. Phase II results for male participants, female participants, and all participants combined are reported in relation to seven of nine research questions given in chapter one. The second research question, specific to gender, is not presented in phase II results because that variable was dropped from this model. Results of these procedures are given in Tables 8, 9, and 10.

Research Questions and Results

1. When statistically controlling for exercise and non-exercise variables, what is the relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores of college students in health/fitness physical education classes?

Results for male participants (Table 8) and female participants (Table 9) showed that the independent variable of interest, average weekly caloric expenditure, was significantly ($p < .05$) related to final written exam scores. Caloric expenditure was not significantly related to final written exam scores for all participants combined.

2. {This question was dropped from Phase II model.}

3. When statistically controlling for exercise and non-exercise variables, what is the relationship between physical fitness level and final written exam scores of college students in health/fitness physical education classes?

Physical fitness level (i.e., 1.5-mile fitness run time) and final written exam scores for male participants (Table 8) were significantly ($p < .001$) related. Physical fitness was significantly ($p < .05$) related to final written exam scores for female participants (Table 9) and was significantly ($p < .01$) related to final written exam scores for all participants combined (Table 10).

4. When statistically controlling for exercise and non-exercise variables, what is the relationship between class instructor and final written exam scores of college students in health/fitness physical education classes?

Class instructor and final written exam scores for male participants (Table 8) and all participants (Table 10) were significantly ($p < .0001$) related. Female participants also showed a significant ($p < .01$) relationship between these variables (Table 9).

5. When statistically controlling for exercise and non-exercise variables, what is the relationship between grade point average and final written exam scores of college students in health/fitness physical education classes?

GPA was significantly ($p < .01$) related to final written exam scores for all participants combined (Table 10). Male participants and female participants showed no significant relationship between GPA and final exam scores.

6. When statistically controlling for exercise and non-exercise variables, what is the relationship between grade option and final written exam scores of college students in health/fitness physical education classes?

Grade option was significantly related to final written exam scores for male participants ($p < .05$) and for all participants combined ($p < .01$) as represented in Table 8 and Table 10, respectively. Female participants showed no significant relationship between grade option and final exam scores.

7. When statistically controlling for exercise and non-exercise variables, what is the relationship between body composition and final written exam scores of college students in health/fitness physical education classes?

There was no significant relationship between body composition (BMI or percent body fat) and final written exam scores for male participants, female participants, or all participants combined.

8. When statistically controlling for exercise and non-exercise variables, what is the relationship between the interaction effect of specific variables and final written exam scores of college students in health/fitness physical education classes?

The interaction effect of (GPA x GDO) was significantly ($p < .05$) related to final written exam scores for male participants (Table 8) and all participants combined (Table 10). The interaction effect of (kcalavg x kcalavg) was significantly ($p < .05$) related to final written exam scores for female participants (Table 9).

Table 8

Phase II Reduced Model ANOVA for Male Participants.

Source	*df*	F- value	Type III MS	Prob > F
Regression	11	6.4	579.3	< .0001
Kcalavg	1	6.1*	573.9	0.0100
Instructor	2	17.7****	1659.6	< .0001
GPA	1	3.9	365.9	0.0500
1.5 Run	1	13.9***	1301.9	0.0003
BMI	1	1.1	99.0	0.3100
% Fat	1	2.7	249.5	0.1200
GDO	1	5.9*	548.6	0.0200
GPA x GDO	1	4.4*	412.3	0.0400
BMI x GDO	1	2.7	255.8	0.1000
Kcalavg x Kcalavg	1	4.8	453.7	0.0300
Error	118		93.8	

Note. R^2 = .372. Coefficient of variation = 12.1%. Final exam score mean = 80.1.
*p < .05. **p < .01. ***p < .001. ****p < .0001.

Table 9

Phase II Reduced Model ANOVA for Female Participants.

Source	*df*	F- value	Type III MS	Prob > F
Regression	11	2.90	186.2	0.012
Kcalavg	1	5.70*	358.1	0.020
Instructor	2	6.60**	411.8	0.005
GPA	1	1.70	106.8	0.200
1.5 Run	1	4.40*	276.9	0.040
BMI	1	0.20	9.8	0.690
% Fat	1	0.10	2.9	0.830
GDO	1	0.03	1.8	0.860
GPA x GDO	1	1.40	88.7	0.240
BMI x GDO	1	0.50	27.9	0.510
Kcalavg x Kcalavg	1	4.40*	271.1	0.040
Error	24		62.4	

Note. R^2 = .577. Coefficient of variation = 7.9%. Final exam score mean = 78.9.
*p < .05. **p < .01.

Table 10

Phase II Reduced Model ANOVA for All Participants.

Source	*df*	F- value	Type III MS	Prob > F
Regression	11	7.2	656.9	< .0001
Kcalavg	1	3.5	317.2	0.0600
Instructor	2	221.7****	1975.9	< .0001
GPA	1	6.9**	632.1	0.0090
1.5 Run	1	7.3**	661.4	0.0080
BMI	1	0.6	50.4	0.4600
% Fat	1	3.7	334.6	0.0600
GDO	1	7.9**	721.7	0.0050
GPA x GDO	1	5.2*	476.4	0.0200
BMI x GDO	1	3.5	321.5	0.0600
Kcalavg x Kcalavg	1	2.7	243.9	0.1000
Error	154		90.9	

Note. R^2 = .341. Coefficient of variation = 11.9%. Final exam score mean = 79.8.
*p < .05. **p < .01. ***p < .001. ****p < .0001.

Phase III Separate Regression and Analysis of Variance

Separate multiple regressions were conducted in phase III to explore the relationship between fitness-related variables and extreme final written exam scores. Regressions were run on all participants (n = 31) with superior ("A") final written exam scores (scores □ 90), and on all participants (n = 26) with below average final written exam scores (scores □ 69). The independent fitness-related variables in the model were BMI, percent body fat, physical fitness level, and kcal average.

The statistical fit of the model for the below average score analysis was very poor. There were no significant variables identified; therefore, these results are not being reported. The general linear model for the superior score analysis is reported in Table 11 and the associated analysis of variance (ANOVA) for regression is in Table 12. The separate regression results for male participants, female participants, and all participants combined are reported in relation to the ninth research question that was given in chapter one.

Research Question and Results

9. What is the relationship between fitness-related variables and superior ("A") final written exam scores of college students in health/fitness physical education classes?

Physical fitness level ($p < .01$) and percent body fat ($p < .05$) were significantly related to superior final written exam scores of college students in health/fitness physical education classes (Table 12).

Table 11

General Linear Model for the Regression of Final Exam "A" Scores on the Independent Variables.

Parameter	b_i	Standard Error (s_{bi})
Intercept	117.9897940	9.62722986
Kcalavg	-0.0000382	0.00028090
1.5 Run	-1.9346829	0.57169436
BMI	-0.3164856	0.33663513
% Fat	0.3649701	0.16140852

Table 12

ANOVA for Regression of the Final Exam "A" Scores on the Independent Variables.

Source	*df*	Type III MS	F-value	Prob > F
Regression	4	28.3	2.90	0.030
Kcalavg	1	0.2	0.02	0.893
1.5 Run	1	109.2	**11.50	0.002
BMI	1	8.5	0.90	0.350
% Fat	1	48.9	*5.10	0.030
Error	26	9.6		

Note. R^2 = .313. Coefficient of variation = 3.3%. Final exam score mean = 94.8.

*p < .05. **p < .01.

CHAPTER V

DISCUSSION

The purpose of this investigation was to identify the relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores of college students in health/fitness physical education classes at North Carolina State University. Independent co-variables, selected because of their association with exercise and classroom cognitive performance, were used in order to analyze nine research questions.

