ENERGY COST OF PARTICIPATION IN GOLF

AS DETERMINED BY TELEMETRY

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PREFACE

Physical conditioning and physical fitness have been given a great deal of attention by the American public in recent years. One of the obligations and a primary function of physical education research is to explain its many activities and to assess their contributions to physical fitness. This study is an attempt to evaluate the energy cost of golf participation under three variables and what contributions toward physical fitness are gained.

The investigator would like to express sincere appreciation to the many people who assisted in the formulation and completion of this study.

Special acknowledgment goes to Dr. A. B. Harrison, my adviser, for his encouragement, guidance and untiring assistance and to the members of my committee, Drs. A. P. Warner, John Bayless and Harry K. Brobst for their many helpful suggestions.

Gratitude goes to Mr. Paul Hanks for his sincere cooperation for use of the Stillwater Golf and Country Club golf course.

Deep appreciation is extended to each subject for his dedication of time, effort and cooperation.

Finally, my most sincere thanks to my wife, Virginia, and sons, Bernie and Chris, for their patience, understanding and encouragement throughout the entire study.

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CHAPTER I

INTRODUCTION

An important issue in our technological civilization concerns the physiological decline of the human body. Is this physiological decline inevitable due to aging or is it partly a consequence of our automated sedentary living? According to many exercise scientists the aging person who participates in regular physical exercise can delay or minimize this degeneration. However, the question has not been answered as to how much physical activity is needed and what activities may best serve the purpose of developing and maintaining a sound physiological body.

Without question, the game of golf, based on its millions of participants, and first in total sales of sports equipment is one of the most popular sports in the twentieth century. Are these participants looking to golf for their physiological fitness, and if so to what degree? Does carrying the clubs, using a pull cart, or riding in a motorized cart have any significant effect on the degree of fitness one attains? It is with these thoughts in mind that this study evolved.

The sport of golf, traceable to early historical times, originated centuries ago. Shepherds amused themselves by striking small stones with their crooks, vying with each other for distance and accuracy.

Caesar's armies carried the game to Britain. However, most agree that golf had its real origin in Scotland around the 14th century.[1]

Golf became so popular in Scotland that in 1457 King James II persuaded Parliament to ban it on the grounds because it interfered with the practice of archery, the principle art of war.[2]

During the 15th century another Scottish King, James IV, saved golf by becoming a regular player and avid fan. His granddaughter, Mary, Queen of Scotland, was the first woman golfer. Her attentive army cadet was the forerunner of the caddy of today. The Royal and Ancient Golf Club of St. Andrews of Scotland was founded in 1754, and is considered the seat of authority for all matters pertaining to the game of golf.[3]

Golf crossed the Atlantic to Canada and America in the latter part of the 19th century. John G. Reid introduced the games to his friends in a cow pasture in Yonkers, New York, in 1885. This Scotsman, who became known as the "Father of American Golf", was instrumental in establishing the first golf club, St. Andrews of Yonkers, in 1888. Five of the private clubs in the Eastern United States joined together to form the United States Golf Association in 1894. From its beginning, the United States Golf Association has been the governing body for many prominent tournaments.[4]

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[1]Billy Ann Cheatum, Golf, W. B. Saunders Company, Philadelphia, Pa., 1969, p. 2.

[2]"Golf", Teaching Lifetime Sports Skills, the President's Council on Physical Fitness in Cooperation with Lifetime Sports Foundation Fore, Inc., 2020 R Street, N. W., Washington, D. C.

[3]Maryhelen Vannier, Hally Beth Poindexter, Physical Activities for Women, W. B. Saunders Company, Philadelphia, Pa., 1966, p. 101.

[4]Ibid.

Early in the 20th century enthusiastic women golfers were granted playing privileges at private courses and numerous public courses. The development of equipment for consistent and accurate play and mass manufacturing brought the price of golf into the range of millions of people.

Today in the United States approximately ten million people play golf annually spending 235 million dollars, using 35 million golf balls and playing on approximately 7,900 golf courses.[5]

The benefits of golf are numerous. Unlike many sports, golf can be enjoyed from youth through old age. It is a game which is well suited for men and women to play together, and it is a sport which girls can play without loss of femininity.

Few sports offer as great an opportunity for life long enjoyment as golf. It has tremendous social value, and for the older person golf is just the type of physical exercise recommended by their doctors, since players can set their own playing pace. It was used extensively by the military hospitals during and after World War II as an aid in the rehabilitation of the sick and the wounded.

Probably no other person has ever given the game of golf the "push" that Dwight D. Eisenhower did when he became president, and set up his "summer white house" adjacent to the Augusta National Courses in Georgia.

There are not many games that present the possibility of displaying the high degree of sportsmanship exhibited in golf. It is truly worthy

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[5]"Golf", Teaching Lifetime Sports Skills, the President's Council on Physical Fitness in Cooperation with Lifetime Sports Foundation Fore, Inc., 2020 R Street, N. W., Washington, D. C.

of the label "a gentlemen's game". It is challenging, tremendously satisfying and offers effective relaxation from the mental tensions so prevalent today in our American society. One successfully executed shot during a game is often sufficient to cause the player to return for another round.

Lifetime Sports Foundation, a recently organized association, initiated in the summer of 1965 "The Lifetime Sports Education Project" where efforts were made to increase participation in several sports, including golf, which may be enjoyed throughout life.

This organization in cooperation with the President's Council on Physical Fitness has compiled a number of booklets which may serve as guides to teaching such fundamental sports as tennis, bowling, golf, and badminton.

The research advisory committee of the Lifetime Sports Education Project under the leadership of Edward D. Greenwood, M.D., Stanford University, and G. Lawrence Rarick, Ph.D., University of Wisconsin, has approved such research projects as; "A Survey of the Medical and Psychiatrics Literature on the Values of Sports and Physical Activities for Better Mental Health", "Values of Lifetime Sports and Physical Activities as Revealed by a Geriatric Population in Retirement Homes", and "Psychophysiological Responses of Middle-Aged Men Participating in Selected Lifetime Sports", of which golf is one.

Because of frequent opportunity for rest, or the use of carts, caddies, or riding machines, golf is presumably considered light exercise. Studies show, however, that while playing eighteen holes on an average length course, a golfer takes about 300 swings (including practice), walking over four miles, loses somewhat between one and four pounds, and expends enough energy to life his weight forty stories high, five times.[6]

Dr. A. B. Harrison of the Department of Health and Physical Education at Oklahoma State University, after wearing a pedometer for several rounds, concluded that he walked 6-7 miles for eighteen holes of golf.[7]

In recent years a great deal of attention by the American public has been given to physical conditioning and physical fitness. Many of our nation's leaders, notably the late President John F. Kennedy, have expressed their interest in support of an active physical fitness program. The President's Council on Physical Fitness has indicated continuing high-level interest in this important subject.

It has frequently been said, and rightly, that the human body is a machine, and that its activity should be explainable by the known facts of physics and chemistry.[8] The muscular power and the mechanical efficiency of the body, together with the conditions which modify and control these, are topics that appear to individuals from different points of view. The physiologist largely views these from the standpoint of oxygen and carbon dioxide exchange and the concepts of aerobic and anaerobic work.

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[6]Kenneth D. Miller, <u>Physical Education Activities for College Men and Women</u>, Wm. C. Brown Company, Dubuque, Iowa, 1963.

[7]Dr. A. B. Harrison, <u>Personal Communication</u>, Department of Health and Physical Education, Oklahoma State University, Stillwater, Oklahoma, March, 1968.

[8]Peter V. Karpovich, <u>Physiology of Muscular Activity</u>, 6th Edition, W. B. Saunders Company, Philadelphia and London, 1965, p. 66.

In his book Aerobics, Dr. Kenneth H. Cooper,[9] M.D., M.P.H., Major, U.S.A.F. Medical Corps, states that the foundation on which any fitness program should be built is aerobic (with oxygen) exercises. He has set up a point system based on work load for a number of activities including golf. His point system for the various activities ranges from 1-34 and some of the activities are running in place, running, cycling, rope skipping, skating, tennis, skiing, volleyball, basketball, swimming, walking, handball and golf.

The basic principle of Dr. Cooper's point system is that one must maintain a minimum of 30 points a week and exercise at least four times a week or every other day. The point value for eighteen holes of golf is three. This would mean that an individual would have to play ten rounds of eighteen holes of golf a week to secure 30 points a week to maintain a satisfactory level of fitness.

A number of methods have been used from time to time for estimating caloric expenditure during performance of a task. The method most commonly used has been that of collecting expired gases during performance of a task and analyzing these gases for oxygen used. Since this method has been found cumbersome and time consuming, various field methods have been tried. In one of the methods, minute ventilation was used as a measure of energy expenditure. To use this method, a correlation curve was required to be worked out separately for each individual

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[9]Kenneth H. Cooper, M.C., M.P.H., Major, U.S.A.F. Medical Corps, Aerobics, Bantam Book Company, Inc., New York, 1968.

by taking six readings for energy expenditure and minute ventilation during performance of standard tasks in the laboratory.[10]

In some activities, which require considerable amounts of fast running and jumping in unpredictable directions, it is impossible to estimate the amount of energy used by collecting expired air in a Douglas bag. One cannot play tennis, basketball or soccer with a Douglas bag strapped to his back. For this purpose, another indirect method has been suggested. It is based on the observation that there is a linear relationship between the oxygen consumed and the pulse rate.[11]

The heart rate has been recognized as an important measurement of cardiac activity for quite some time. According to the current thinking in cardiovascular research, the heart rate is an excellent indicator of the severity of physical exercise or activity.

The heart rate at rest varies widely from individual to individual, and also within the same individual from one observation to another under similar circumstances; therefore, it is almost meaningless to speak of a normal rate. It may be said, however, that the average heart beat is seventy-two beats per minute without implying that a rate of forty (observed in highly trained endurance athletes) or one hundred is necessarily abnormal.

Malhotra, Gupta, and Rai[12] conducted a study "Pulse Count and Energy Expenditure" using seven young adult male subjects. Each

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[10]Peter V. Karpovich, Physiology of Muscular Activity, 6th Edition, W. B. Saunders Company; Philadelphia and London, 1965, p. 66.

[11]Ibid, p. 73.

[12]M. S. Malhotra, J. Gupta, and P. M. Rai, "Pulse Count as a Measure of Energy Expenditure", _Journal of Applied Physiology_, Vol. 18, p. 994, 1963.

exercised on a bicycle ergometer with a workload varying from 50-600 kg-m/min. After about 8-9 minutes of cycling when the steady state had been reached expired gases were collected using a Kofranyi - Michaelis respirometer; pulse rate was recorded by palpitation during the gas collection period. The expired gases were analyzed using a Scholander microgas analyzer, and the energy expenditure calculated. The relationship between the pulse rate and energy expenditure was determined. To estimate the errors of using pulse rate for measuring energy expenditure the same subjects were given various field tasks such as marching, running, walking, hopping, hammering, etc. During performance of these tasks energy expenditure and pulse rate were measured using the same technique. They found a linear relationship between the oxygen consumed and the pulse rate at low and moderate work intensities. Using this technique one can indirectly measure the oxygen consumed (energy expenditure) from the pulse rate of an activity at different work loads.

Approximately ten years ago, a member of the Electrical Engineering Department at the University of Michigan became interested in working on a telemetering unit for transmitting the heart rate during sports participation. This unit has since undergone many changes to the point where it now consists mainly of a wireless transistorized transmitter, an F.M. receiver and amplifier, and a two-channel paper recorder.[13]

Telemetry allows us to conveniently measure heart rate during exercise. Knowing pulse rate during the activity we can predict the oxygen consumed. Knowing the oxygen consumed in an activity such as a

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[13]Paul Hunsicker and Andrew J. Kozar, "A Study of Telemetered Heart Rate During Sports Participation of Young Adult Men", The Journal of Sports Medicine and Physical Fitness, Vol. 3, No. 1, March, 1963, pp. 1-5.

round of golf, one could determine the exercise load or what fitness potential one gets from golf.

Statement of the Problem

It was the intent of this study to determine the energy cost of participation in 27 holes of golf by seven selected adult males under varying conditions. These subjects represented high and low skill ability in golf performance.

Sub-problems were: (1) Does heart rate increase more during putting due to emotional stress which is brought about by a cardiovascular response that is quite similar to the response to exercise; (2) Does the resulting heart rate during putting equal the heart rate while walking from tee to green and also during the tee shot; (3) Does the skilled golfer have the lowest heart rate; (4) What is the comparative energy cost of playing golf while carrying clubs, using a pull cart, and riding in a golf cart.

Assumption of the Problem

Subjects performed under similar weather conditions, with temperatures ranging from 70-90 degrees and wind gusts up to 10 miles per hour. Any changes within these ranges were assumed to have no effect on any one subject more than any other subject.

The physical characteristics as well as the occupations and working habits of the subjects were assumed to have had no effect on the performance of any one subject more than any other subject. Further it was assumed that the exercise would not effect any one subject more than any other subject within the age ranges of 35 to 53.

With performances occurring when temperature and wind condition were 70-97 degrees and wind gusts up to 10 miles per hour, it was assumed that playing in the morning or the afternoon had no effect on the subjects.

If repeated measurements of heart rate or oxygen consumption were made on the same person working at a fixed rate, the results may have differed due to instrumental error or physiological variation of the individual.

Finally it was assumed that pulse rate and energy cost of the subject was not effected through emotional response to the telemetry equipment.

Limitation of the Problem

The subjects for this study were six male volunteers from the faculty and staff of Oklahoma State University, Stillwater, Oklahoma, and one male golf professional. The subjects ranged in age from 35 to 53 and from high to low in golf ability. The low group had a handicap of under 10 and the high group had a handicap of over 11.

The study was limited to twenty-seven holes of golf, with the subjects playing nine holes of golf at three different times performed under the following circumstances of carrying the clubs, using a pull cart and riding a motorized cart.

Significance of the Study

Due to the ever increasing amount of leisure time available in our modern society people are seeking avenues for adequate use of this leisure time. Many are also aware of the importance of individual physical fitness and seek means to acquire this in some manner. More leisure time has increased the number of people participating in golf, probably because it is an activity that is suitable to youth as well as old age, male and female, and allows each individual tremendous social value. These individuals as well as physical educators should have some knowledge as to how much exercise is provided by playing a round of golf. Is it enough to maintain desirable levels of physical fitness? How much energy is used in a round of golf? These are some of the more important issues that the writer will attempt to answer. We should be able to give the necessary information to the individual so that he can make the right decision in regards to selecting an activity that will be most conducive to maintaining desirable levels of physical fitness.

CHAPTER II

REVIEW OF LITERATURE

Up to the present there has been a lack of scientific investigation to determine the contributions of golf to physical fitness. This review of the related literature will be presented in three phases: (1) Energy cost, validity of a linear relationship betwen heart rate and oxygen consumption and methods used to obtain the data, (2) telemetry, a brief overview of methods of collecting heart rates of many different kinds of physical activity which can be used as an indicator of physiological stress, and (3) physical fitness, the hypothesis that the degree of response to exercise stress and the speed at which adjustment and recovery takes place are valid measures of physical fitness.

Energy Cost

Physiological study of human energy expenditure and the capacity for physical work began about seventy years ago. Also, the validity of using rates of oxygen consumption as the basis for measuring energy expenditure was firmly established. In this early period rates of energy expenditure during a variety of human activities was recorded. This interest in energy expenditure has increased due to the development of apparatus which can be conveniently applied under many conditions.