Participants were students enrolled in seven health/fitness physical education classes (PE 107, run conditioning) at North Carolina State University in Raleigh, North Carolina during the 2002 spring semester. Participants represented all classifications (year in school) with a division among males (n = 130) and females (n = 36). Age range of the participants was 18 - 43 years. Data related to class performance (physical measures and written components) were collected and recorded by class instructors throughout the 16-week semester. In addition to regular class activities, participants completed a modified version of the Aerobics Center Longitudinal Study Physical Activity Questionnaire (Kohl et al., 1988) on three separate occasions to determine average weekly caloric expenditure via exercise during a three-month period. Statistical analyses, based upon general linear regressions, were performed as separate models on male participants, female participants, and all participants combined. Analyses were performed in three phases to determine the relationship between the independent variables and final written exam scores.

Conclusions

Data for this study were categorized as physical measures or written components. The impact that the independent variables in each category had on the explanation of final written exam scores is discussed in the following section. Although the exercise/activity questionnaire is a written component, it was used to calculate caloric expenditure and is thus represented by that physical measure variable. Two independent interaction variables (BMI x GDO; kcalavg x GDO) were combinations of physical measures and written components and are thus discussed under the written component section.

Physical measures.

1. When data were separated by gender, results showed that average weekly caloric expenditure via exercise during a three-month period was significantly related to final written exam scores. When data for males and females were combined, the relationship between these variables was not significant. The imbalance in the number of male and female participants may have contributed to the discrepancy seen in these analyses. Male participants, on average, burned slightly more than 4,300 kcals via exercise per week, while females averaged an expenditure of 2,835 kcals per week. No conclusions could be drawn from the data that support an optimal level of caloric expenditure in relation to final written exam scores.

2. Results from all analyses (phases I, II, & III) showed that physical fitness level and final written exam scores for all participants combined were significantly related. This finding supports the significant correlation between physical fitness level and caloric expenditure reported in chapter four and suggests that there could be an interaction effect from these variables on final written exam scores. Only female participants (phase I) did not show a significant relationship between physical fitness level and final written exam scores. This difference could be attributed to the relatively small sample size for females (n = 36) as compared to males (n = 130).

3. There was no significant relationship between body composition (BMI or percent body fat) and final written exam scores for male participants, female participants, or all participants combined as shown in phase I and phase II results. This finding supports the correlation results (chapter four) that indicate a relationship exists between body composition and caloric expenditure, but no relationship exists between body composition and final written exam scores. Percent body fat was significantly related to final written exam scores only when superior ("A") scores were used in the phase III analysis.

Written components.

1. All statistical analyses in phase I and phase II indicated a significant relationship between class instructor and final written exam scores. This relationship showed the highest level of significance when all participants were analyzed together. As described in chapter three (methodology section), three instructors gathered the data for this study. The average final exam scores in sections taught by different instructors ranged from a low of 74.8 to a high of 87.4. Teaching experience, age, and gender

differences may have all contributed to the variation seen in the average final exam scores for participants in each instructor's classes.

2. Phase II results for all participants combined showed that grade option and GPA each significantly contributed to the explanation of final written exam scores, as did the interaction effect of (GPA x grade option). These findings support the significant correlation of GPA and final written exam scores reported in chapter four.

3. Gender was not significantly related to final written exam scores based upon results from phase I analysis. Gender was not included as an independent variable in the reduced model (phase II), nor was it included in the separate regression ANOVA in phase III. A disproportionate number of male participants in the health/fitness classes may have influenced the statistical tests related to gender.

4. Results from phase I and phase II analyses indicated that several paired variables were significantly related to final written exam scores. However, none of these interaction effects can be identified as consistent contributors to the explanation of final written exam scores.

Observations

During the data collection process, the class instructors and the study investigator noted several general findings.

1. Participants opting to take the class for credit only (n = 108) completed class requirements in a similar fashion to those participants taking the class for a letter grade (n = 58). Minimal differences between these groups in physical test results (e.g. 1.5-mile cardiovascular fitness run) and cognitive performance (e.g. final written exam) validate

this observation. Lepper (1988) theorized that extrinsically motivated students who elect to take a class as credit only (i.e. pass/fail) would not be as motivated to prepare for class requirements as compared to students taking the class for a letter grade. Thus, extrinsically motivated physical education students may be more likely to take a physically challenging course as credit only.

2. Many participants in health/fitness classes that utilize only one mode of aerobic exercise during instruction (e.g., run conditioning) tend to use different types of exercise (e.g., cross-training) during out-of-class workouts. Thus, a choice of training methods may contribute to an increase in weekly caloric expenditure.

3. Caloric expenditure calculation lectures can be included in health/fitness classes as a method of promoting exercise and nutritional knowledge. Students are often taught how to determine caloric input without being instructed on how to measure caloric output accurately.

Significance of Study Results

The results of this study will not end the debate concerning the relationship between exercise and cognitive performance, but key variables were identified that can influence classroom cognitive performance of college students in health/fitness physical education classes. Results indicate that 1) class instructor, 2) physical fitness level, and 3) caloric expenditure via exercise all shared in the explanation of final exam scores more than any other variable. Three possible effects that the results of this study may have on the physical education profession were given in chapter one. The following section will list these statements and will discuss each as related to the study's results.

1. A positive relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores may enhance the argument for expanded physical education programs in school-based settings.

The results of this study provide evidence that exercise can be a predictive variable of a college student's academic success. Consequently, this study may be used to support the inclusion and promotion of physical education as a core curricular program in colleges and universities. Hensley (2000) reported that between 1994 and 1999, over 25% of colleges and universities with a basic instruction program in physical education had their requirement challenged and considered for elimination. Hensley noted that once a requirement is eliminated, the program immediately encounters a significant enrollment drop that will show only a slight recovery toward previous participation levels in the following years. This study, by showing that exercise can be an important variable that contributes to the explanation of cognitive performance, helps to validate the academic importance of physical education programs and supports the concept that physical education is a "core" academic subject.

2. A positive relationship between average weekly caloric expenditure via exercise during a three-month period and final written exam scores may reduce the impact that dualistic theory has long had upon the physical education profession.

Kretchmar (1983) defined object dualism as the act of tending the body, and not the mind, by coaching, teaching, and training, which implies that physical educators neglect the whole person. Kretchmar also defined value dualism as the promotion of mental activity being superior to the body, with the academic implication that non-physical education disciplines are more important than physical education. For many years, object and value dualism have been entrenched in the physical education profession at all levels of instruction. The results of this study show that exercise can be a predictor of cognitive performance at the college level and, thus, gives evidence of a link between the mind and body. Now is the time for college teaching professionals to refer to their courses as *physical education* classes rather than *activity* classes as a means of promoting themselves as holistic educators of the mind and body, and not just trainers of the body.

3. The results of this study may illustrate the influence of diversity (i.e. gender, race, age) on the classroom performance of college students in health/fitness physical education classes.

A homogeneous participant pool limited the ability to generalize the results of this study, especially in the areas of race, gender, and age. Nearly 92% of all participants were Caucasian, which left a minority representation of less than 15 participants. The majority of participants were of traditional college age (18-22 years), which limits the ability to generalize the results to younger and/or older populations. There was also an unexpected imbalance in participant gender, with 78% of all participants being male and 22% female. A larger, more diversified population should be examined in future studies.

Recommendations

Although several recommendations can be made from this study, it is recognized that many questions remain unanswered and additional research in this area of study is needed. Specific recommendations from this study and suggestions for future research are given in the following section.

1. More research is necessary to determine what amount of caloric expenditure may best predict classroom cognitive success. Statistical analysis (using the equation $\hat{Y} = b_o + b_1X + b_2X^2$) revealed that final exam scores began to decline when average weekly caloric expenditure was ≥ 7,906 kcals for males. This indicates a possible effect of "diminishing returns" for those participants who exercised significantly beyond the recommended level of 2,000 kcals per week for a healthy adult population (ACSM, 2000).

2. A follow-up study is needed to compare caloric expenditure to a different measure of classroom cognitive performance. The dependent variable could be expressed as overall classroom performance that consists of all grading criteria within the intact classroom, or the written exam format could be changed from objective to subjective.

3. It is recommended that further investigation be performed regarding the impact of the class instructor on participants' classroom cognitive performance. The minority student population at all school levels in the United States is growing each year, though the representation of minority instructors remains low in comparison (Foster, 1997). These and other changes in school population diversity may enhance the interaction between students and instructors as a critical teaching issue in the United States.

4. It is recommended that a larger, more diverse population be studied in future research that involves exercise and cognitive performance.

5. An expansion of the primary mode of exercise during class instruction should be included in future studies. A more diversified exercise routine for participants may introduce other variables that can help explain classroom cognitive performance results.

Appendix A

NCSU IRB APPROVAL

North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina

Office of Research and Graduate Studies

NC STATE UNIVERSITY

Sponsored Programs and
Regulatory Compliance
Campus Box 7514
1 Leazar Hall
Raleigh, NC 27695-7514
919.515.7200
919.515.7721 (fax)

From: Debra A. Paxton, Regulatory Compliance Administrator
North Carolina State University
Institutional Review Board

Date: September 13, 2001

Project Title: The Relationship of Exercise and Cognitive Performance of College Students in Health/Fitness Physical Education Classes

IRB#: 277-01-9

Dear Mr. Roberts:

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101.b.2). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations.
   For NCSU projects, the Assurance Number is: M1263; the IRB Number is: 01XM.

2. Review de novo of this proposal is necessary if any significant alterations/additions are made.

Please provide a copy of this letter to your faculty sponsor. Thank you.

Sincerely,

Debra Paxton
NCSU IRB

Appendix B

MTSU IRB APPROVAL

Developmental Studies

Peck Hall 217
P.O. Box 16
Middle Tennessee State University
Murfreesboro, Tennessee 37132
Office: (615) 898-2568
FAX: (615) 898-5907
www.mtsu.edu/~devstud

Sept. 16, 2002

Tom Roberts
128 Murphy Center - Box 96

Relationship between exercise and cognitive performance of college students in health/fitness physical education classes.
Protocol #: 03-026

Mr. Roberts,

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. It has determined that the study poses minimal risk to subjects and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110.

Approval is granted for 175+ subjects based on the number submitted in the protocol.

Final approval is valid for one (1) year from the date of this letter.

Please note that any change to the protocol must be submitted to the IRB or to your college representative before implementing the change.

Final Approval: September 16, 2002

Sincerely,

Lawanna Fisher
Member, MTSU Institutional Review Board

Appendix C

DATA COLLECTION SCHEDULE*

Semester Week #	Measurement
1	orientation to study; informed consent forms
2	1.5-mile fitness run (pre)
6	body height and weight
7	grade option via university records; GPA via university records; 1st exercise/activity questionnaire
11	2nd exercise/activity questionnaire
14	skin folds for percent body fat calculation
15	1.5-mile fitness run (post); 3rd exercise/activity questionnaire
16	final exam

* Three instructors taught the seven health/fitness classes that were involved in the data collection. There were 166 participants within these seven classes. All procedural instruction, scheduling, and data collection was performed identically for each class.

Appendix D

INFORMED CONSENT

Project Title: "The Relationship Between Exercise and Cognitive Performance of College Students in Health/Fitness Physical Education Classes"

Principal Investigator: Tom Roberts

You are invited to participate in a research study. The purpose of this study is to investigate the association between exercise (as measured by energy expenditure in kilocalories) and cognitive performance (as determined by final written exam scores).

INFORMATION

This PE 107 class will be conducted in its usual format. Students will not be required to perform any activities in or out of class that are different from previous PE 107 classes. Your only "extra" duty beyond the normal class work will be to provide accurate information for our data collection sheet. Data will be collected (anonymously) for statistical analysis. Your data sheet will include the following information: Exercise/Activity Questionnaire; Reference code; Age; Sex; Height; Weight; Most recent grade point average (GPA); Class grading option (credit or credit only); Time for 1.5 mile run; Final exam score; body composition. This study will conclude within the time frame of this Spring, 2002 semester-length course at N.C. State University.

RISKS

There are no risks or discomforts above those associated with the normal demands of this course that will arise from participating in this study.

BENEFITS

The benefit of this study will be its contribution to the body of knowledge that exists concerning physical fitness and its association with academic performance.

CONFIDENTIALITY

The information in the study records will be kept strictly confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports which could link you to the study.

COMPENSATION

There will be no financial compensation for participating in this study.

EMERGENCY MEDICAL TREATMENT

Such conditions are covered as part of this PE 107 class.

CONTACT

If you have questions at any time about the study or the procedures, you may contact the researcher, Tom Roberts, at tcr2a @mtsu.edu. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Matthew Zingraff, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7514, NCSU Campus (919/513-1834) or Mr. Matthew Ronning, Assistant Vice Chancellor, Research Administration, Box 7514, NCSU Campus (919/513-2148)

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed.

CONSENT

I have read and understand the above information. I have received a copy of this form. I agree to participate in this study.

Subject's signature_________________________________ Date ____________

Investigator's signature_____________________________ Date____________

Appendix E

EXERCISE/ACTIVITY QUESTIONNAIRE

For the last (circle) **one/two/three months**, which of the following moderate or vigorous activities have you performed *regularly* in and/or out of class? Provide an estimate of the amount of activity for all exercise performed within each category. Be complete.

WALKING

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________ = _____ METs

JOGGING or RUNNING

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________ = _____ METs

CYCLING

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________ = _____ METs

SWIMMING LAPS

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________ = _____ METs

AEROBIC DANCE

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________ = _____ METs

WEIGHT TRAINING

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________= ______ METs

MODERATE SPORTS (e.g. leisure volleyball, golf (not riding), doubles tennis)

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________= ______ METs

SPORTS or EXERCISE INVOLVING RUNNING (e.g. basketball, soccer)

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________= ______ METs

VIGOROUS RACQUET SPORTS (e.g. racquetball, singles tennis, competitive badminton)

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________= ______ METs

OTHER ACTIVITIES: please specify____

How many sessions per week? __________

Average duration (minutes) per session? __________

Intensity (moderate, vigorous, highly vigorous) __________= ______ METs

Appendix F

DATA COLLECTION SHEET

Descriptive Information:

______Participant Code

______Sex _____Age ______Instructor _____Section

______GPA ______Year (FR / SO / JR / SR / GR)

______Grade option

Physical Measurements:

______Height ______Weight ______BMI

______SS1 ______SS2 ______SS3 ______SST ______%Fat

Performance Measurements:

______:______1.5 mile run PRE ______:______1.5 mile run POST

__________Kcals avg. 1 (February; week 7)

__________Kcals avg. 2 (March; week 11)

__________Kcals avg. 3 (April; week 15)

__________Kcals weekly avg for 3 months (independent variable)

__________FX score (dependent variable)

Appendix G

COOPER FITNESS CLASSIFICATION SCALE

Female Fitness Category	Ages 13-19	Ages 20-29
Very Poor	> 18:30	> 19:00
Poor	16:55-18:30	18:31-19:00
Average	14:31-16:54	15:55-18:30
Good	12:30-14:30	13:31-15:54
Excellent	11:50-12:29	12:30-13:30
Superior	< 11:50	< 12:30

Male Fitness Category	Ages 13-19	Ages 20-29
Very Poor	> 15:30	> 16:00
Poor	12:11-15:30	14:01-16:00
Average	10:49-12:10	12:01-14:00
Good	9:41-10:48	10:46-12:00
Excellent	8:37- 9:40	9:45-10:45
Superior	< 8:37	< 9:45

Female Fitness Category	Ages 30-39	Ages 40-49
Very Poor	> 19:30	> 20:00
Poor	19:01-19:30	19:31-20:00
Average	16:31-19:00	17:31-19:30
Good	14:31-16:30	15:56-17:30
Excellent	13:00-14:30	13:45-15:55
Superior	< 13:00	< 13:45

Male Fitness Category	Ages 30-39	Ages 40-49
Very Poor	> 16:30	> 17:30
Poor	14:46-16:30	15:36-17:30
Average	12:31-14:45	13:01-15:35
Good	11:01-12:30	11:31-13:00
Excellent	10:00–11:00	10:30-11:30
Superior	< 10:00	< 10:30