Each individual has his own basal metabolic rate which is required to maintain life. From 210 to 295 cc. of oxygen per minute are required to provide for the "basal" metabolism of adults.[1]

The heavier the meal the more energy used. Karpovich[2] stated that more energy is required to stand at attention than at ease, and more required to stand at ease than for sitting and more for sitting than for lying. The energy cost of various body positions are affected by the previous meal.

Energy cost of walking depends on the speed of walking and the weight of the walker. Passmore and Durvin[3] combined data obtained in England, Austria, the United States, Germany and Italy and found the results for energy cost of walking for men and women weighing between 80-200 pounds walking at a speed of 3.5 m.p.h. to be from 3.0 to 6.0 calories per minute.

Daniels[4] completed a study showing that walking in combat boots on a treadmill required ten per cent less energy than walking on asphalt or cinder road. Ralston[5] completed a similar study but had his subject wear rubber sole shoes and walk on a smooth linoleum floor. His

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[1]Peter V. Karpovich, Physiology of Exercise. W. B. Saunders Company, Philadelphia and London, 1965, p. 85.

[2]Ibid.

[3]R. Passmore and J. V. Durvin. "Human Energy Expenditure", Physiological Review, 35:801, 1955.

[4]F. Daniels, Jr., J. H. Vanderbil, and C. L. Bommarito. "Energy Cost of Load Carrying On a Treadmill", Fed. Proc. 11:30, 1952.

[5]H. J. Ralston. "Comparison of Energy Expenditure During Treadmill Walking and Floor Walking", Journal of Applied Physiology, 15:1156, 1960.

results showed energy cost of walking on the treadmill and on the floor were the same.

Because of the wide range of speeds obtainable, running affords a striking illustration of the class relationship between the speed of motion and the energy cost.[6] Sargent,[7] tested an experienced athlete weighing 139 pounds who could run the 100 yards in 10.2 seconds. His energy cost was based on his oxygen debt and he developed about 14 horsepowers of energy. Fenn[8] ascertained that the rate of expenditure of energy during running at maximum speed has about 13 horsepowers for an average man. Knuttgen[9] showed that the energy cost of running is much higher when the step length at various speeds was kept constant instead of allowing the runner to adjust the step length to the speed.

Durvin[10] conducted a study with regard to treadmill walking. His results indicated that older men showed a greater response to two levels of walking exercise. More energy was used, higher heart rates resulted, and lower respiratory efficiency was observed in the older men. The

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[6]Peter V. Karpovich. Physiology of Exercise. W. B. Saunders Company, Philadelphia and London, 1965, p. 85.

[7]R. M. Sargent. "Relation Between Oxygen Requirement and Speed in Running", Proc. Royal Society of London, B, 100:10, 1926.

[8]W. O. Fenn. "Work Against Gravity and Work Due to Velocity Changes in Running; Movement of the Center of Gravity Within the Body and Foot Pressure on the Ground", American Journal of Physiology, 93:433, 1930.

[9]H. G. Knuttgen. "Oxygen Uptake and Pulse Rate While Running With Undetermined and Determined Stride Lengths at Different Speeds", Acta Physiology, Scandiva, 52:366, 1961.

[10]J.V.G.D. Durvin and V. Makulicis. "The Influence of Grade Exercise on the Oxygen Consumption, Pulmonary Ventilation, and Heart Rate of Young and Elderly Men", Quarterly Journal of Experimental Physiology, 41:442-452, 1956.

degree of this physiological deterioration became more marked as the severity of the work increased.

The evaluation of the energy cost of physical activity may also be accomplished by respiratory calorimetry including gas analysis. Energy expenditures for an activity can be closely approximated by determining the volume of expired air and its oxygen and carbon dioxide content. From the volume of expired air and its oxygen and carbon dioxide content one can measure the amount of oxygen consumed and the respiratory quotient. Carpenter[11] completed tables, factors and formulae for computing respiratory exchange and biological transformations of energy. The indirect calorimetry in respiratory metabolism experiments have been validated by the studies of Atwater and Benedict,[12] and Benedict and Milner[13] to the extent that it has long been accepted as a method which can be used to determine the energy cost of various physical education activities.

The closed circuit spirometry is another method of obtaining data with regard to respiratory metabolism. Warren E. Collins[14] advocates it as the simplest and most practical answer to the problem of measuring

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[11] T. M. Carpenter. Tables, Factors, and Formulae for Computing Respiratory Exchange and Biological Transformations of Energy. (4th Edition, Washington: Carnegie Institute of Washington, 1968), Table 13, p. 104.

[12] W. O. Atwater and F. G. Benedict. Experiments on the Metabolism of Matter and Energy in the Human Body. U. S. D. A., Office of Experimental Stations, 1903, pp. 1-136.

[13] F. G. Benedict and R. D. Milner, Experiments on the Metabolism of Matter and Energy in the Human Body. 1903-1904, U. S. D. A., Office of Experimental Stations, 1907, pp. 1-175.

[14] Warren E. Collins, Clinical Spirometry, Warren E. Collins, Inc., Braintree, Mass., p. 1.

and recording respiratory excursions, lung volumes and oxygen uptakes. Graphic recordings of oxygen consumption are indispensable for guarantee accuracy with this method.

Karpovich[15] concluded that from 210 to 295 cc. of oxygen per minute are required to provide for the basal metabolism of adults. He further concluded that if the basal usage of oxygen is 250 cc. then the human body would average 1.20 calories of energy per minute.

Christensen[16] set forth the following as a classification of industrial tasks.

Intensity	Energy Expenditure
Light	2.5 cal/min (.5 liter of O_2 per min.)
Moderate	5.0 cal/min (1.0 liter of O_2 per min.)
Heavy	7.5 cal/min (1.5 liter of O_2 per min.)
Very Heavy	10.0 cal/min (2.0 liter of O_2 per min.)
Unduly Heavy	12.5 cal/min (2.5 liter of O_2 per min.)

Passmore and Durvin[17] classified the following activities as moderate exercises and assigned the following energy cost for each:

Recreation	Energy Cost = Cal/Min
Driving a car	2.8
Driving a motorcycle	3.4
Canoeing, 2.5 m.p.h.	3.0
Canoeing, 4.0 m.p.h.	7.0
Cycling, 5.5 m.p.h.	4.5
Cycling (own pace)	10.3
Dancing, foxtrot	5.2
Dancing, waltz	5.7
Dancing, rumba	7.0

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[15] Peter V. Korvich. Physiology of Exercise. W. B. Saunders Company, Philadelphia and London, 1965, p. 85.

[16] E. H. Christensen. "Physiological Valuation of Work in the Nykroppa Iron Works", Ergonomics Section Symposium on Fatigue, F. W. Floyd and A. Welford (London: H. K. Lewis, 1953), pp. 93-108.

[17] R. Passmore and J. V. G. D. Durvin. "Human Energy Expenditure", Physiological Review. 35:801-839, 1955.

Recreation	Energy Cost = Cal/Min
Gymnastics exercises balancing	2.5
abdominal	3.0
trunk bending	3.5
Volleyball	3.5
Bowling	4.4
Golf	5.0
Archery	5.2
Cricket, fielding	3.9
Cricket, bowling	5.2
Cricket, batting	6.0
Tennis	7.1
Football, association	8.9
Swimming, breast stroke	11.0
Swimming, back crawl	11.5
Swimming, side stroke, 40 yd./min.	11.0
Swimming, crawl stroke, 55 yd./min.	14.0
Cross country running	10.6
Skiing, level hard snow	15.9
Skiing, up hill hard snow	18.6

Heart Rate and Telemetry

Physiologists have long recognized heart rate as an important measurement of cardiac activity. The current thinking in cardiovascular research is that the heart rate is an excellent indicator of the severity of physical exercise or activity.

The early classical approach to the study of the heart rate and exercise was limited to pre and post-exercise measurement. With the development of the cardio-tachometer, rates could be secured while the subject was exercising. However, the subject was restricted to the immediate vicinity of the recording apparatus because of the wire attachments. This imposed a definite limitation on the type of data that could be obtained.

Approximately ten years ago, a member of the Electrical Engineering Department at the University of Michigan became interested in working on a telemetering unit for transmitting the heart rate during sports participation. This unit has since undergone many changes to the point where it now consists mainly of a wireless transistorized transmitter, and F. M. receiver and amplifier, and a two-channel paper recorder.

Hunsicker and Kozar[18] conducted a study to determine the relative strenuousness of six related sports (handball, paddle ball, tennis, badminton, volleyball and bowling) utilizing heart rate for a given time of participation as the criterion for determining their severity. The basic assumption for their study was: the activity which produced the highest heart rate per unit time is the most strenuous activity. For this study telemetered heart rate records of twenty-three adult men were obtained. These subjects were selected from the students and faculty of the University of Michigan on the basis of good physical condition and superior sports skills. The findings of their study were that handball, paddle ball, tennis and badminton do not differ significantly in heart rate, but that they were significantly greater than volleyball and bowling. All of the sports except handball showed that the peak heart rate was attained after eight minutes of the activity had elapsed.

Kozar[19] completed a study in which he tested a gymnastic champion during exercises on gymnastic apparatus which included the high bar, parallel bars, side horse, and steel rings. Telemetered heart rate reflected the strenuousness of each exercise performed. The heart rate for the first performance on the parallel bars for 31 seconds was 169

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[18]Paul Hunsicker and Andrew J. Kozar, "A Study of Telemetered Heart Rate During Sports Participation of Young Adult Men", The Journal of Sports Medicine and Physical Fitness, Vol. 3, No. 1, March, 1963, pp. 1-5.

[19]Andrew J. Kozar, "Telemetered Heart Rates Recorded During Gymnastic Routine", The Research Quarterly, Vol. 34, No. 1, pp. 102-106, 1963.

and for the second performance for 35 seconds was 150. The peak heart rate produced by the high bar for 15 seconds was 160 beats which occurred on the second performance. The first performance which lasted nine seconds had a peak heart rate of 140. The heart rate for the first performance on the steel rings for 31 seconds was 145 as compared to the 160 beats on the second performance for the same length of time. The heart rate for the side horse for 15 seconds was 155. There was only one perfornance on the side horse.

Skubic and Hodgkins[20] of the University of California completed a study dealing with cardiac response to participation in tennis, badminton, golf, archery, and bowling as measured by telemetry. Two college women served as subjects. Heart rates, rectal temperatures and recovery heart rates were studied to determine the relative strenuousness of these sports and to classify them according to work load. It was found that tennis and badminton proved to be significantly more strenuous than golf, archery and bowling. Golf was found to be significantly more strenuous than archery and bowling, but none of these required a mean heart rate higher than 106 and were classified as light work. Tennis and badminton were classified as moderate work. Rectal temperatures followed the same pattern of increase as heart rates.

Skubic and Hilgendorf[21] telemetered heart rates of five school girls in four track events and found no significant differences in heart

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[20] Jean Hodgkins and Vera Skubic, "Cardiac Response to Participation In Selected Individual and Dual Sports as Determined by Telemetry", The Research Quarterly, Vol. 36, No. 3, pp. 316-326, 1965.

[21] Vera Skubic and Jane Hilgendorf, "Anticipatory, Exercise, and Recovery Heart Rates of Girls as Affected by Four Running Events", Journal of Applied Physiology, Vol. 19, pp. 853-856, 1964.

rate during exercise or recovery when the 220-yard, 440-yard, 880-yard, and mile runs were compared. All four of these events were considered strenuous by Skubic and Hilgendorf.

Hanson[22] of Macalester College in St. Paul, Minnesota conducted a study of cardiac response to participation in Little League baseball competition as determined by telemetry. His subjects were 10 volunteer Little League baseball players from Greenbelt, Maryland, whose ages ranged from 9-12 years. These subjects represented all fielding positions excluding pitchers and catchers. The data collected for this study showed heart rate response for each of the 10 subjects greatest when they were "at bat". Of the three highest heart rates recorded for each subject, only two of a possible 30 were in situations other than while at bat. There was median response for "at bat" which was 163 beats per minute with the greatest being 204 beats per minute and the least 145 beats per minute. The median rate at rest pregame sitting was 95 beats per minute as compared to the median postgame sitting at rest rate of 100 beats per minute. The pregame standing at rest was 112 beats per minute as compared to the median postgame heart rate while standing at rest was 121 beats per minute. The median rate for fielding was 127 beats per minute while sitting in the dugout was 113 beats per minute.

The major findings of this study seem to be (1) that the exercise involved at the time of the game was minimal and could not be considered

[22]Dale L. Hanson, "Cardiac Response to Participation in Little League Baseball Competition as Determined by Telemetry", The Research Quarterly, Vol. 38, pp. 384-388, 1966.

as a major factor contributing to the development of cardio-vascular respiratory fitness; (2) the high heart rates while at bat certainly showed emotional stress, but of a very short time.

A study of heart rates of track participants was conducted by Rose and Dunn[23] of the University of Nebraska using the telemetering system. A standard 220 or 440-yard run was used to screen the subjects for cardiac abnormalities which were not detected by the usual medical examination and electrocardiographic methods. The most significant result of this study was the "T-wave recovery time". This was the time in minutes needed for a T-wave to return to pre-exercise after a standard 220 or 440-yard run. It was concluded that short "T-wave recovery times" on track men, following the standard run, were identified with good cardiovascular systems.

Telemetry at the University of North Carolina was used by Howard, Blyth, and Thornton[24] to discover and record the differences in heart rates when specified exercise routines were performed without a preliminary "warm-up" and following a "warm-up". The study received special emphasis with regard to anticipatory increase in heart rate, the maximum heart rate and the decrease in heart rate during periods of recovery. It was found that the maximum heart rates were generally higher during the routines which were completed after a "warm-up",

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[23]K. D. Rose and F. L. Dunn, "A Study of Heart Function in Athletes by Telemetered Electro Cardiography", Proceedings 5th Annual Conference on the Medical Aspects of Sports, American Medical Association, December, 1963.

[24]G. E. Howard, C. S. Blyth and W. E. Thornton, "A Study of the Continuously Recorded, Telemetered Heart Rate of Track Athletes During Exercise", National Convention of the American Association for Health, Physical Education and Recreation, Washington, D. C., May, 1964.

however, differences were not statistically significant at the 5 per cent level of confidence. Also, the differences between anticipatory heart rates and recovery heart rates were not significant.

A study conducted by Rozenblat[25] in Russia obtained pulse rate by radio telemetry on various types of athletes during training. These activities included skijumpers, gymnasts, basketball players, skiers, runners, and skaters. From his findings, he was able to establish some provisional normal standards for pulse changes associated with various exercises and concluded that the changes in the pulse rates during the exercise bore no obvious relationship to the resting pulse rates. He also proposed a new index. This index could be used to determine the optimum intensity of training efforts to be demanded of athletes in practice. This index was based on a mean pulse rate for specific training exercises. Pulse rates of 29 subjects were taken during competition runs and they showed an increase from 120 to 132 beats a minute at the start to between 180 and 216 beats a minute during the race and to from 204 to 230 beats a minute at the end of the race.

Telemetered heart rate recordings of subjects during training sessions of distances of 100, 400, 800, 1,500, 5,000, and 10,000 meters were studied by Vasilena[26] at the Lesgaft State Institute of Physical Culture. When at rest these subjects' heart rates ranged from 52-60 beats a minute. After they had changed to track uniforms, and the

[25] V. V. Rosenblat, "Heart Rate in Man During Natural Muscular Activity (data obtained by dynamic radiotelemetry)", Federation Preceeding (Translation Supplement), 22:T766, July, 1963.

[26] V. V. Vasilena, "Analyse telemetrique de la frequence cardiaque dans la course sur differentes distances", Revue de l' education physique, Vol. III: 25-30, January, 1963.

testing equipment had been attached, their heart rates ranged from 70 to 80 beats a minute. After warming up and waiting at the starting line for the gun to start the race, their heart rates ranged from 115 to 132 beats a minute. While running the different distances, the heart rates of the subjects increased consistently as they ran and reached a maximum rate at the end of the running effort. Irrespective of the distance ran, the heart rates were almost identical. In the 100 and 400 meter distances, the acceleration of the heart was more rapid, and in the 10,000 meter distance, the maximum heart rate was not reached until after he had been running for 7 minutes. In all cases the heart rate had not returned to the resting level at the end of a ten-minute period of rest.

Bailey[27] of the University of Saskatchewan studied heart and respiration rates during "second wind" by means of radio telemetry. Eleven subjects were used for this study. They were tested while running one mile as fast as possible. All maximum heart and respiration rates were reached by all subjects at the end of a run. The results showed that the runner whose heart rates rose to near maximal levels in the shortest periods of time also ran the one-mile distance in the shortest time.

Orban,[28] also of the University of Saskatchewan, studied heart rate responses to interval running on an indoor board track. Five subjects

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[27] D. A. Bailey, "The Physiological Response of Athletes During All-Out Sports Performance as Monitored by Radio-telemetry", Progress Report for Fitness and Amateur Sports Research Grant, (Saskatoon, Canada, University of Saskatchewan, November, 1963).

[28] W. A. R. Orban, "Heart Rate Response to Interval Running Using Radio Telemetry", Journal of Sports Medicine and Physical Fitness, 3: 252-253, December, 1963.

ran intervals of 330-yard distances with various recovery intervals interspersed between them. He found the "absolute value" of the heart rate in each interval run was inversely related to the length of the recovery interval.

Physical Fitness

Kristufek's[29] study showed the effects of a three-mile-a-day running program which lasted for a 49-day period on the physical fitness of a 22-year old subject. Cardiovascular-respiratory improvement was demonstrated by increases in oxygen intake, stroke volume and heartograph measures.

Pohndorf[30] completed a study of a training program of 1,000 yards per day of swimming. The subjects were a husband and wife who had been sedentary for the previous 15 years. He concluded that improvements were made in pulse rates, pulse pressure, systolic and diastolic blood pressures, quiet heartometer measures, and step test recovery.

The Canadian 5BX Program was compared with an interval running program by Hoope.[31] The 5BX Program had 10 men and the interval running program had 7 men. Each program included a 13 week period. The 5BX group performed the five basic exercises daily for eleven minutes.

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[29] C. J. Kristufek, "Effects of Endurance Training on an Adult Subject", (Unpublished master's thesis, School of Physical Education, University of Illinois, Urbana, 1951), pp. 1-87.

[30] R. H. Pohndorf, "Improvement in Physical Fitness of Two Middle-Aged Adults", (Unpublished Ph.D. thesis, College of Physical Education, University of Illinois, Urbana, 1957), pp. 1-94.

[31] D. D. Hoope, "The Contribution of the Canadian 5BX Plan to the Physical Fitness of Adult Men", (Unpublished master's thesis, College of Physical Education, University of Illinois, Urbana, 1964), pp. 1-78.

The running group exercised at least 35-45 minutes, four days per week, supplemented by rhythmical endurance exercises. Cardiovascular fitness and motor fitness showed significant changes in both groups, with running group showing significantly larger gains.

Studies completed by Hopkins[32] and Wolbers[33] with regard to volleyball indicated no significant improvement in cardiovascular endurance.

Cureton[34] has long been a leader of the thesis that a systematic method of exercise which progressively and gradually increases the over-load will improve the physical endurance and cardiovascular - respiratory fitness of older men. Circulatory fitness is the most important fitness and the previous evidence of decline with aging clearly points this out. In the United States, 55 per cent of all deaths are due to cardiovascular disease.[35] The medical profession is beginning to look to vigorous exercises as a stimulator of physical health. Heart specialist, Paul Dudley White,[36] states that physical fitness should be uppermost in the minds of everyone in the middle-age

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[32]R. E. Hopkins, Jr. "The Effects of Volleyball and Calisthenics on the Physical Fitness of Adult Men", (Unpublished master's thesis, School of Physical Education, University of Illinois, Urbana), pp. 1-85.

[33]C. P. Wolbers. "The Effects of Volleyball on the Physical Fitness of Adult Men", (Unpublished master's thesis, School of Physical Education, University of Illinois, Urbana, 1949), pp. 1-103.

[34]T. K. Cureton. "The Case for Physical Fitness", Think. September, 22-25, 1958.

[35]W. Raab. "Prevention of Degenerative Heart Disease by Physical Activity", Quest. Monograph III, December, 1964, p. 19.

[36]Paul D. White. "Today's Health News", Today's Health, 39:9, 1961.

bracket. Another heart specialist, Sprague,[37] claims the best insurance against a coronary disease is exercise . . . . lots of it.

Dr. Kenneth Cooper[38] in his best-seller Aerobics, noted that if the exercise is vigorous enough to produce a sustained heart rate of 150 beats per minute or more, the training-effect benefits begin about five minutes after the exercise starts and continue as long as the exercise is performed. If the exercise is not vigorous enough to produce or sustain a heart rate of 150 beats per minute, but is still demanding oxygen, the exercise must be continued considerably longer than five minutes, the total period of time depending on the oxygen consumed. In his point system he awarded nine (9) holes of golf, 1-1/2 points, so the average golfer would have to play 180 holes of golf a week to gain the necessary 30 points per week to maintain fair physical fitness.

In an article, "Should Youngsters Adopt Golf as a Major Sport",[39] opinions were voiced by Dr. Hans Kraus and golf Professional Arnold Palmer. Dr. Kraus emphatically said no, "we all need more demanding activity than golf if we're going to keep our physical condition and health at the level it should be". On the other hand Arnold Palmer said, "Yes, I feel that golf helps build character and emotional maturity in a youngster, more so, in fact, than will team sports". It gives them a better, earlier introduction into today's world; they learn how to be gentlemen.

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[37] American Medical Association. Exercise and Health - A Point of View. (Bureau of Health Education, 1958), p. 6.

[38] Kenneth H. Cooper, M.D., M.P.H., Major, U.S.A.F. Medical Corps. Aerobics. Bantam Books, Inc., New York, 1968, p. 23.

[39] "Should Your Youngster Adopt Golf as a Major Sport?" Golf. Vol. II, No. 3, March, 1959, p. 48.

It is the opinion of Mr. Palmer that golf is not as physically demanding as many other sports, but if one practices a lot in a serious attempt to improve his game, it does become strenuous. He further points out that youngsters who participated in other sports are usually in good physical condition, but once out of high school they are not as conscious of their physical condition as they would have been had they been playing golf through those years and into their adult lives.

Summary

Physiologists agree that when the relationship between oxygen intake and heart rate or workload are treated statistically the results provide strong support for the utilization of the heart rate in determination of severity of sports investigated.

Many studies have been made to provide data on energy cost on a variety of activities of which golf has been one. There is some lack of agreement as to the strenuousness of this activity. In view of the need for endurance type activity to build cardiovascular fitness and endurance, one wanders if golf offers this type of activity.

CHAPTER III

RESEARCH PROCEDURES

The seven subjects for this study consisted of six male faculty and staff members of Oklahoma State University and one male golf professional. Their jobs were all of the sedentary nature and their ages range from 35-53. They all considered themselves to be weekend golfers, in that they did not play more than twice a week. This did not include the professional golfer who had no special time for game participation, but who felt he played enough to keep his game at par golf. Three of the golfers were in the high handicap level of participation (10 and above) and three were in the low handicap level of participation (11 and under). One was a par golfer with no handicap.

Establishing A Valid Oxygen
Consumption Line

In keeping with the premise that there is a linear relationship between oxygen consumed and heart rate the writer set forth to establish a graph of an activity that would be most similar to that of golf participation. Two activities for this were selected and tried on one subject. They were riding the "Monark Bicycle Ergometer" at two different work loads with the same speed and walking the Quinton Treadmill (Model #24-72 of Seattle, Washington) at two different work loads with the same speed. This was accomplished by changing the elevation of the treadmill.

Preliminary Test for Heart Rate and Oxygen Consumption

Resting heart rate and oxygen consumption were first established by the following procedure using the following telemetry system:

(a) EKG-EMG-EEG Transmitter FM-1100 E2E and M Instrument Co., Inc., Houston, Texas

(b) Biotelemetry Receiver Model FM-110-7E and M Instrument Co., Inc., Houston, Texas

(c) A four channel physiograph Projector Model Type PMP-4AE and M Instrument Co., Inc., Houston, Texas.

Electrode Placement and Attachment

The procedure of placement and attachment of electrode is considered by most investigators as very important in recording the heart rate during muscular activity. A good signal by the heart beat for any period of time results from well-placed and attached electrodes. Many preliminary investigations were made by the writer on electrode placement and attachment to find the position that would give the clearest tracings recorded during movement.

Placement and attachment of one electrode was on the subjects sternum at the manubrosternal junction. The other electrode was placed two inches below the left nipple. For attaching the electrodes the following procedure was employed: (a) the skin area was cleaned with soap and water and dried with a towel; (b) a clear plastic bandage, one inch square with a hole in the middle the size of the electrode cup, was then placed on the electrode; (c) the electrode cup was then filled with

ECG Kontax Cream and placed on the cleaned skin of the subject. This process was completed for both ends of the placement and attachment of the electrodes. A four inch elastic ace bandage was used to wrap around the chest of the subject to ensure contact between the electrode cup and the skin.

A preliminary test was made to see if all instruments were functioning properly. This was done by turning the units on and listening from the ear plug of the tape recorder for the beep beep sound of the heart. It was emphasized to the subject that no particular effort would be required during quiet breathing, and that the concentration on subject matter other than breathing would be helpful in obtaining a regular and quiet tracing without voluntary hyper-ventilation.[1]

The subject was placed in a comfortable, sitting position and a face mask of rubber and plastic was adjusted to his comfort. This was then connected to the W. C. Collins 9 liter Respirometer. The control valve was opened to allow free breathing of room air.

The subject was allowed to become adjusted to breathing through the respirometer for a few minutes.

After complete adjustment of the subject to breathing room air, a valve was closed and the subject began to breathe pure oxygen from the respirometer. The physiograph was turned on and the heart rate of the subject was picked up by the telemetry system and played into the physiograph. In this way the oxygen consumed was recorded by the respirometer and the heart rate was recorded by the physiograph. This

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[1]Warren E. Collins, Clinical Spirometry, Warren E. Collins: Braintree, Massachusetts, p. 6.

was continued for a three minute period. Immediately afterwards the temperature and the barometric pressure were recorded. The control valve on the respirometer was then turned to allow the subject to breathe room air. At this time the respirometer was refilled with pure oxygen.

The subject was then moved to the "Monark Bicycle Ergometer" which was adjusted to a resistance of 300 KPM. The subject was instructed to maintain a speed of 50 RPM as noted on the speedometer. The respirometer valve was then closed, the respirometer and physiograph turned on and the subject instructed to begin the three minute ride.

Respiratory data was recorded on the respirometer and heart rates were recorded on the physiograph. At the end of the three minute ride the valve was opened for the subject to breathe room air, the temperature and barometric pressure were recorded and the respirometer was again refilled with pure oxygen. The resistance was increased to 450 KPM and the speed remained the same. The valve was again turned off and the subject began to breathe pure oxygen from the respirometer. The subject was again instructed to ride the ergometer for three minutes with the resistance at 450 KPM, and a speed of 50 RPM. At the end of the three minute period, the temperature and barometric pressure were recorded. The face mask was removed and the subject allowed to rest. Oxygen intake, pulmonary ventilation, and breaths per minute were computed for each of the three variables, resting, riding the bicycle ergometer at a resistance of 300 KPM and speed of 50 RPM; and at a resistance of 450 KPM and a speed of 50 RPM.

After a fifteen minute rest period, during which the subject's heart rate had returned to normal, tests on the treadmill began. The subject was allowed to take as many practice walks on the treadmill as necessary to allow complete comfort in getting on the treadmill, walking and getting off it.

The respirometer was placed on two-two by four boards across the front of the treadmill. Once again the face mask of rubber and plastic was adjusted to the subject. The valve was opened to allow the subject to breathe room air and become adjusted to the face mask. The face mask was then connected to the respirometer and the subject began to walk on the treadmill at a speed of 3.4 m.p.h. and 0% grade. The respirometer was turned on and the valve was closed so that the subject was now breathing pure oxygen from the respirometer. The physiograph was turned on to record the heart rate from the telemetering system. The subject continued this for three minutes. After three minutes he stepped off the treadmill, the valve was opened to allow the subject to breathe room air. The physiograph was turned off as was the respirometer. The temperature and barometric pressure were recorded and the respirometer was filled with pure oxygen. The treadmill was raised to a 2% grade and maintained a speed of 3.4 m.p.h. The subject again walked for three minutes while the respirometer charted oxygen intake and the physiograph recorded heart rate. The temperature and the barometric pressure were recorded and the oxygen intake, pulmonary ventilation and breaths per minute were computed.

A comparison of the results showed the linear relationship of oxygen intake and heart rate to be best during the treadmill walk. It was also felt that this activity was most similar to golf participation. Therefore, the treadmill walk at two different speeds was chosen as the laboratory exercise by which the oxygen consumption graphs for each subject would be constructed. Each subject subsequently followed a similar laboratory procedure and his own graph showing relationship of heart rate and oxygen consumption was constructed.

Golf Participation

The writer contacted the proper authorities in request for the use of the facilities of the Stillwater Golf and Country Club. Permission was granted and all subjects used the same golf course. Participation began May 12, 1969 and was concluded June 16, 1969. With exception of one subject, all participation occurred at the same time of day.

A totalizing anemometer, equipped with a roter that consists of three concical beaded cups mounted on arms, with the spindle and mechanism protected by a weather proof housing and mounted in a standard U. S. Weather Bureau 3/4" x 1" tapered pintle was used to measure the wind velocity in m.p.h. All participation occurred when wind was below 7 m.p.h.

A Taylor Hi-Lite thermometer was used for temperature recordings. Temperature was recorded three times during each nine hole series and the average was then taken. No participation occurred when temperature was below 70 or above 97 degrees.

A Zebco spring scale was used to measure the weight of the bag and clubs of each subject.

A Sportcraft Pedometer model No. 09301 was used to determine the distance walked for each variable for each subject. First each subject was asked to walk six normal paces, this was measured and an average for each pace was found. This average was then set on the Pedometer. The Pedometer was then suspended from the belt of the subject on the left rear as this would not interfere with the performance of the subject and would still allow the writer to get the total distance walked for each variable.

A preliminary round of golf was played by the same subject who rode the bicycle and walked on the treadmill in the physiology laboratory to experiment with the proper placement and attachment of the electrodes since a different type of electrode, transmitter and receiver was used than the one in the physiology laboratory. The telemetering instruments used for the golf participation were:

(a) a wireless ECG Preamp Transmitter Model 16085 channel 7- Medtronic Co., Minneapolis, Minnesota.