Appendix H

MET VALUES

METS	Activity	Description
7.0	Badminton	competitive
4.5	Badminton	social
8.0	Basketball	game
6.0	Basketball	non-game, general
4.0	Bicycling	< 10 mph, general leisure
6.0	Bicycling	10-11.9 mph, light effort
8.0	Bicycling	12-13.9 mph, moderate effort
10.0	Bicycling	14-15.9 mph, vigorous effort, racing
12.0	Bicycling	16-19.9 mph, very fast, racing
16.0	Bicycling	> 20 mph, racing, no drafting
12.0	Boxing	in ring, sparring
6.0	Boxing	punching bag
4.5	Calisthenics	pushups, pull-ups, sit-ups; light or moderate effort
8.0	Calisthenics	pushups, pull-ups, sit-ups, vigorous effort
6.0	Dancing	aerobic, ballet or modern
5.0	Dancing	aerobic, low impact
7.0	Dancing	aerobic, high impact
6.0	Fencing	general
9.0	Football	competitive
8.0	Football	flag, touch
3.5	Frisbee	ultimate
5.5	Golf	carry clubs
5.0	Golf	pulling clubs
12.0	Handball	competitive
8.0	Hockey	ice, field, competitive
7.0	Racquetball	general, casual
10.0	Racquetball	competitive
12.0	Rope jumping	vigorous
10.0	Rope jumping	moderate
8.0	Rope jumping	slow
3.5	Rowing	50 W, light effort
7.0	Rowing	100 W, moderate effort
8.5	Rowing	150 W, vigorous effort
12.0	Rowing	200 W, very vigorous effort
8.0	Running	5 mph, 12 min-mile
9.0	Running	5.2 mph, 11.5 min-mile
10.0	Running	6 mph, 10 min-mile
11.0	Running	6.7 mph, 9 min-mile
11.5	Running	7 mph, 8.5 min-mile

METS	Activity	Description
12.5	Running	7.5 mph, 8 min-mile
13.5	Running	8 mph, 7.5 min-mile
14.0	Running	8.6 mph, 7 min-mile
15.0	Running	9 mph, 6.5 min-mile
16.0	Running	10 mph, 6 min-mile
18.0	Running	10.9 mph, 5.5 min-mile
15.0	Running	up stairs
7.0	Skiing	cross country, 2.5 mph, light effort
8.0	Skiing	cross country, 4.0-4.9 mph, moderate effort
9.0	Skiing	cross country, 5.0-7.9 mph, vigorous effort
14.0	Skiing	cross country, > 8.0 mph, racing pace
9.5	Ski machine	general effort
10.0	Soccer	competitive
5.0	Softball or baseball	fast or slow pitch
12.0	Squash	competitive
3.0	Stationary Bike	50 W, very light effort
5.5	Stationary Bike	100 W, light effort
7.0	Stationary Bike	150 W, moderate effort
10.5	Stationary Bike	200 W, vigorous effort
12.5	Stationary Bike	250 W, very vigorous effort
6.0	Swimming	leisurely, not laps
8.0	Swimming	laps, freestyle, moderate effort
8.0	Swimming	backstroke, general
10.0	Swimming	laps, freestyle, vigorous effort
10.0	Swimming	laps, breaststroke, vigorous effort
11.0	Swimming	laps, butterfly, general
6.0	Tennis	doubles
8.0	Tennis	singles
4.0	Volleyball	competitive
3.0	Volleyball	non competitive
2.0	Walking	very slow, < 2.0 mph
2.5	Walking	slow, 2.0–2.5 mph
3.5	Walking	moderate pace, 2.6-3.0 mph
4.0	Walking	brisk pace, 3.1-3.5 mph
4.5	Walking	very brisk pace, 3.6-4.0 mph
6.0	Walking	hiking, cross country
6.5	Walking	rapidly, race walking
8.0	Walking	up stairs, moderate pace
4.0	Water Aerobics	water calisthenics
8.0	Weight Training	circuit training, general

Appendix I

FINAL EXAM

PE 107 HEALTH AND FITNESS FORM A; #______

PLACE YOUR **NAME** AND **CLASS** ON THE **ANSWER SHEET**.
PLACE AN X OVER THE **CORRECT ANSWER** ON THE **ANSWER SHEET**.
DO NOT WRITE ON THIS EXAM.

1. Stress can be the result of
   a. Negative situations
   b. Pleasurable challenges
   c. Achievement of goals
   d. All of the above

2. The steady increase in the number of obese people in modern societies is due mainly to:
   a. an increased number of fat cells
   b. the increased consumption of fats
   c. lack of regular exercise
   d. "pigging out"

3. Which of the following programs (i.e. sets, reps, intensity) would be most likely to help an individual reach the goal of maximizing strength gains?
   a. 70% of 1RM, 10-12 reps, 2 sets
   b. 75% of 1RM, 8-10 reps, 2 sets
   c. 85% of 1RM, 6-8 reps, 2 sets
   d. 95% of 1RM, 4-6 reps, 2 sets

4. What role is played by the pectoralis major muscle during the execution of the bench press exercise?
   a. synergist
   b. antagonist
   c. fixator
   d. prime mover

5. The system of weight training that would be most conducive to developing a combination of strength, endurance and cardiorespiratory fitness would be:
   a. Power lifting
   b. Olympic lifting
   c. Isokinetic training
   d. Circuit training

6. Which class of nutrients is **not** considered to be a source of energy?
   a. proteins
   b. carbohydrates
   c. vitamins
   d. fats

7. After a five mile run in hot, humid conditions, a runner determines that they have lost 5 pounds of body weight during the session. For every pound lost, this runner should consume ____ ounces of water.
   a. 8 – 12
   b. 10 – 12
   c. 12 - 14
   d. 16 – 18

8. Overuse or overtraining injuries are **most** likely to occur when you
   a. Train 3 days per week
   b. Warm-up prior to exercise and cool down after exercise
   c. Increase frequency before you increase the intensity
   d. Increase the intensity before increasing the duration

9. Cardiorespiratory endurance is developed best by activities that
   a. Involve working with weight or against resistance
   b. Gently extend joints beyond their normal range of motion
   c. Alternate between periods of maximal exertion and rest
   d. Involve continuous rhythmic movements of large-muscle groups

10. Low back pain (LBP) is often a result of:
    a. over development of the abdominal muscles and weak hip flexors
    b. underdeveloped abdominal muscles and tight hamstrings and hip flexors
    c. underdeveloped gluteal muscles and overly flexible hamstrings
    d. a muscular imbalance between the trunk extensors and trunk flexors

11. Most medical authorities recommend that weight loss should not generally exceed:
    a. 12-16 pounds per month
    b. 4-8 pounds per month
    c. 16-20 pounds per month
    d. 10-15 pounds per month

12. Which of the following is not a beneficial physiological result of a warm-up?
    a. increased blood flow to the muscle
    b. increased muscle temperature
    c. increase in oxygen usage by the muscle
    d. all of the above are beneficial

13. When a muscle contracts and the force generated equals the resistance and no visible movement occurs, this is called a/an __________contraction.
    a. isometric contraction
    b. isokinetic contraction
    c. isotonic contraction
    d. concentric contraction

14. If it is 40° outside and you are going outside for a run, you would want to dress like it is actually

a.	20°	c.	50°
b.	60°	d.	80°

15. All of the following statements are true **except**?
    a. saturated fats are normally solid at room temperature
    b. all fats contain cholesterol
    c. fats should comprise no more than 25-30% of your diet
    d. unsaturated fats are usually of vegetable origin

16. Slow-twitch muscle fibers
    a. are the predominant type of muscle fibers in the upper body
    b. have a richer blood supply than fast twitch fibers and contain myoglobin
    c. would be used primarily in activities resulting in anaerobic metabolism
    d. all of the above

17. If you wanted to lose 20 pounds in the next 20 weeks, you would need to create a daily negative caloric balance of ______ calories through diet and exercise.