(b) an F. M. Wireless Preamp Receiver Model 16080 channel 7- Medtronic Co., Minneapolis, Minnesota.

(c) a Sony Matic Solid State Tape Recorder, TC-900A

The metal plates of the electrodes were covered with plastic cups, which were filled with electrode cream. The subject's skin over the mid-point of the sternum and below the left nipple was cleaned and dried with a towel. The electrode cups were taped to the cleaned area with medical clear plastic tape. A four inch elastic ace bandage was then wrapped around the chest area covering the electrodes. This was to make sure the electrodes maintained contact with the skin during participation of the activity, but did not in any way affect the respiratory movements of the thorax during participation. At the same time the wires were not hanging so loosely as to permit them to bounce against the subject's body while engaging in the activity. They were taped to the left side and midway between the electrode cup and belt line. The end of the electrodes was placed in the transmitter which was connected to an adjustable belt and worn on the left hip of the subject.

The subject was right handed so this placement had no effect on the performance of the subject.

The writer carried the receiver, and the transisterized tape recorder. The subject was allowed as much time as needed to adequately warm-up. When he was ready to begin the first tee shot, the transmitter, receiver and recorder were all turned on. A blinking light and a beep-beep sound from the tape recorder were turned on. Before and after all tee-shots and putting, a ten second interval was produced on the tape by turning off the receiving unit. This indicated on the tape every tee shot and all putting. The score, time, number of putts, and the total distance walked were recorded for each hole.

The tape was then taken back to the physiology laboratory and played from the tape recorder through the F.M. Wireless Preamp receiver to the physiograph which produced heart rate readings for the nine holes of golf. This revealed that the method of telemetry used for obtaining heart rates while playing golf was satisfactory.

Data computed included mean heart rates for tee-shots, putting, and for the nine holes of participation. The procedure for calculating the mean heart rate for tee-shots and putting was by taking the heart rate one minute before tee-shots and putting, during the tee-shots and putting and one minute after the tee-shot and putting. Mean predicted oxygen intake and multiple of resting oxygen intake were also computed.

Golf Participation Under Three Variables

The three variables used in this investigation of each nine holes of golf participation were riding, using a pull cart, and carrying the golf clubs. No attempt was made by the writer to control the order in which each subject would participate with regard to the three variables. Each subject was allowed to make his own selection as to when he would ride, carry the clubs, or use the pull cart.

Each subject met the writer at the golf course at a pre-arranged time. Upon arrival, the electrodes and the transmitter were attached to the subject in the same manner as in the preliminary investigation which gave very satisfactory results. The anemometer was set up and wind was recorded in miles per hour. The subject was asked to walk six normal paces which was measured and a mean for the length of each stride was computed. This mean was then adjusted on the pedometer and attached to the waist belt over the left hip. The temperature was recorded. The subject was allowed as much time as needed to adequately warm-up. When he was ready to begin the first tee-shot, the transmitter receiver and tape recorder were turned on. A blinking light and a beep-beep sound indicated that all instruments were functioning properly. The writer carried the receiver and tape recorder for each nine holes played by each subject. Before and after all tee-shots and putts, a ten second time interval was produced on the tape recorder by turning off the receiving unit. This indicated on the tape every tee-shot and all putting. The temperature was recorded every three holes and the mean was computed for nine holes. The time, score and number of putts was recorded for each hole, and a sum for each was found at the end of the nine holes. Also the pedometer reading was recorded as to the total miles walked for the nine holes and the wind gage was read and miles per hour for the wind was recorded. This procedure was followed for each of the seven subjects for participation in each variable.

All of the tapes were taken to the physiology laboratory and each was played from the tape recorder to the F.M. Preamp Receiver Model 16080 Channel 7 and into the four channel physiograph Projector Model Type PMP-4A. Heart rates for each nine holes for each variable were produced.

Analysis of results included comparison of mean heart rates for nine holes of each of the three variables (riding, using a pull cart, and carrying the clubs). Mean heart rates for tee-shots and putting for nine holes for each of the three variables were computed.

Tables for each subject were completed showing the relationship of heart rate and oxygen intake at various activity levels. Based on these results the writer was now able to show a relationship of heart rate and predicted oxygen intake during the three variables of golf participation of nine holes of riding, using a pull cart and carrying the clubs.

Since heart rates were recorded during the nine holes of participation for each variable with the exception of the ten second interval in the tape showing the tee-shots and putting, the writer was able to establish mean heart rates for each hole. Also, by keeping the time played for each hole served as a check on the physiograph records which also showed the time played for each hole. This added more validity to the mean heart rate for each hole played under the three variables. This also allowed the writer to establish mean heart rates for tee-shots and for putting.

Group Relationship

Analysis of results with regard to group data included the following. Means and standard deviations of heart rates of nine holes, heart rates for tee-shots, heart rates for putting, total distance walked, predicted oxygen intake, and a multiple of resting oxygen intake were computed for each of the three variables of riding, using a pull cart, and carrying the clubs. Also, the mean and standard deviation was computed for the oxygen intake at rest. A mean golf score was computed for each of the three variables.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

This chapter includes a summary and description of data collected in the three variables of golf participation and the analysis of data for the seven subjects who participated in these three variables. All of the heart rates and other statistical information were computed from the heart rate scores obtained by telemetry.

A preliminary investigation was made, using one subject, concerning the relationship of heart rate measurements to oxygen intake. The writer was satisfied that oxygen intakes during a walk on the treadmill at a speed of 3.4 and a grade of 0% for three minutes and a grade of 2% for three minutes showed a linear relationship to heart rate. This relationship (and that of bicycle pedalling) are shown in Figure No. 1.

Subject No. I

Relationship of Heart Rate to Oxygen Intake During Treadmill Walking

After a fifteen minute reclining resting period the subject had a resting heart rate of 60 and a resting oxygen intake of .464 liters per minute. Pulmonary ventilation was 4.5 liters per minute and he averaged eleven (11) breaths per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0%, Subject No. I averaged 11 breaths per minute, his pulmonary ventilation was 13.5 liters per

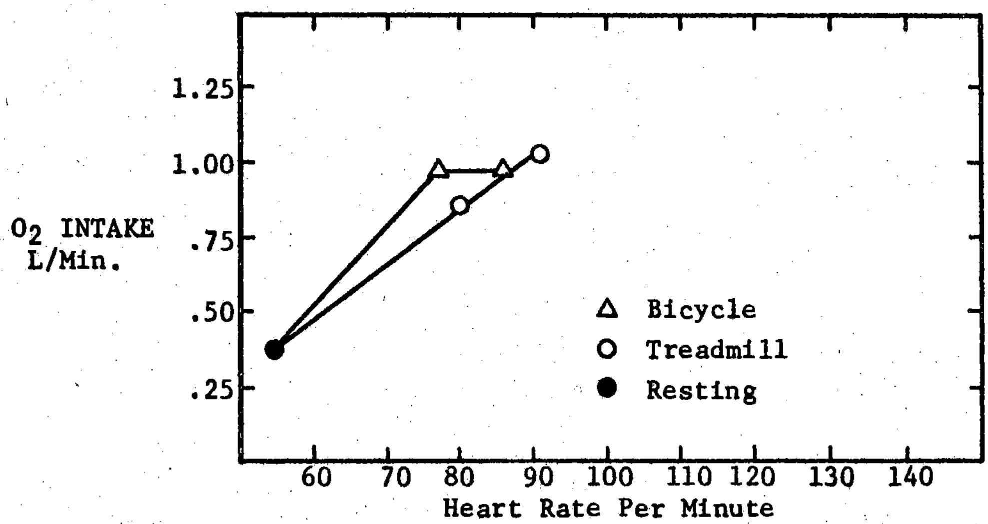

Figure 1. Subject No. I - Comparison of Heart Rates and Oxygen Intake When Bicycle Riding and Treadmill Walking

minute and his heart rate was 72 beats per minute. His oxygen intake was 1.26 liters per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 2% he had an oxygen intake of 1.39 liters per minute and a heart rate of 84. Pulmonary ventilation was 16 liters per minute and he averaged 15 breaths per minute. (See Table I and Figure 2.)

Heart Rate and Predicted Oxygen Intake During Golf Rounds

Riding: When playing nine holes of golf, and riding a motorized cart, the subject had a mean heart rate of 86.5 with a mean predicted oxygen intake of 1.40 liters per minute. (See Figure 3.) Mean oxygen intake at rest was .464 liters per minute and the multiple of resting oxygen intake when riding was 3.01. His mean heart rate for tee shots was 94.7. The mean heart rate for putting was 99. The score for nine holes of riding was 49, which covered a distance walked of 2.9 miles. This included looking for lost balls, walking on the putting green and to and from the tee. (See Table II and Figures 4, 5, and 6.)

With pull cart: When playing nine holes of golf using the pull cart the subject had a mean heart rate of 94.1 and mean predicted oxygen intake of 1.47 liters per minute. (See Figure 4.) Mean oxygen intake at rest was .464 liters per minute and the multiple of resting oxygen intake when using the pull cart was 3.16. The mean heart rate for the tee shots was 95.3 while the mean for putting was 97.1. The score for nine holes was 52 and the total distance walked was 4.5 miles. (See Table II and Figures 4, 5, and 6.)

TABLE I

SUBJECT NO. I - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade; 3.4 Speed
Average Breaths per/min.	11	11	15
Pulmonary Ventilation L/min.	4.5	13.5	16
Heart Rate	60	72	84
Oxygen Intake L/min.	.464	1.26	1.39

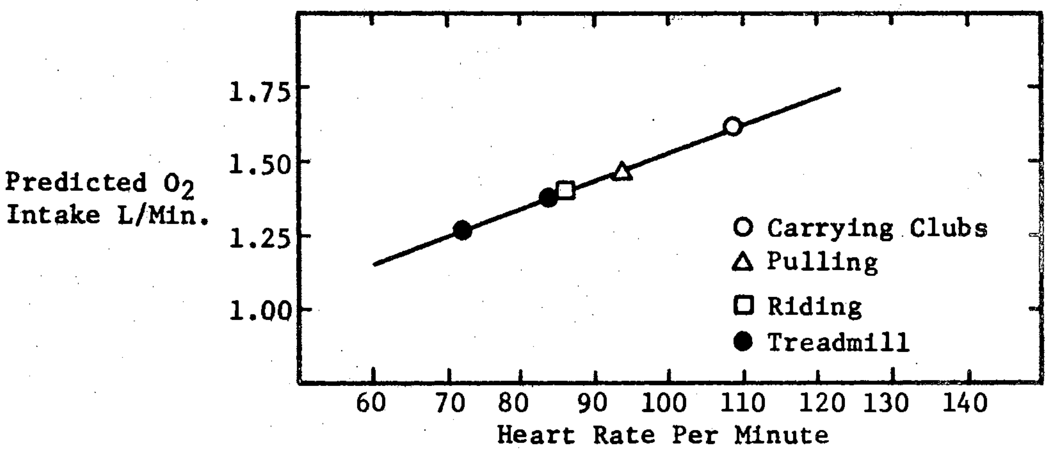

Figure 2. Subject No. I - Predicted Oxygen Intakes

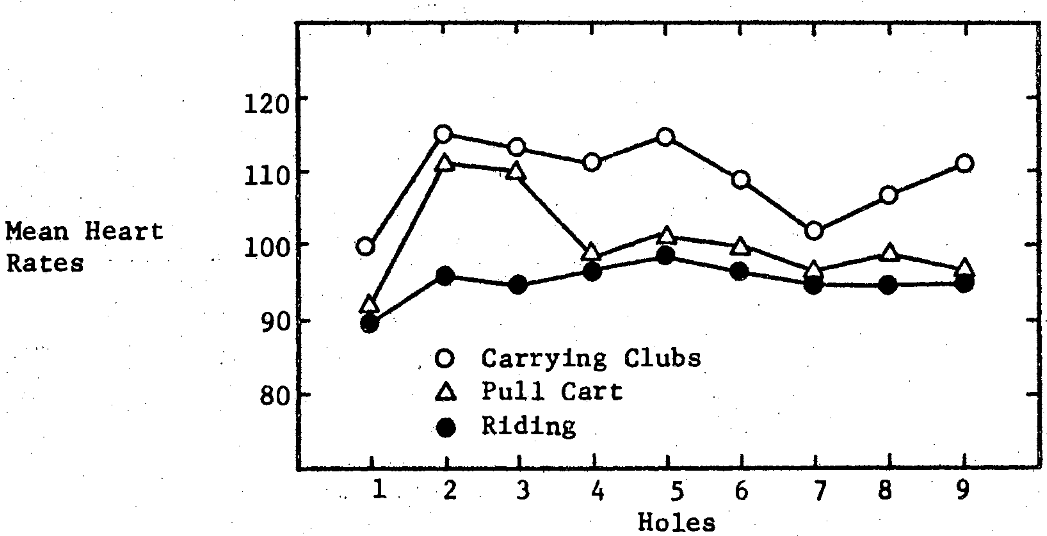

Figure 3. Subject No. I - Mean Heart Rates by Holes

TABLE II

SUBJECT NO. I

Age	54
Height	5 Feet 10½ inches
Weight	178 pounds
Regularity of Golf Participation	2 times weekly
Handicap	20
Weight of Bags and Clubs	30 pounds
Oxygen Intake at Rest	.464 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	86.5	94.1	109.1
Heart Rate Mean during Tee Shots	94.7	95.3	109.6
Heart Rate Mean during Putting	99	97.1	112.3
Total Score	49	52	48
Total Distance Walked (miles)	2.9	4.5	4.2
Mean Predicted Oxygen Intake (L/min)	1.4	1.47	1.63
Multiple of Resting Oxygen Intake	3.01	3.16	3.51

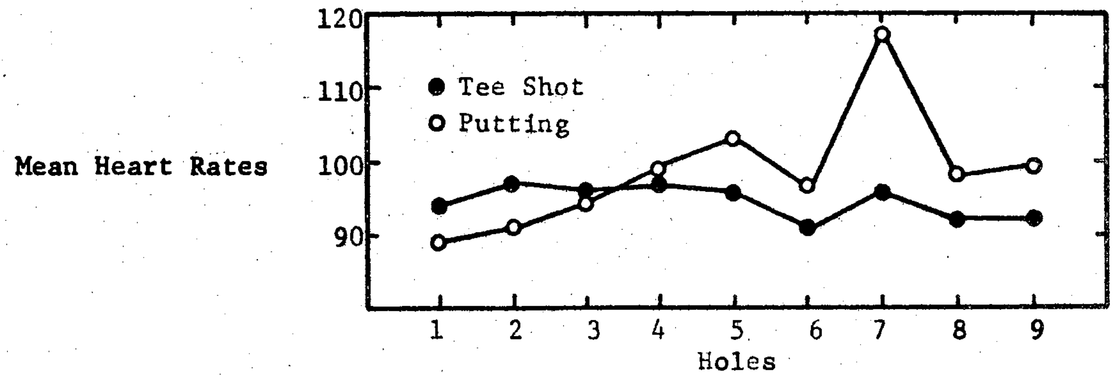

Figure 4. Subject No. I - Heart Rates During Tee Shots and Putting, Riding

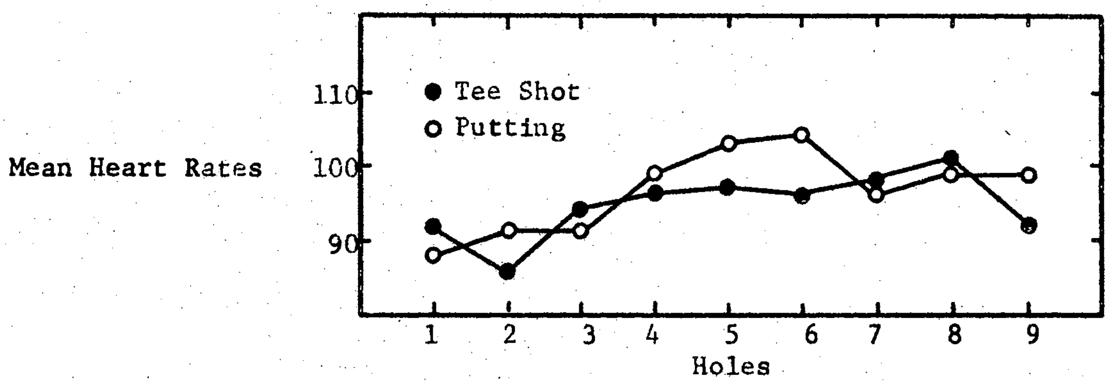

Figure 5. Subject No. I - Heart Rates During Tee Shots and Putting, Using Pull Cart