a.	5,000	c.	3,500
b.	500	d.	350

18. What is the connection between stress and diseases/conditions such as colds, anxiety, & depression?
    a. People with high levels of stress are more susceptible to such conditions
    b. People without much stress in their lives are more susceptible to such conditions
    c. Connections between physical conditions and stress are determined by age
    d. There is no significant connection

19. A serious runner would have the following weight training goals *except*:
    a. strengthening the knee flexors and extensors
    b. maximal hypertrophy
    c. developing a high strength to weight ratio
    d. both a and c

20. Which of the following items is the best source of **complete** protein?

a.	chicken	c.	peanuts
b.	green beans	d.	whole wheat bread

21. Which of the following is not a component of the cardiorespiratory system?

a.	The brain	c.	the blood vessels
b.	The heart	d.	the lungs

22. All of the following are true concerning flexibility except:
    a. there is a trade off between joint flexibility and joint stability
    b. the degree of flexibility is not specific to each joint but is rather a general characteristic of the body as a whole
    c. improving flexibility may decrease muscular-skeletal injuries
    d. stretching for a warm-up and stretching for improved flexibility are synonymous and entail the same frequency and duration

23. Vitamins are classified as either ____________________ or ____________________.
    a. toxic or nontoxic
    b. fat-soluble or water-soluble
    c. saturated or unsaturated
    d. complex or uncomplex

24. A cardiorespiratory workout should be a minimum of _____ minutes in order to improve your cardiorespiratory fitness.
    a. 10
    b. 20
    c. 30
    d. 40

25. Recommended treatment of minor soft tissue injuries includes all of the following **except**
    a. Immobilization
    b. Rest
    c. ice
    d. elevation

26. Slow steady stretching to the point of discomfort and then holding that position for a period of time is probably most effective in:
    a. bypassing the stretch reflex
    b. avoiding injury to connective tissue
    c. avoiding the valsalva phenomena
    d. avoiding hyperplasia to the connective tissue

27. A type of flexibility training that involves repeatedly stretching and then contracting a muscle isometrically is referred to as:
    a. ballistic stretching
    b. static stretching
    c. PNF
    d. dynamic stretching

28. The rapid increase in strength that is often experienced during the first two or three weeks after the initiation of a weight training program is most likely the result of:
    a. muscle hypertrophy
    b. an increase in actin and myosin
    c. increased motor unit recruitment
    d. muscle hyperplasia

29. Cardiorespiratory endurance is best measured in terms of
    a. Maximal oxygen uptake
    b. Minutes per mile
    c. maximal pounds lifted
    d. blood pressure

30. A beginning weight trainer gets a little carried away and performs numerous exercises, sets, and reps. Although the individual did not experience much soreness immediately, the following day they could hardly move. This type of soreness is referred to as _____ and is probably the result of _______.
    a. post workout syndrome, an accumulation of lactic acid
    b. painful body syndrome, depletion of muscle glycogen
    c. delayed muscle soreness, actual damage to the muscle tissue
    d. delayed muscle soreness, poor lifting form

31. The primary function(s) of protein is/are:
    a. growth and repair of tissues
    b. digestion and utilization of fats
    c. energy
    d. roughage

32. Which of the following would **not** be part of a healthy diet?
    a. increasing your intake of complex carbohydrates
    b. increasing your intake of saturated fats in proportion to unsaturated fats
    c. reducing your intake of sodium to □2,400 mg per day
    d. reducing your intake of cholesterol to □300 mg per day

33. An example of super setting that focuses on exercising antagonistic muscles would be performing alternate sets of:
    a. Leg curls and leg extensions
    b. Bench press and military press (shoulder press)
    c. Pull-ups and curls
    d. Squats and crunches

34. Muscle cramps, a painful spasm of the muscle, is normally caused by
    a. Too much stretching
    b. Running at a pace that you have not trained for
    c. Not eating before your workout
    d. Depletion of electrolytes and water due to dehydration

35. Benefits of strength training include all of the following except:
    a. increased muscle fiber size
    b. increased tendon and ligament tensile strength
    c. increased muscle fiber number
    d. increased bone density/strength

36. ACSM's basic recommendations concerning resistance training for all major muscle groups is:
    a. 2-3 sets of 8-12 repetitions performed 2-3 days per week
    b. 3-5 sets of 6-10 repetitions performed 2-3 days per week
    c. 2-3 sets of 8-12 repetitions performed 5-6 days per week
    d. 3-5 sets of 6-12 repetitions performed 5-6 days per week

37. What should you do at the end of a long run?
    a. Lie on the ground
    b. Bend over and touch your toes
    c. Walk or jog slowly
    d. A few short wind sprints

38. With regards to making permanent changes in muscle flexibility, all of the following are true except:
    a. Each stretch should be held for about one minute
    b. a good warm-up should precede flexibility training
    c. each stretch should be held 10 to 15 seconds'
    d. post workout is usually the best time to engage in flexibility training

39. Holding your breath during a weight lifting exercise can result in very dramatic increases in blood pressure which in turn can effect the venous return of blood to the heart resulting in a drop in blood pressure accompanied with dizziness or possibly fainting. This sequence of events is called the:
    a. valsalva phenomenon
    b. pressure syncope
    c. heart burn special
    d. lifters high

40. Healthy body composition is best developed and maintained by the combination of:
    a. sensible diet, weight training, and cardiorespiratory exercise
    b. sensible diet, stretching, and cardiorespiratory exercise
    c. sensible diet, weight training, and stretching
    d. weight training, stretching, and cardiorespiratory exercise

41. The key to improving fitness is to
    a. Exercise very hard
    b. Exercise consistently
    c. Choose the best form of exercise
    d. Exercise for long periods of time

42. The oxidative energy system produces ATP (energy) in structures called
    a. Ventricles
    b. Capillaries
    c. atria
    d. mitochondria

43. Which of the following nutritional components can be utilized for energy in the <u>absence of oxygen</u>?
    a. minerals
    b. protein
    c. fats
    d. carbohydrates

44. Cardiorespiratory exercise tends to decrease all of the following **<u>except</u>**
    a. VO_2 max
    b. resting heart rate
    c. LDL levels
    d. blood pressure

45. Alveoli serve what function in the lungs during aerobic activities?
    a. They ensure that air flows completely through the lungs
    b. They allow for exchange of carbon dioxide and oxygen
    c. They prevent dust and pollens from entering the lungs
    d. They help to expand and contract the lungs

46. Which one of the following statements about monitoring exercise heart rate is true?
    a. Count your pulse for one minute
    b. Count your pulse immediately after stopping exercise
    c. Use your thumb, not one or more of your fingers
    d. Press firmly on the carotid artery

47. Which of the following is not an adaptation of cardiorespiratory training?
    a. Increased stroke volume at rest
    b. Decreased resting heart rate
    c. Increased maximal heart rate
    d. Decreased resting blood pressure

48. College students would be considered obese if their % body fat were greater than or equal to:
    a. 25% for men; 30% for women
    b. 15% for men; 20% for women
    c. 10% for men; 17% for women
    d. 20% for men; 30% for women

49. The amount of energy used at complete rest is known as:
    a. thermogenic dynamics
    b. basal metabolic rate
    c. dynamic thermogenesis metabolism
    d. reserve capacity metabolism

50. The normal progression for the general adaptation syndrome is
    a. Alarm, exhaustion, resistance
    b. Exhaustion, alarm, resistance
    c. Resistance, exhaustion, alarm
    d. Alarm, resistance, exhaustion

Appendix J

GLOSSARY OF STATISTICAL TERMS

Analysis of variance: A statistical analysis in which the variation in a set of data is partitioned into specified classes (e. g. Regression and Error). Usually significance tests are performed for these classes in connection with the analysis.

Coefficient of variation (CV): A relative measure of variation for a set of data. It is defined as a ratio of the standard deviation divided by the general mean multiplied by 100.

Degrees of freedom: The degree of constraint which exists on a set of data with regard to the values which may be taken on by estimates (e. g. the Error).

F-tests: A test of the ratio of two mean squares. In multiple regression, it is the ratio of the mean square regression and the mean square error.

Full model: The regression model which contains all variables initially thought to be related to the dependent variable.