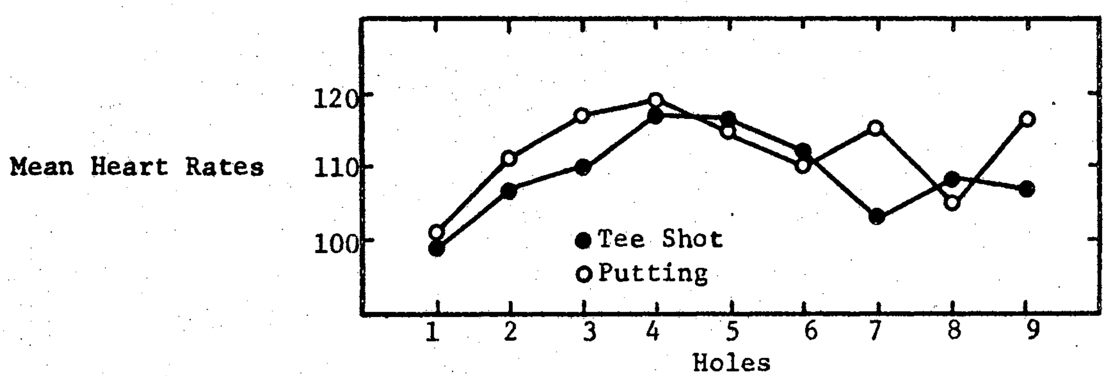

Figure 6. Subject No. I - Heart Rates During Tee Shots and Putting, Carrying Clubs

From the analysis of the results, it was concluded that Subject No. I had the highest heart rates including the tee shots and putting when carrying the clubs. (See Table II and Figures 4, 5, and 6.) Also, he had the lowest score when carrying the clubs. A decrease in total distance walked was probably due to the fact that when carrying the clubs the player is allowed to walk right up to the putting green, lay his bag down and begin putting, whereas using the pull cart the player has to leave the cart, walk to the putting green and then back to the cart before moving to the next tee.

Subject No. II

Relationship of Heart Rate and Oxygen Intake During Treadmill Walking

The subject was allowed a fifteen minute reclining resting period after which he had a resting heart rate of 85.2 and an oxygen intake of .85 liters per minute. His pulmonary ventilation was 6.3 liters per minute and he averaged 14 breaths per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and at a grade of 0% he averaged 19 breaths per minute, his pulmonary ventilation was 20.4 liters per minute and his heart rate was 97 beats per minute. His oxygen intake was 1.205 liters per minute. Following a three minute walk on the treadmill at a speed of 3.4 m.p.h. and at a grade of 2% he had an oxygen intake of 1.3172 liters per minute and a heart rate of 101 beats per minute. Pulmonary ventilation was 22.5 liters per minute and mean breaths per minute were 20. (See Table III and Figures 7 and 8).

TABLE III

SUBJECT NO. II - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade: 3.4 Speed
Average Breaths per/min.	14	1.205	20
Pulmonary Ventilation L/min.	6.3	20.4	22.5
Heart Rate	85.2	97	101
Oxygen Intake L/min.	.85	1.205	1.3172

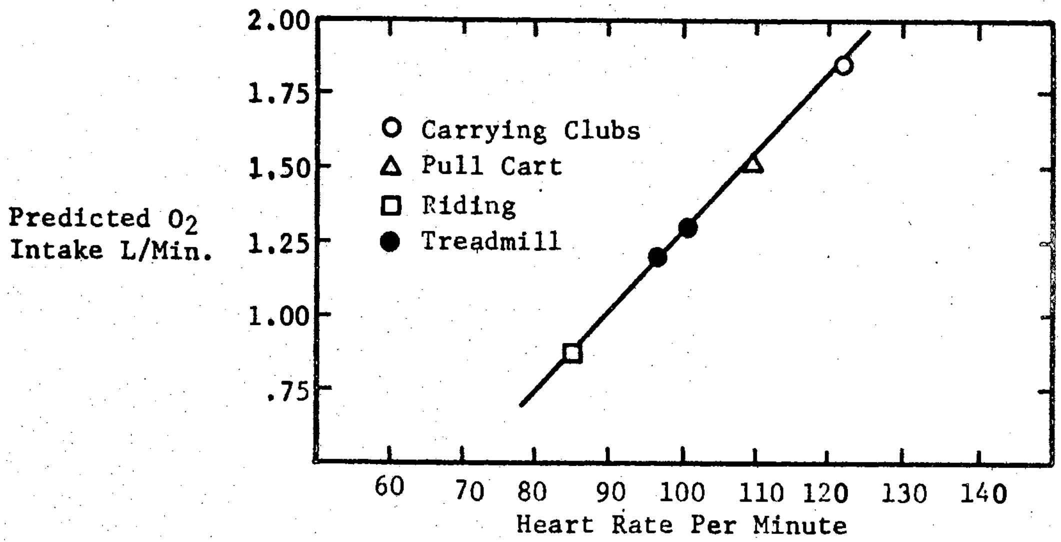

Figure 7. Subject No. II - Predicted Oxygen Intakes

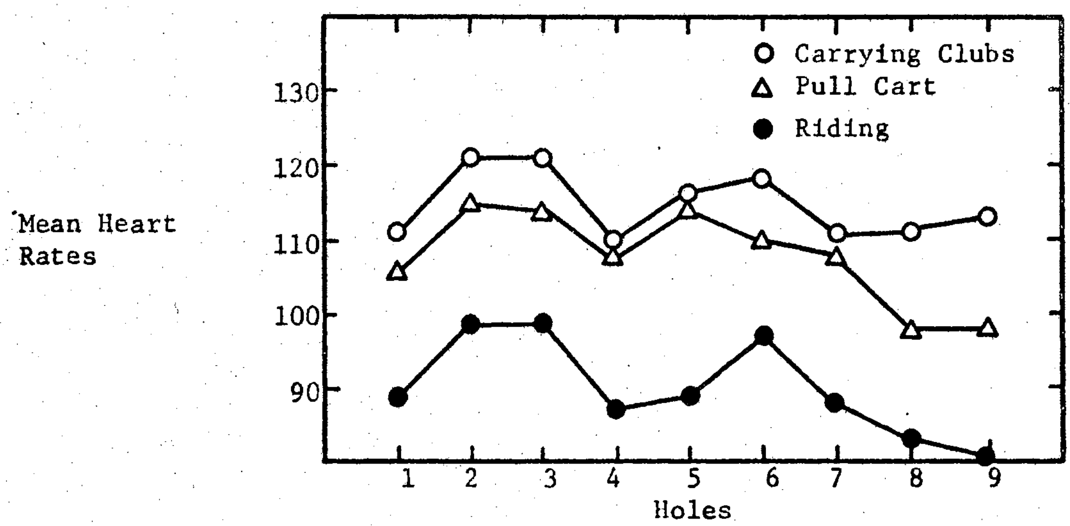

Figure 8. Subject No. II - Mean Heart Rates by Holes

<u>Heart Rates and Predicted Oxygen Intake During Golf Rounds</u>

<u>Riding</u>: During nine holes of golf while riding, Subject No. II had a mean heart rate of 85.3 with a mean predicted oxygen intake of .87 liters per minute. Mean oxygen intake at rest was .85 liters per minute and the multiple of resting oxygen intake when riding was 1.02 liters per minute. His mean heart rate for tee shots was 87.4 and for putting was 90. The score for nine holes of golf while riding was 45 and the subject walked a total distance of 2.3 miles. (See Table IV and Figures 9, 10, and 11.)

<u>With pull cart</u>: The mean heart rate of Subject No. II during the nine holes of golf while pulling the cart was 110.1 with a predicted oxygen intake of 1.53 liters per minute. Mean oxygen intake at rest was .85 liters per minute and the multiple of resting oxygen intake when using a pull cart was 1.80. The mean heart rate for tee shots was 114.1 and for putting was 122. The score for nine holes of golf when using the pull cart was 52 and the subject walked a total distance of 4.2 miles. (See Table IV, Figures No. 9, 10 and 11.)

<u>Carrying clubs</u>: During the nine holes of golf carrying the clubs, the subject had a mean heart rate of 122.8 and a predicted oxygen intake of 1.85 liters per minute. Mean oxygen intake at rest was .85 liters per minute and the multiple of resting oxygen intake when carrying the clubs was 2.17. The mean heart rate for tee shots was 108.6 and for putting was 112.2. The subject's score for nine holes when carrying the clubs was 45 and he walked a total distance of 3.2 miles. (See Table IV and Figures 9, 10, and 11.)

TABLE IV

SUBJECT NO. II

Age	53
Height	6 feet 1½ inches
Weight	180 pounds
Regularity of Golf Participation	2 times weekly
Handicap	17
Weight of Golf Bag and Clubs	20 pounds
Oxygen Intake at Rest	.85 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	85.3	101.1	122.8
Heart Rate Mean during Tee Shots	87.4	114.1	108.6
Heart Rate Mean during Putting	90	122	112.2
Total Score	45	52	45
Total Distance Walked (miles)	2.3	4.2	3.2
Mean Predicted Oxygen Intake (L/min)	.87	1.53	1.85
Multiple of Resting Oxygen Intake	1.02	1.80	2.17

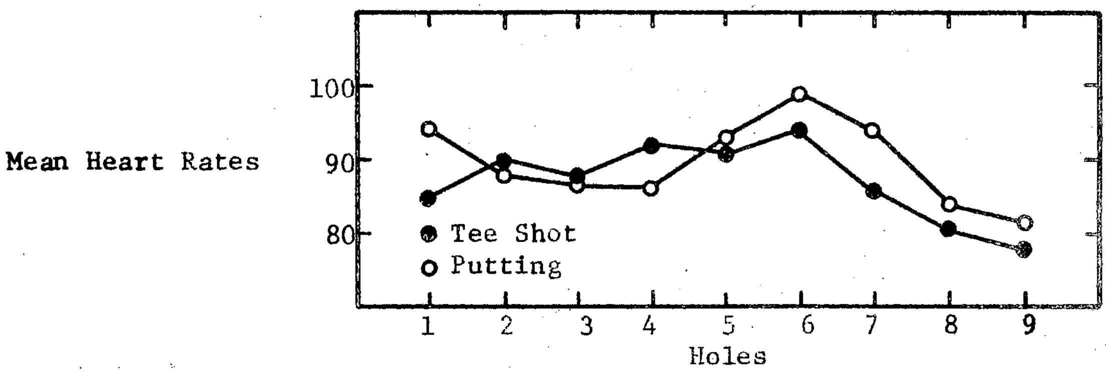

Figure 9. Subject No. II - Heart Rates During Tee Shots and Putting, Riding

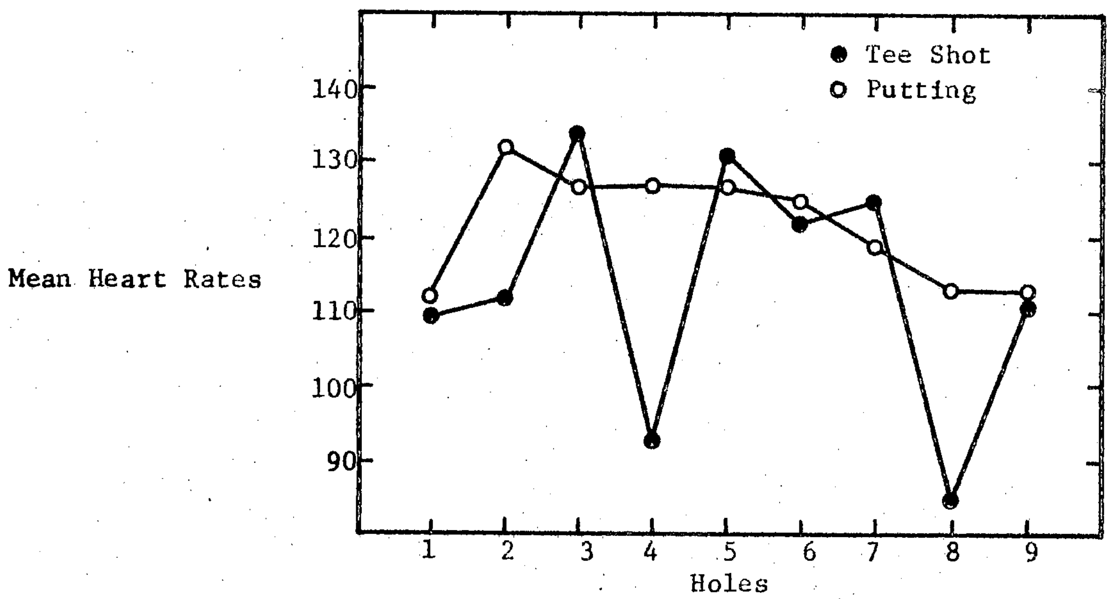

Figure 10. Subject No. II - Heart Rates During Tee Shots and Putting, Using Pull Cart

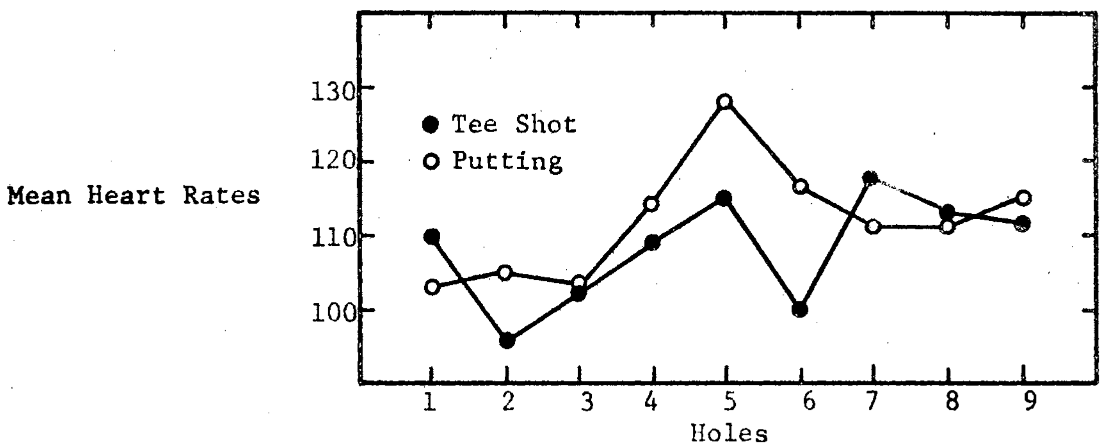

Figure 11. Subject No. II - Heart Rates During Tee Shots and Putting, Carrying Clubs

From the analysis of the results with regard to Subject No. II, it was concluded that the highest heart rate occurred when carrying the clubs. The lowest heart rate occurred when riding and highest score when using the pull cart. The lowest score was obtained when riding and carrying the clubs. The greatest distance walked occurred when the subject was using the pull cart.

Subject No. III

Relationship of Heart Rate to Oxygen Intake During Treadmill Walking

A fifteen minute reclining rest period was allowed the subject upon his arrival to the physiology laboratory. After this resting period the subject had a resting heart rate of 78 and a resting oxygen intake of .299 liters per minute. Pulmonary ventilation was 6.3 liters per minute while resting and he averaged 15 breaths per minute. Following a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0% he averaged 21 breaths per minute, his pulmonary ventilation was 10.4 liters per minute, and his heart rate was 121 beats per minute. His oxygen intake was .929 liters per minute. After a three minute walk on the treadmill at the speed of 3.4 m.p.h. and a grade of 2% he had an oxygen intake of 1.18 liters per minute and a heart rate of 139 per minute. Pulmonary ventilation was 17.1 liters per minute and he averaged 21 breaths per minute. (See Table V and Figure 12.)

Heart Rates and Predicted Oxygen Intake During Golf Rounds

Riding: After playing nine holes of golf while riding, the subject had a mean heart rate of 89.4 and a mean predicted oxygen intake of .52

TABLE V

SUBJECT NO. III - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade: 3.4 Speed
Average Breaths per/min.	15	21	21
Pulmonary Ventilation L/min.	6.3	10.4	17.1
Heart Rate	78	121	139
Oxygen Intake L/min.	.299	.929	1.18

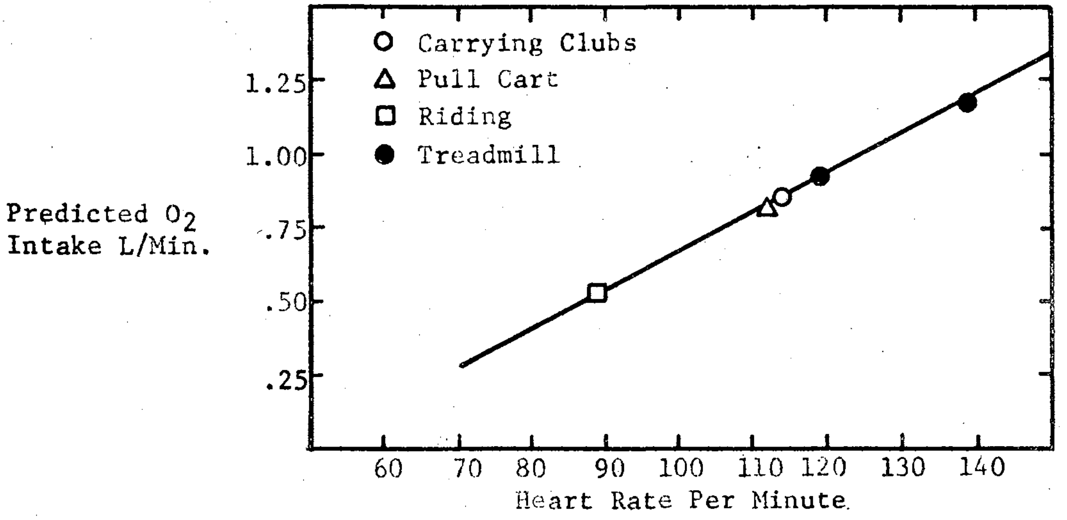

Figure 12. Subject III - Predicted Oxygen Intakes

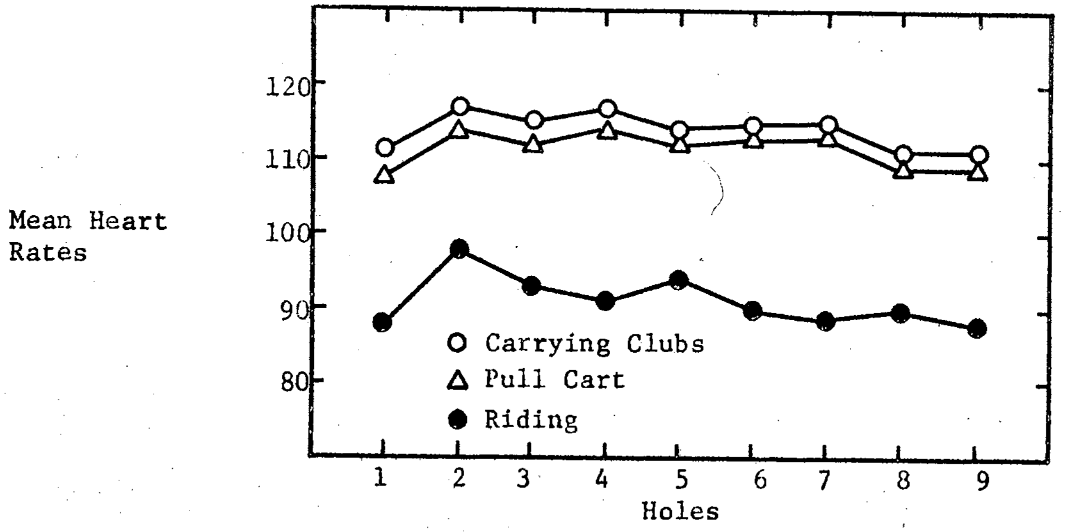

Figure 13. Subject No. III - Mean Heart Rates by Holes

liters per minute. Mean oxygen intake at rest was .299 liters per minute and the multiple of resting oxygen intake when riding was 1.77 liters per minute. His mean heart rate for tee shots was 89.1 while his mean heart rate for putting was 92. The score for nine holes of golf while riding was 42, and the total distance walked was 2.1 miles. (See Table VI and Figures 14, 15, and 16.)

With pull cart: During the nine holes of golf when using a pull cart, the subject had a mean heart rate of 11.8 with a predicted oxygen intake of .83 liters per minute. Mean oxygen intake at rest was .299 liters per minute and the multiple of resting oxygen intake when using the pull cart was 2.77. The mean heart rate for tee shots during the nine holes was 114.1 and for putting it was 115.4. Subject III had a total score of 42 when using the pull cart and he walked a distance of 5.4 miles. (See Table VI and Figures 14, 15 and 16.)

Carrying clubs: After the nine holes of golf when carrying the clubs, the subject had a mean heart rate of 112.8 and a predicted oxygen intake of .85 liters per minute. Mean oxygen intake at rest was .299 liters per minute and the multiple of resting oxygen intake when carrying the clubs was 2.84. His mean heart rate for tee shots was 112.3 and for putting was 120. The total score for Subject No. III after nine holes when carrying the clubs was 36 and he walked a total distance of 4.5 miles. (See Table VI and Figures 14, 15 and 16.)

Analysis of the data of Subject No. III indicates that the highest heart rate occurred during putting when the subject was carrying the

TABLE VI

SUBJECT NO. III

Age 40

Height . . . . 5 feet 10 inches

Weight . . . . 140 pounds

Regularity of Golf Participation . . . . 2 times weekly

Handicap 11

Weight of Golf Bag and Clubs . . . . 27 pounds

Oxygen Intake at Rest . . . . .299 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	89.4	111.8	112.8
Heart Rate Mean during Tee Shots	89.1	114.1	112.3
Heart Rate Mean during Putting	92	115.4	120
Total Score	42	42	36
Total Distance Walked (miles)	2.1	5.4	4.5
Mean Predicted Oxygen Intake (L/min)	.53	.83	.85
Multiple of Resting Oxygen Intake	1.77	2.77	2.84

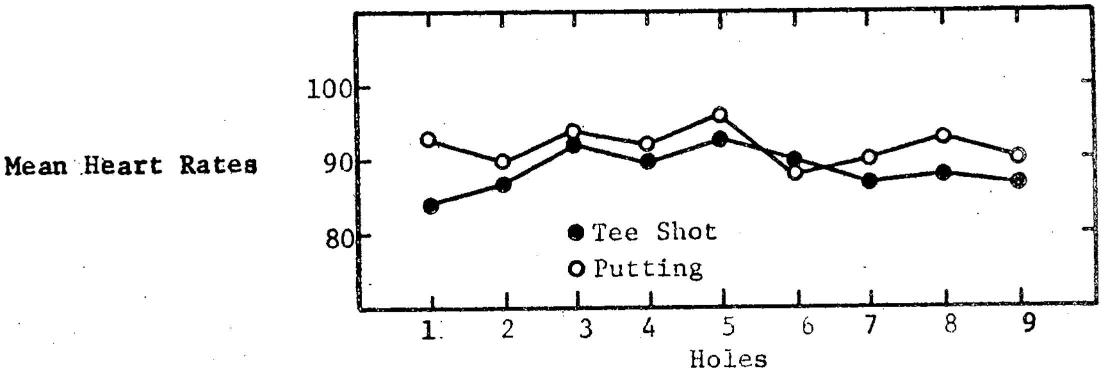

Figure 14. Subject No. III - Heart Rates During Tee Shots and Putting, Riding

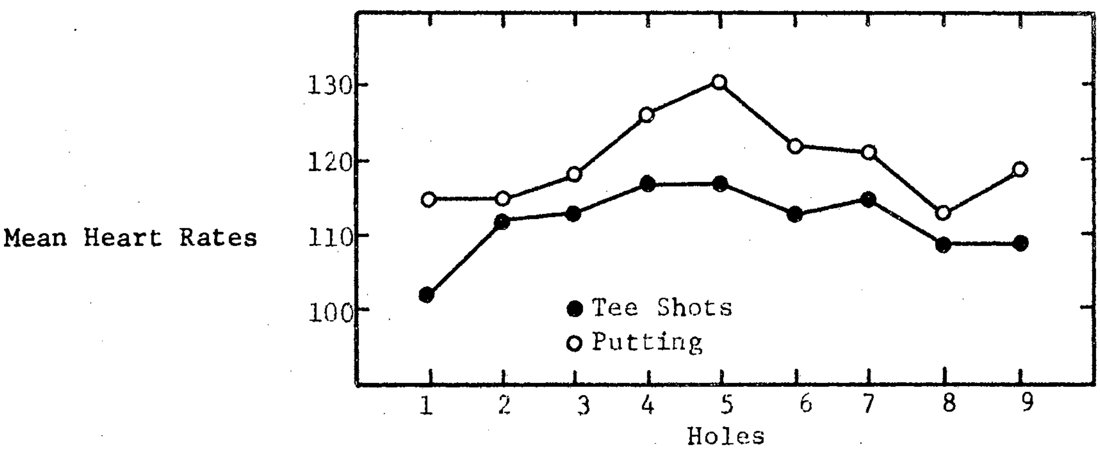

Figure 15. Subject No. III - Heart Rates During Tee Shots and Putting, Using Pull Cart

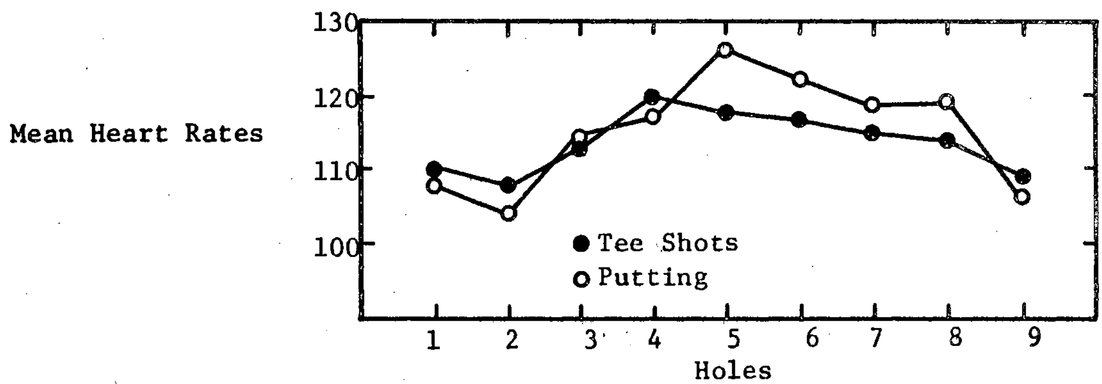

Figure 16. Subject No. III - Heart Rates During Tee Shots and Putting, Carrying Clubs

clubs. The lowest score occurred (36) when carrying the clubs, and the greatest distance walked (5.4 miles) occurred when using the pull cart.

Subject IV

Relationship of Heart Rate to Oxygen Intake During Treadmill Walking

When Subject No. IV reported to the physiology laboratory he was allowed a fifteen minute reclining rest period. His resting heart rate was 66 and his oxygen intake was .474 liters per minute. Resting pulmonary ventilation was 6.2 liters per minute and he averaged 16.2 breaths per minute. Following a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0%, he averaged 17 breaths per minute, his pulmonary ventilation was 13.5 liters per minute and his heart rate was 102 beats per minute. His oxygen intake was 1.19 liters per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 2%, he had an oxygen intake of 1.50 liters per minute and a mean heart rate of 109. Pulmonary ventilation was 14.5 liters per minute and he averaged 20 breaths per minute. (See Table VII and Figure 17.)