Multiple linear regression: an analysis in which the variation in a dependent variable (Y) is related to two or more independent variables (X_i).

Pearson correlation coefficient (r) : A coefficient lying between -1 and + 1 which reflects the strength of the relationship between two variables.

Coefficient of variation (CV): Reduced model: A regression model which results from deleting variables from the full model which were not significant at a specified level of significance in the full model.

Regression coefficient (b_i): The number of units change in the dependent variable per unit change in the independent variable with all other variables in the model held constant.

R^2 (coefficient of multiple determination): The proportion of variation in the dependent variable explained by the combined set of independent variables in the model. The range is from 0 to 100 %.

t-test of a regression coefficient: A test of a hypothesis about a regression coefficient. Usually the null hypothesis is that β_i , the population regression coefficient, is zero. However, other values of β may be hypothesized in the test. There is a relationship between t under the null hypothesis of zero regression and F for Type III Mean Square in a regression when the degrees of freedom for the numerator is one regardless of the degrees of freedom for the denominator (i. e. $t^2 = F$). In this case, the degrees of freedom for t are equal to those of the denominator of F.

Type III mean square: A measure of the average contribution of a regression variable to the regression explanation when the variable is adjusted for the contributions of the other variables in the regression model.

Appendix K

MODEL FOR MULTIPLE LINEAR REGRESSION ANALYSIS

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 \ldots + e,$$

Where Y = final exam grade (dependent variable)

b_0 = intercept

b_i = regression coefficient for independent variable *i*

X_1 = average weekly Kcal expenditure via exercise for prior three months

X_2 = grade point average (gpa)

X_3 = year in school (discrete variable)

X_4 = finishing time in 1.5 mile fitness run

X_5 = instructor (discrete variable)

X_6 = race (discrete variable)

X_7 = gender (discrete variable)

X_8 = age

X_9 = body mass index (bmi)

X_{10} = percent body fat (% fat)

X_{11} = grade option (letter grade or credit only)

X_{12} = (grade option * gpa)

X_{13} = (grade option * bmi)

X_{14} = (grade option * kcalavg)

$X_{15} = X_1^2$

e = deviation from regression (also called error)

REFERENCES

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., et al. (2000). Compendium of physical activities: An update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise, 32*(9), 498-516.

Almond, L., & McGeorge, S. (1998). Physical activity and academic performance. *The British Journal of Physical Education, 29*(2), 8-11.

American College of Sports Medicine (2000). *Guidelines for exercise testing and prescription* (6th ed.). Baltimore, Md: Lippincott, Williams & Wilkins.

Barabasz, M. (1991). Effects of aerobic exercise on transient mood state. *Perceptual and Motor Skills, 73*(2), 657-659.

Barringer, F. (1993, April 28). When English is a foreign tongue: Census finds a sharp rise in 80's. *New York Times*, p. A1.

Betts, J. R., & Morell, D. (1999). The determinants of undergraduate grade point average: The relative importance of family background, high school resources and peer group effects. *Journal of Human Resources, 34*(2), 268-270.

Bills, A. G. (1927). The influence of muscular tension on the efficiency of mental work. *American Journal of Psychology, 38*, 227-251.

Blair, S. N., Kohl, H. W., Paffenbarger, R. S., Clark, D. G., Cooper, K. H., & Gibbons, L. W. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association, 262*(17), 2395-2401.

Blinde, E. M., & Taub, D. E. (1999). Personal empowerment through sport and physical fitness activity: Perspectives from male college students with physical and sensory disabilities. *Journal of Sport Behavior, 22*(2), 18-20.

Blomquist, K. B., & Danner, F. (1987). Effects of physical conditioning on information-processing efficiency. *Perceptual and Motor Skills, 65*, 175-186.

Blusztajn, J. K., & Wurtman, R. J. (1983). Choline and cholinergic neurons. *Science, 221*, 614-620.

Britton, B. K., & Tesser, A. (1991). Effects of time-management practices on college grades. *Journal of Educational Psychology, 83*(3), 405-411.

Brown, B .S., Payne, T., Kim, C., Moore, G., Krebs, P., & Martin, W. (1979). Chronic response of rat brain norepinephrine and serotonin levels to endurance training. *Journal of Applied Physiology, 46*(1), 19-23.

Brown, J. D. (1991). Staying fit and staying well: Physical fitness as a moderator of life stress. *Journal of Personality and Social Psychology, 60*(4), 555-562.

Brown, S., Armstrong, S., & Thompson, G. (1998). *Motivating students*. London: Kogan Page.

Butler, J., & Walter, J. (1991). *Transforming the curriculum: Ethnic studies and women's studies*. Albany, NY: State University of New York Press.

Call, G., Beer, J., & Beer, J. (1994). General and test anxiety, shyness and grade point average of elementary school children of divorced and nondivorced parents. *Psychological Reports, 74*(2), 512-515.

Cambridge Dictionaries Online (2001). *Cambridge University Press*. Retrieved September 14, 2001 from http://dictionary.cambridge.org/define.asp

Card, S. K., Moran, T. P., & Newell, A. (1983). *The psychology of human-computer interaction*. Hillside, NJ: Lawrence Erlbaum Associates.

Carrell, L. J., & Menzel, K. E. (1997). The impact of preparation and motivation on learning performance. *Communication Education, 46*(4), 262-273.

Chodzko-Zajko, W. J., Soloman, J., Heinl, B., & Ellis, B. R. (1992). The influence of physical fitness on automatic and effortful memory changes in aging. *International Journal of Aging and Human Development, 35*(4), 265-286.

Collins, D. E. (1999). Comparing test preparation methods. *Radiologic Technology, 70*(3), 287-292.

Condry, J., & Chambers, J. (1978). Intrinsic motivation and the process of learning. In *The hidden costs of reward*, H. Lepper and B. Greene (Eds.), (pp. 61-84). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Conlay, L. A., Sabounjian, L. A., & Wurtman, R. J. (1992). Exercise and neuromodulators: Choline and acetylcholine in marathon runners. *International Journal of Sports Medicine, 13*, 141-142.

Conlay, L. A., Wurtman, R. J., Blusztajn, J. K., Lopez, G., Coviella, I., Maher, T. J., & Evoniuk, G. E. (1986). Marathon running decreases plasma choline concentration. *New England Journal of Medicine, 315*, 892-898.

Cooper, K. H. (1982). *The aerobics program for total wellbeing.* New York: Bantam Books.

Daley, A. J., & Buchanan, J. (1999). Aerobic dance and physical self-perceptions in female adolescents: Some implications for physical education. *Research Quarterly for Exercise and Sport, 70*(2), 196-201.

Daley, A. J., & Ryan, J. (2000). Academic performance and participation in physical activity by secondary school adolescents. *Perceptual and Motor Skills, 91*(2), 531-535.

Delucchi, M. (1993). Academic performance in college town. *Education, 114*(1), 96-101.

Diller, A., Houston, B., Morgan, K. P., & Ayim, M. (1996). *The gender question in education.* Boulder, CO: Westview Press.

Dillon, R. F., & Schmeck, R. R. (1983). *Individual differences in cognition.* New York: Academic Press.

Drake, D. D. (1993). Student diversity: Implications for classroom teachers. *The Clearing House, 66*(5), 264-266.

Dua, J., & Hargreaves, L. (1992). Effect of aerobic exercise on negative effect, positive effect, stress and depression. *Perceptual and Motor Skills, 75*(2), 355-442.

Dustman, R. E., Emmerson, R., & Shearer, D. (1994). Physical activity, age, and cognitive function. *Journal of Aging and Physical Activity, 2*, 143-181.

Dwyer, T., Blizzard, L., & Dean, K. (1996). Physical activity and performance in children. *Nutritional Review, 4*(II), 27-31.

Etnier, J. L., Salazar, W., Landers, D. M., Petruzello, S. J., Han, M., & Nowell, P. (1997). The influence of physical fitness and exercise upon cognitive functioning: A meta-analysis. *Journal of Sport & Exercise Psychology, 19*(3), 249-278.