Heart Rate and Predicted Oxygen Intake During Golf Rounds

Riding: During nine holes of golf when riding, the subject had a mean heart rate of 88.1 and a mean predicted oxygen intake of 1.33 liters per minute. His oxygen intake at rest was .474 liters per minute and the multiple of resting oxygen intake when riding was 2.80 liters per minute. His mean heart rate for the nine holes while riding for tee shots was 85.3 and for putting was 86. His total score for the nine

TABLE VII

SUBJECT NO. IV - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade: 3.4 Speed
Average Breaths per/min.	16.2	17	20
Pulmonary Ventilation L/min.	6.2	13.5	14.5
Heart Rate	66	102	109
Oxygen Intake L/min.	.474	1.19	1.50

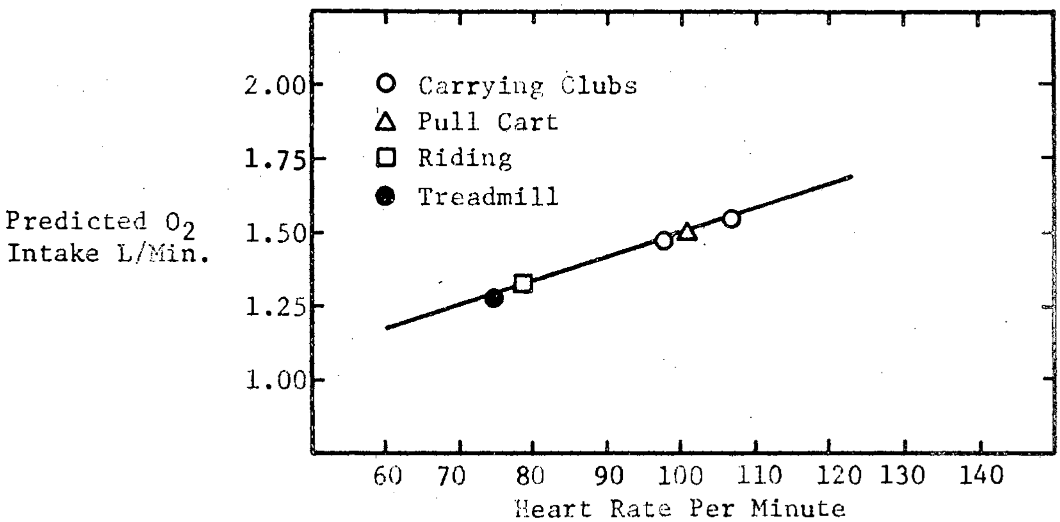

Figure 17. Subject No. IV - Predicted Oxygen Intakes

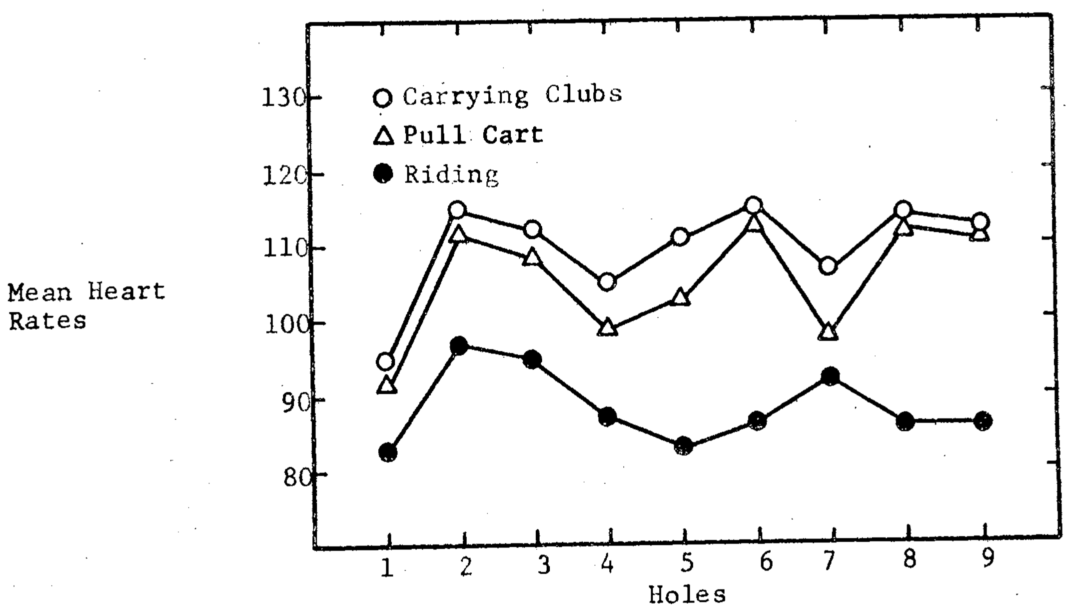

Figure 18. Subject No. IV - **Mean Heart Rates by Holes**

holes was 41 and he walked a total distance of 2.2 miles. (See Table VIII and Figures 19, 20 and 21.)

<u>With pull cart</u>: When playing nine holes of golf using the pull cart, Subject No. IV Had a mean heart rate of 98 with a mean predicted oxygen intake of 1.52 liters per minute. Mean oxygen intake at rest was .474 liters per minute and the multiple of resting oxygen intake when using a pull cart was 3.20. His mean heart rate for tee shots during the nine holes was 101.8 and for putting was 107.5. His total score was 42 and he walked a total distance of 4.4 miles. (See Table VIII and Figures 19, 20 and 21.)

<u>Carrying clubs</u>: During nine holes of golf when carrying the clubs the subject had a mean heart rate of 122.6 with a mean predicted oxygen intake of 1.55. Mean oxygen intake at rest was .474 liters per minute and multiple of resting oxygen intake when carrying the clubs was 3.27. His mean heart rate during the nine holes while carrying the clubs for tee shots was 104.7 and for putting was 107.5. His total score was 41 and he walked a total distance of 4.1 miles. (See Table VIII and Figures 19, 20 and 21.)

Analysis of the data of Subject No. IV indicated that the highest heart rate (122.6) occurred while carrying the clubs, also the greatest mean predicted oxygen intake (1.55) occurred when carrying the clubs. The lowest score occurred when riding and carrying the clubs (41). The greatest distance walked occurred when using the pull cart (4.4 miles).

TABLE VIII

SUBJECT NO. IV

Age 40

Height . . . . 5 feet 8 inches

Weight . . . . 150 pounds

Regularity of Golf Participation . . . . 2 times weekly

Handicap 11

Weight of Gold Bag and Clubs . . . . 18 pounds

Oxygen Intake at Rest .447 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	88.1	98	122.6
Heart Rate Mean during Tee Shots	85.3	101.8	104.7
Heart Rate Mean during Putting	86	107.5	107.5
Total Score	41	42	41
Total Distance Walked (miles)	2.2	4.4	4.1
Mean Predicted Oxygen Intake (L/min.)	1.33	1.52	1.55
Multiple of Resting Oxygen Intake	2.80	3.20	3.27

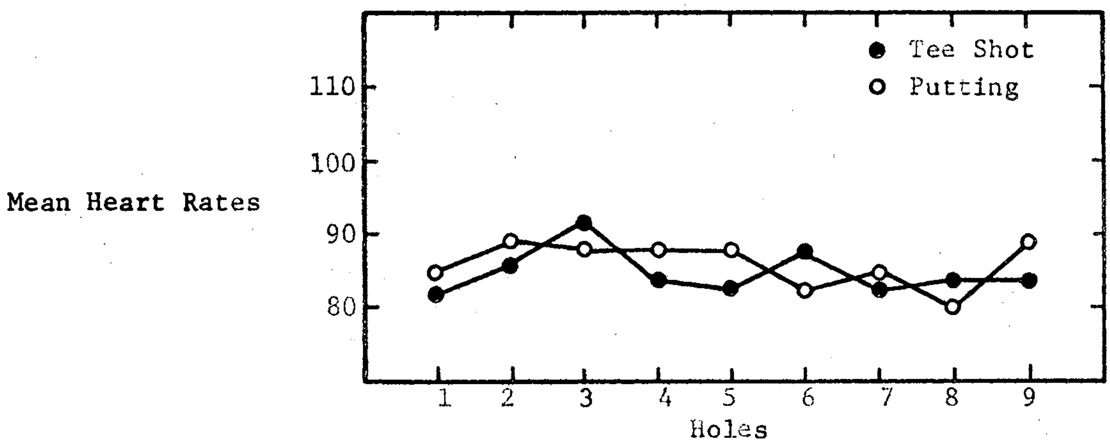

Figure 19. **Subject No. IV - Heart Rates During Tee Shots and Putting, Riding**

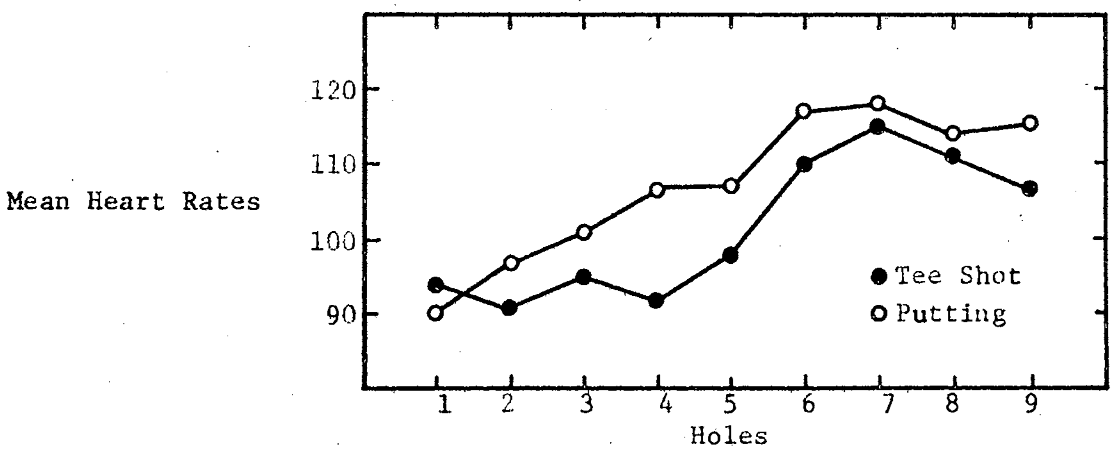

Figure 20. **Subject No. IV - Heart Rates During Tee Shots and Putting, Using Pull Cart**

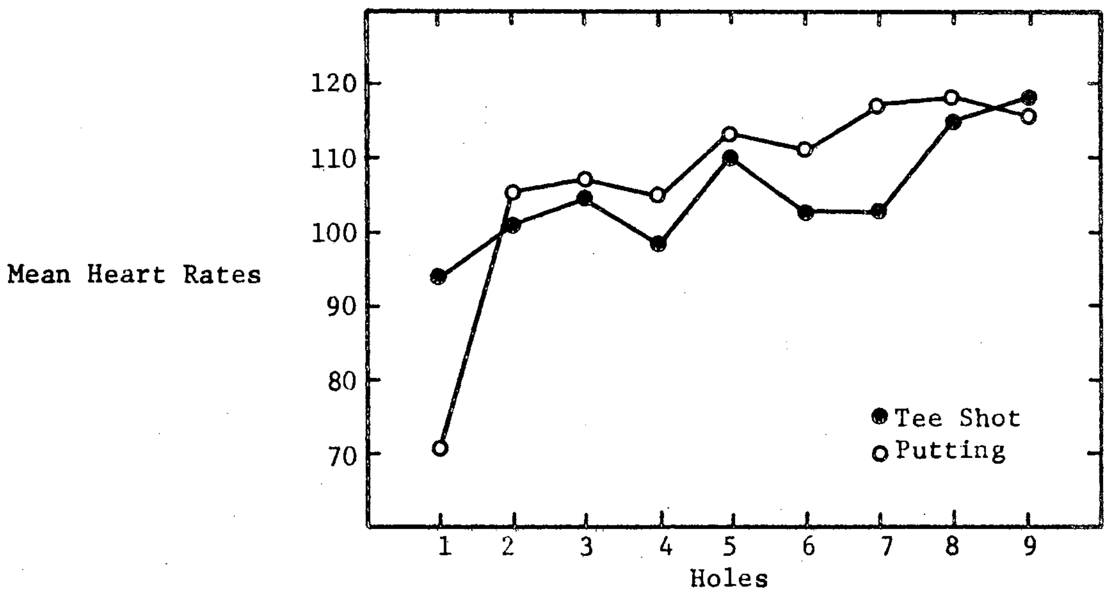

Figure 21. Subject No. IV - Heart Rates During Tee Shots and Putting, Carrying Clubs

Subject V

Relationship of Heart Rate to Oxygen Intake During Treadmill Walking

When the subject arrived at the physiology laboratory he was allowed a fifteen minute reclining rest period. At this time he had a resting heart rate of 66 and an oxygen intake of .628 liters per minute. His pulmonary ventilation was 6.7 liters per minute and he averaged 15 breaths per minute. Following a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0% subject No. V averaged 17 breaths per minute, his pulmonary ventilation was 15 liters per minute and his heart rate was 75 beats per minute. His oxygen intake was 1.28 liters per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 2% he had a heart rate of 98 with an oxygen intake of 1.48 liters per minute. His pulmonary ventilation was 17.2 liters per minute and he averaged 19 breaths per minute. (See Table IX and Figure 22.)

Heart Rates and Predicted Oxygen Intake During Golf Rounds

Riding: At the conclusion of nine holes of golf when riding, the subject had a mean heart rate of 79.3 and a mean predicted oxygen intake of 1.28 liters per minute. Mean oxygen intake at rest was .628 liters per minute and the multiple of resting oxygen intake when riding was 2.03 liters per minute. Mean heart rates for tee shots and putting were 78.2 and 80.5. The total score was 34 and the subject walked 1.1 miles. (See Table X and Figures 24, 25 and 26.)

TABLE IX

SUBJECT NO. V - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade: 3.4 Speed
Average Breaths per/min.	15	17	19
Pulmonary Ventilation L/min.	6.7	15	17.2
Heart Rate	66	75	98
Oxygen Intake L/min.	.628	1.28	1.48

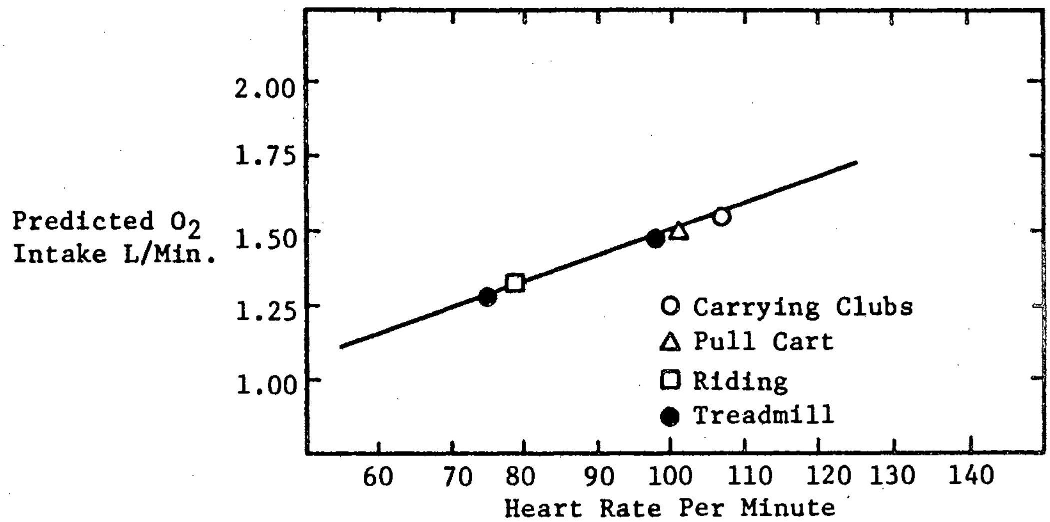

Figure 22. Subject No. V - Predicted Oxygen Intakes

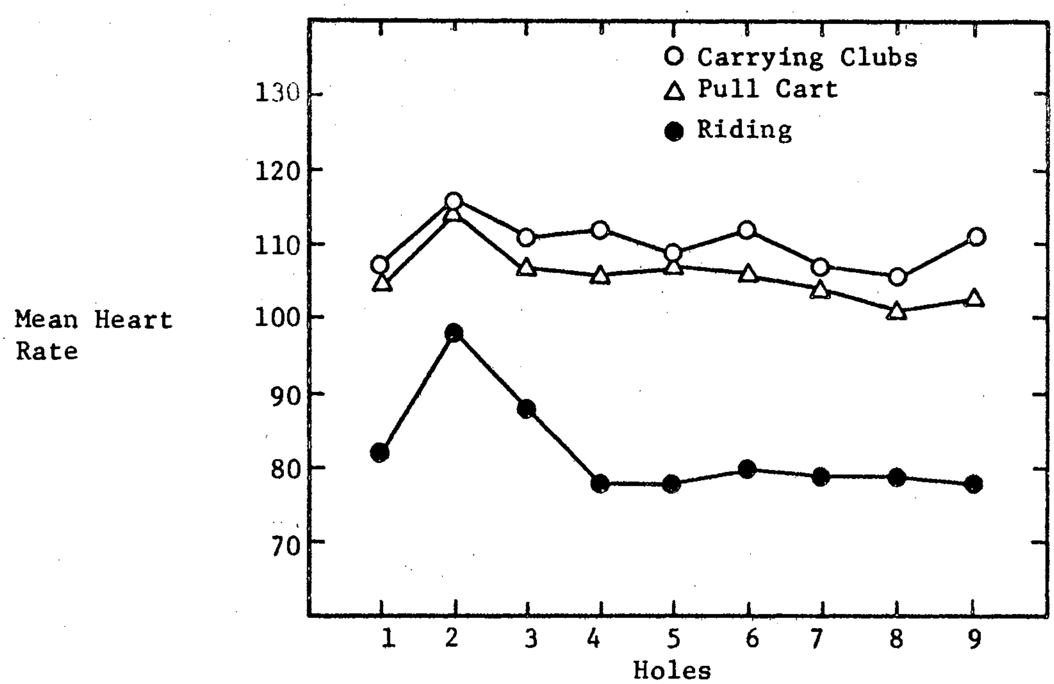

Figure 23. Subject No. V - Mean Heart Rates by Holes

TABLE X

SUBJECT NO. V

Age	48
Height	6 feet 0 inches
Weight	200 pounds
Regularity of Golf Participation	2 times weekly
Handicap	2
Weight of Golf Bag and Clubs	30 pounds
Oxygen Intake at Rest	.628 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	79.3	101.2	107.5
Heart Rate Mean during Tee Shotts	78.2	103.9	104.1
Heart Rate Mean during Putting	80.5	105.2	109.8
Total Score	34	38	35
Total Distance Walked (miles)	1.1	4.8	4
Mean Predicted Oxygen Intake (L/min.)	1.28	1.50	1.55
Multiple of Resting Oxygen Intake	2.03	2.38	2.46