Fagard, R. H. (2001). Exercise characteristics and the blood pressure response to dynamic physical training. *Medicine and Science in Sports and Exercise, 33*(6), 484-493.

Foster, J. (1991). *The immaterial self: A defence (sic) of the Cartesian dualist conception of the mind.* London: Routledge.

Foster, M. (1997). Race, gender, and ethnicity: How they structure teachers' perceptions of and participation in the profession and school reform efforts. In B. Bank & P. Hall (Eds.), *Gender, Equity, and Schooling* (pp. 159-186). New York: Garland Publishing.

Gardner, H. (1985). *Frames of mind: The theory of multiple intelligences.* New York: Basic Books.

Gliner, J. A., Matsen-Twisdale, J. A., Horvath, S. M., & Maron, M. B. (1979). Visual evoked potentials and signal detection following a marathon race. *Medicine and Science in Sports, 11*, 155-159.

Godin, G., & Shephard, R. J. (1990). Use of attitude-behavior models in exercise promotion. *Sports Medicine, 10*, 103-121.

Grayling, A. C., (2001). The knot in the brain. *UNESCO Courier, July 2001*, 53-54.

Greasley, K. (1998). Does gender affect students' approaches to learning? In S. Brown, S. Armstrong & G. Thompson (Eds.), *Motivating students* (pp. 105-112). London: Kogan Page.

Gruber, J. J. (1975). Exercise and mental performance. *International Journal of Sport Psychology, 6*, 28-40.

Hanson, H., & McKenzie, L. (1989). Needs, benefits, barriers, change, strategies, politics, QDEP – Is it possible? *Journal of Canadian Alliance of Health, Physical Education & Recreation, 54*(2), 29-38.

Hawken, L., Duran, R. L., & Kelly, L. (1991). The relationship of interpersonal communication variables to academic success and persistence in college. *Communication Quarterly, 39*(4), 297-309.

Hensley, L. D. (2000). State of required physical education in colleges and universities. *Research Quarterly for Exercise and Sport, 71*(1), A-71.

Herholz, K., Buskies, B., Rist, M., Pawlick, G., Hollmann, W., & Heiss, W. D. (1987). Regional cerebral blood flow in man at rest and during exercise. *Journal of Neurology, 234*, 9-13.

Hollmann, W., & Struder, H. K. (1996). Exercise, physical activity, nutrition and the brain. *Nutrition Review, 54*(Supp. II), 37-43.

Hughes, J., Smith, T. W., & Kosterlitz, H. W. (1975). Identification of two related pentapeptides from the brain with potent opiate agonist activity. *Nature, 258*, 577.

Jacklin, C. N. (1989). Female and male: Issues of gender. *American Psychologist, 44*, 127-133.

Jackson, A. S., & Pollock, M. L. (1985). Practical assessment of body composition. *The Physician and Sportsmedicine, 13*(5), 86.

Jensen, A. R. (1998). *The g factor: The science of mental ability.* Westport, CT: Praeger Publishers.

Kagan, D. M., & Berg, K. E. (1988). The relationship between aerobic activity and cognitive performance under stress. *Journal of Psychology, 122*(5), 451-463.

Kelly, W. E., Kelly, K. E., & Clanton, R. C. (2001). The relationship between sleep length and grade point average among college students. *College Student Journal, 35*(1), 84.

Kirkendall, D. R. (1985). Effects of physical activity on intellectual development and academic performance. In G. Stull & H. Ecker (Eds.), *Effects of physical activity on children* (pp. 49-63). Champaign, IL: Human Kinetics.

Kohl, H. W., Blair, S. N., Paffenbarger, R. S., Macera, C. A., & Kronenfeld, J. J. (1988). A mail survey of physical activity habits as related to measured physical fitness. *American Journal of Epidemiology, 127*, 1228-1239.

Kretchmar, R. S. (1983). Ethics and sports: An overview. *Journal of the Philosophy of Sport, 10*, 21-32.

Kretchmar, R. S. (1994). *Practical philosophy of sport.* Champaign, IL: Human Kinetics.

Krus, D. M., Wapner, S., & Werner, H. (1958). Studies in vacariousness: The effect of muscular involvement on visual threshold. *American Journal of Psychology, 71*, 395-398.

Kubitz, K. A., & Mott, A. A. (1996). EEG power spectral densities during and after cycle ergometer exercise. *Research Quarterly for Exercise and Sport, 67*(1), 91-97.

Laughlin, M. H. (1999). Cardiovascular response to exercise. *The American Journal of Physiology, 277*(6), 244.

Lepper, M. R. (1988). Motivational consideration in the study of instruction. *Cognition and Instruction, 5*(4), 289-309.

Lueptow, L. B., & Kayser, B. D. (1973). Athletic involvment, academic achievement and sociological aspiration. *Focus, 7*, 24-36.

Lybrand, W., Andrews, T., & Ross, S. (1954). Systematic fatigue and perceptual organization. *American Journal of Psychology, 67*, 704-707.

Macan, T. H., Shahani, C., Dipboye, R. L., & Phillips, A. P. (1990). College students' time management: Correlations with academic performance and stress. *Journal of Educational Psychology, 82*(4), 760-769.

Mack, M. G., Huddleston, S., Dutler, K. E., & Bian, W. (2000). Mood state changes of students enrolled in physical activity classes. *Perceptual and Motor Skills, 90*(3), 911-915.

Madden, D. J., Blumenthal, J. A., Allen, P. A., & Emery, C. F. (1989). Improving aerobic capacity in healthy older adults does not necessarily lead to improved cognitive performance. *Psychology of Aging, 4*(3), 307-327.

Magee, R., Baldwin, A., Newstead, S., & Fullerton, H. (1998). Age, gender, and course differences in approaches to studying in first-year undergraduate students. In S. Brown, S. Armstrong & G. Thompson (Eds.), *Motivating students* (pp. 83-92). London: Kogan Page.

Malcolm, N. (1971). *Problems of mind: Descartes to Wittgenstein.* New York: Harper & Row.

Maloney, M. T., & McCormick, R. C. (1993). An examination of the role that intercollegiate athletic participation plays in academic achievement: Athletes' feats in the classroom. *Journal of Human Resources, 28*(3), 555-571.

Martens, R. (1974). Arousal and motor performance. In J. Wilmore (Ed.), *Exercise and sport science review* (pp.158-188). New York: Academic Press.

McCloy, C. (1966). How about some muscle? In H.S. Slusher & A. S. Lockhart (Eds.), *Anthology of contemporary readings: An introduction to physical education* (pp. 13-17). Dubuque, IA: Brown.

Meier, K. V. (1979). *Sport and the body: A philosophical symposium.* Philadelphia: Lea & Febiger.

Merleau-Ponty, M. (1963). *The structure of behavior* (A.L. Fisher, Trans.). Boston: Beacon Press.

Miller, J. A. (1995). Bone mass in the bank. *BioScience, 45*(6), 387-389.

Mokdad, A. H., Serdula, M. K., Dietz, W. H., Bowman, B. A., Marks, J. S., & Kaplan, J. P. (1999). The spread of the obesity epidemic in the United States. *Journal of The American Medical Association, 282*(16), 1519.

Morgan, W. J., & Meier, K. V. (1988). *Philosophic inquiry in sport*. Champaign, IL: Human Kinetics.

Morrow, J. R., Jackson, A. W., Disch, J. G., & Mood, D. P. (2000). *Measurement and evaluation in human performance* (2nd ed.). Champaign, IL: Human Kinetics.

National Center for Health Statistics (2000). *Health, United States, with adolescent health chartbook*. Retrieved October 30, 2001 from http://www.cdc.gov/nchs/

National Heart, Lung & Blood Institute (1998). *Clinical guidelines on the evaluation and treatment of overweight and obesity in adults: The evidence*. Bethesda, Md: National Institutes of Health.

Neeper, S. A., Gomez-Pinilla, F., Chol, J., & Cotman, C. (1995). Exercise and brain neurotrophins. *Nature, 373*, 109.

Niebuhr, K. E., & Niebuhr, R. E. (1999). An empirical study of student relationships and academic achievement. *Education, 119(*4), 679.

North Carolina Institute of Medicine (1998). *The 1995 North Carolina child health report card* (brief article). Durham, NC: Author.

Osterhoudt, R. G. (1984). Empiricistic dualism: The paradoxical basis/nemeses of modern physical education. *Quest, 36*, 61-65.

Park, D., & Schwarz, S. (2000). *Cognitive aging: A primer*. Philadelphia: George H. Buchanan Co.

Pate, R. R., Heath, G. W., Dowda, M., & Trost, S. G. (1996). Associations between physical activity and other health behaviors in a representative sample of US adolescents. *American Journal of Public Health, 86*(11), 1577-1581.

Pert, C. (1997). *Molecules of Emotion: Why you feel the way you feel.* New York: Scribner.

Pilcher, J. J., & Walters, A. S. (1997). How sleep deprivation affects psychological variables related to college students' cognitive performance. *Journal of American College Health, 46*(3), 121-131.

Plunk, J. R., & Bowden, R. (2001). The relationship between fitness level and academic success among college students [Abstract]. *Research Quarterly for Exercise and Sport, 72*, A-34.

Posner, M. I., & Mitchell, R. F. (1967). Chronometric analysis of classification. *Psychological Review, 74*, 392-409.

Radak, Z., Kaneko, T., Tahara, S., Nakamoto, H., Puscsok, J., Sasvari, M., et al. (2001). Regular exercise improves cognitive function and decreases oxidative damage in rat brain. *Neurochemistry International, 38*(1), 17-23.

Ratey, J. J. (2001). *A user's guide to the brain: Perception, attention, and the four theaters of the brain.* New York: Pantheon Books.

Robst, J., & Keil, J. (2000). The relationship between athletic participation and academic performance: Evidence from NCAA division III. *Applied Economics, 32*(5), 547-561.

Roecker, K., Niess, A. M., Horstmann, T., Striegal, H., Mayer, F., & Dickhuth, H. M. (2002). Heart rate prescriptions from performance and anthropometrical characteristics. *Medicine and Science in Sports and Exercise*, 34(5), 881-887.

Rogers, H. B., Schroeder, C., Secher, N. H., & Mitchell, J. H. (1990). Cerebral blood flow during static exercise in humans. *Journal of Applied Physiology, 68*, 2358-2370.

Sallis, J. F., McKenzie, T. L., Alcaraz, J. E., Kolody, B., Faucette, N., & Hovell, M. (1997). The effects of a two-year physical education program (SPARK) on physical activity and fitness in elementary school students. *American Journal of Public Health, 87*, 1328-1334.

Sallis, J. F., McKenzie, T. L., Kolody, B., Lewis, M., Marshall, S., & Rosengard, P. (1999). Effects of health-related physical education on academic achievement: Project SPARK. *Research Quarterly for Exercise and Sport, 70*(2), 127-135.

Schoem, D., Frankel, L., Zuniga, X., & Lewis, E. A. (1993). *Multicultural teaching in the university*. Westport, CT: Praeger Publishers.

Shephard, R. J. (1997). Curricular physical activity and academic performance. *Pediatric Exercise Science, 9*, 113-126.

Shephard, R. J., & Lavallee, H. (1994). Academic skills and required physical education: The Trois Rivieres experience. *Journal of Canadian Alliance of Health, Physical Education & Recreation, 1*(1), 1-12.

Simmons, H. D., Van Rheenen, D., & Covington, M. V. (1999). Academic motivation and the student athlete. *Journal of College Student Development, 40*(2), 151-162.

Sleeter, C., & Grant, C. (1987). An analysis of multicultural education in the United States. *Harvard Educational Review, 57*(4), 421-444.

Stein, N., & Motta, R. W. (1992). Effects of aerobic and nonaerobic exercise on depression and self concept. *Perceptual and Motor Skills, 74*(1), 79-90.

Stipp, D. (2001). A pill to help you remember: Suddenly the race is on to develop the thinking person's Viagra. *Fortune, 144*(9), 162-169.

Sullum, J., Clark, M. M., & King, T. K. (2000). Predictors of exercise relapse in a college population. *Journal of American College Health, 48*, 175-177.

Tan, U. (1988). The distribution of hand preference in normal men and women. *International Journal of Neuroscience, 41*, 35-55.

Tan, U. (1990). Relationship of testosterone and non-verbal intelligence to hand preference and hand skill in right-handed young adults. *International Journal of Neuroscience, 54*, 283-290.

Thompson, P. D., Crouse, S. F., Goodpaster, B., Kelley, D., Moyna, N., & Pescatello, L. (2001). The acute versus the chronic response to exercise. *Medicine and Science in Sports and Exercise, 33*(6), 438-445.

Tomporowski, P. D., & Ellis, R. (1986). Effects of exercise on cognitive processes: A review. *Psychological Bulletin, 99*, 338-346.

Tomporowski, P.D., Ellis, R.N., & Stephens, R. (1987). The immediate effects of aerobic exercise on free-recall memory. *Ergonomics, 30*(1), 121-129.

Trice, A. D., Holland, S. A., & Gagne, P. E. (2000). Voluntary class absences and other behaviors in college students: An exploratory analysis. *Psychological Reports, 87*(1), 179-183.

Trockel, M. T., Barnes, M. D., & Egget, D. L. (2000). Health-related variables and academic performance among first year college students: Implications for sleep and other behaviors. *Journal of American College Health, 49*(3), 125-141.

U.S. Department of Health and Human Services (2000). *Healthy people 2010: Understanding and improving health.* Washington DC: US Department of Health and Human Services, US Government Printing Office.

Van Blerkom, M. L. (1992). Class attendance in undergraduate courses. *Journal of Psychology, 126*(5), 487-495.

Van Boxtel, M. P., Paas, G. G., Houx, P. J., Adam, J. J., Teeken, J. C., & Jolles, J. (1997). Aerobic capacity and cognitive performance in a cross-sectional aging study. *Medicine and Science in Sport and Exercise, 29*(10), 1357-1365.

Walters, S. T., & Martin, J. E. (2000). Does aerobic exercise really enhance self-esteem in children? A prospective evaluation in 3rd – 5th graders. *Journal of Sport Behavior, 23*(1), 51.

Weingarten, G. (1973). Mental performance during physical exertion: The benefit of being physically fit. *International Journal of Sports Psychology, 4*, 16-26.

Weingarten, G., & Alexander, J. F. (1970). Effects of physical exertion on mental performance of college males of different physical fitness level. *Perceptual and Motor Skills, 31*, 371-378.

Weiss, P. (1969). *Sport: A philosophic inquiry.* Carbondale, IL: Southern Illinois Press.

Weiss, R. P. (2001). The mind-body connection in learning. *Training & Development, 55*(9), 61-66.

Wentzel, K. R., (1993). Does being good make the grade? Social behavior and academic competence in middle school. *Journal of Educational Psychology, 85*(2), 357-364.

Williams, J. F. (1965). Education through the physical. In A. Paterson & E. C. Hallberg (Eds.), *Background readings for physical education* (pp. 191-196). New York: Holt, Rinehart & Winston.

Wilmore, J. H., & Costill, D. L. (1999). *Physiology of sport and exercise* (2nd ed.). Champaign, IL: Human Kinetics.

Wilson, E. (1979). *The mental as physical.* London: Routledge and Kegan Paul Ltd.

Wlodkowsik, R. J., & Ginsberg, M. B. (1995). *Diversity and motivation: Culturally responsive teaching.* San Francisco: Jossey-Bass Publishers.

Young, R. J. (1979). The effect of regular exercise on cognitive functioning and personality. *British Journal of Sports Medicine, 13*(3), 110-117.

Zalaquett, C. P. (1999). Do students of noncollege-educated parents achieve less academically than students of college-educated parents? *Psychological Reports, 85*(2), 417-422.

Zelasko, C. J. (1995). Exercise for weight loss: What are the facts? *Journal of the American Dietetic Association, 95*(12), 1414-1418.