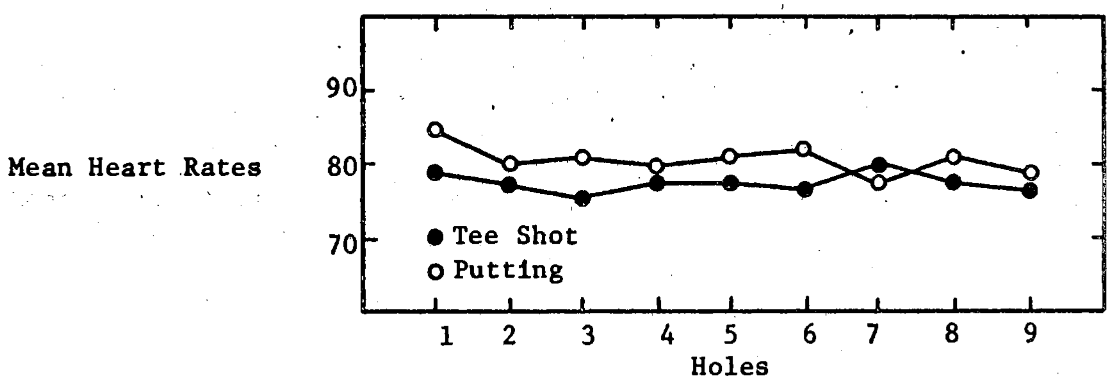

Figure 24. Subject No. V - Heart Rates During Tee Shots and Putting, Riding

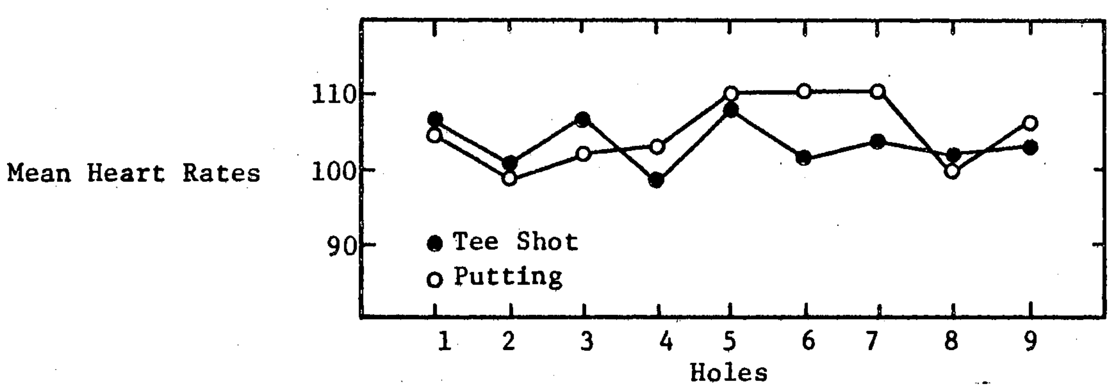

Figure 25. Subject No. V - Heart Rates During Tee Shots and Putting, Using Pull Cart

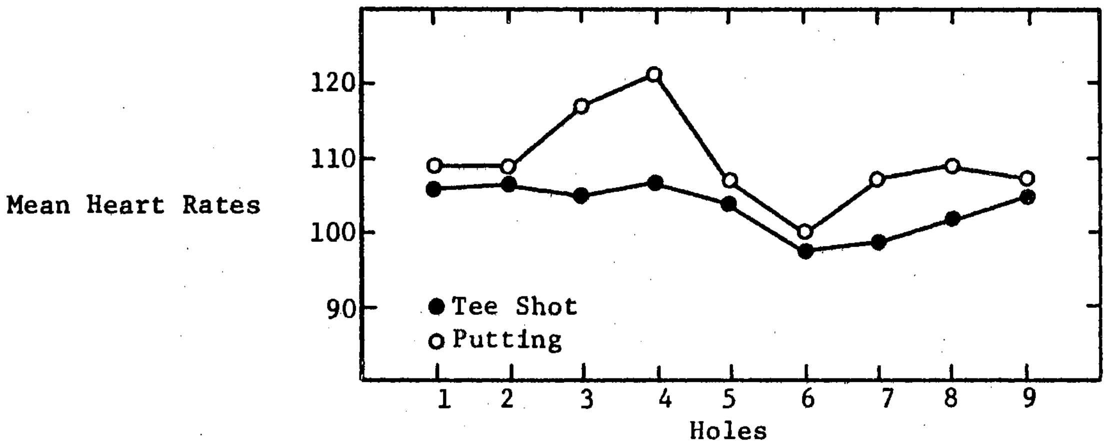

Figure 26. Subject No. V - Heart Rates During Tee Shots and Putting, Carrying Clubs

With pull cart: After nine holes of golf when using the pull cart, Subject No. V had a mean heart rate of 101.2 and a mean predicted oxygen intake of 1.50 liters per minute. Mean oxygen intake at rest was .628 liters per minute and the multiple of resting oxygen intake when using the pull cart was 2.38. For tee shots and putting he had a mean heart rate of 103.9 and 105.2. His total score was 38 and he walked a total distance of 4.8 miles. (See Table X and Figures 24, 25 and 26.)

Carrying clubs: When Subject No. V concluded nine holes of golf while carrying his clubs he had a mean heart rate of 107.5 and a mean predicted oxygen intake of 1.55 liters per minute. Mean oxygen intake at rest was .628 liters and the multiple of resting oxygen intake when carrying the clubs was 2.46. His mean heart rate for tee shots was 104.1 and for putting was 109.8. His total score was 35 and he walked a total distance of 4 miles. (See Table X and Figures 24, 25 and 26.)

Analysis of the data of Subject No. V indicates that the highest mean heart rate occurred when carrying the clubs as well as the highest mean predicted oxygen intake. The lowest score occurred when riding and the greatest distance walked occurred when using the pull cart.

Subject VI

Relationship of Heart Rate to Oxygen Intake During Treadmill Walking

The subject was allowed a fifteen minute reclining resting period upon his arrival to the physiology laboratory. Subject No. VI had a resting heart rate of 73 and a resting oxygen intake of .410 liters per minute. His pulmonary ventilation was 8.66 liters per minute and he averaged 20 breaths per minute. Following a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0% he averaged 20 breaths per minute, his pulmonary ventilation was 24 liters per minute and his heart rate was 90 beats per minute. His oxygen intake was 1.056 liters per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 2% the subject had a heart rate of 105 and an oxygen intake of 1.496 liters per minute. His pulmonary ventilation was 24.33 and he averaged 21 breaths per minute. (See Table XI and Figure 27.)

Heart Rates and Predicted Oxygen Intake During Golf Rounds

Riding: During nine holes of golf when riding, the subject had a mean heart rate of 114 and a mean predicted oxygen intake of 1.73 liters per minute. Mean oxygen intake at rest was .410 liters per minute and the multiple of resting oxygen intake when riding was 4.21. His mean heart rate for tee shots for the nine holes was 116.6 and for putting was 123.3. His total score was 33 and he walked a total distance of 1.1 miles. (See Table XII and Figures 29, 30 and 31.)

With pull cart: When using the pull cart for nine holes the subject had a mean heart rate of 116.3 and a mean predicted oxygen intake of 1.80 liters per minute. Mean oxygen intake at rest was .410 liters per minute and the multiple of resting oxygen intake when using a pull cart was 4.39. His mean heart rate for tee shots during the nine holes was 119.3 and for putting 120.9. He had a total score of 34 and walked a total distance of 4 miles. (See Table XII and Figures 29, 30 and 31.)

TABLE XI

SUBJECT NO. VI - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade: 3.4 Speed
Average Breaths per/min.	20	20	21
Pulmonary Ventilation L/min.	8.66	24.0	24.33
Heart Rate	73	90	105
Oxygen Intake L/min.	.410	1.056	1.496

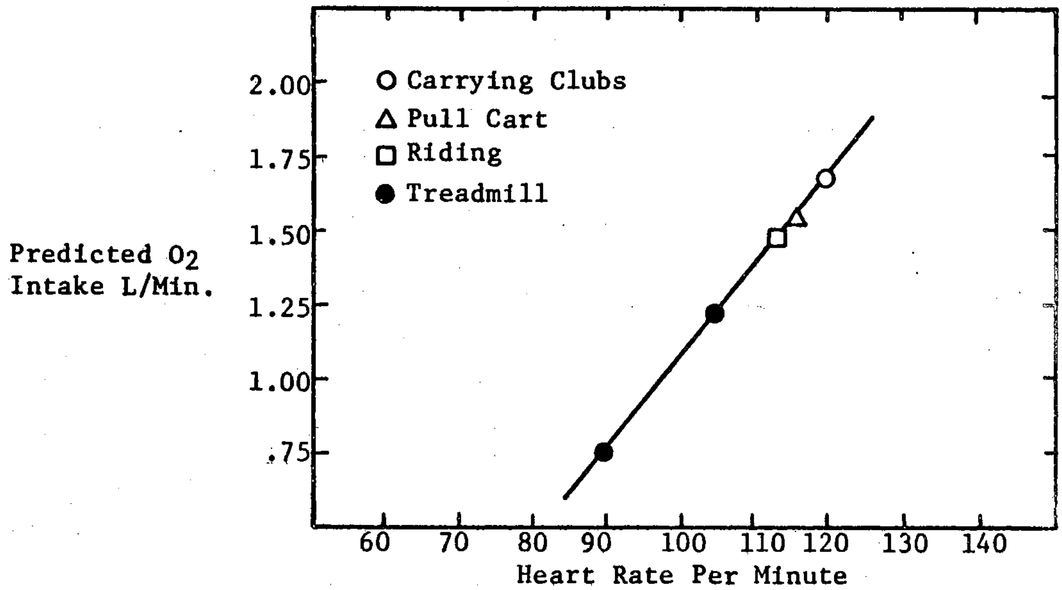

Figure 27. Subject No. VI - Predicted Oxygen Intakes

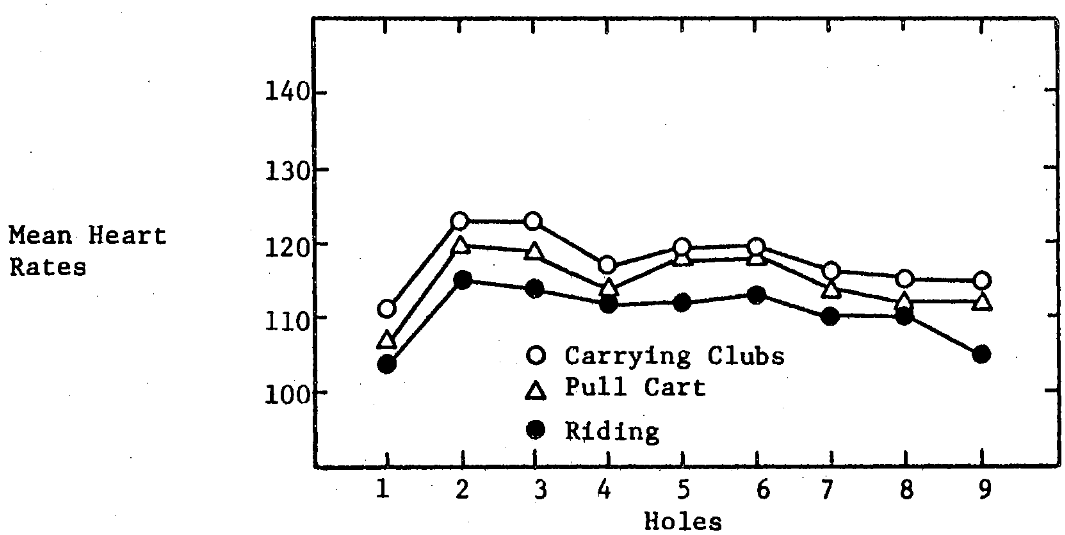

Figure 28. Subject No. VI - Mean Heart Rates by Holes

TABLE XII

SUBJECT NO. VI

Age 32

Height . . . . 6 feet 0 inches

Weight . . . . 190 pounds

Regularity of Golf Participation . . . . No definite schedule

Handicap 0

Weight of Golf Bags and Clubs . . . . 27.5 pounds

Oxygen Intake at Rest .410 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	114.0	116.3	120.5
Heart Rate Mean during Tee Shots	116.6	119.3	111.3
Heart Rate Mean during Putting	123.3	120.9	123.8
Total Score	33	34	37
Total Distance Walked (miles)	1.1	4	3.8
Mean Predicted Oxygen Intake (L/min.)	1.73	1.80	1.95
Multiple of Resting Oxygen Intake	4.21	4.39	4.75

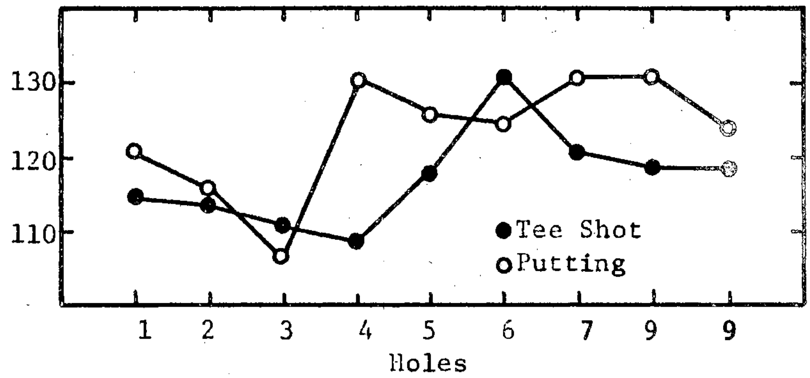

Figure 29. Subject No. VI - Heart Rates During Tee Shots and Putting, Riding

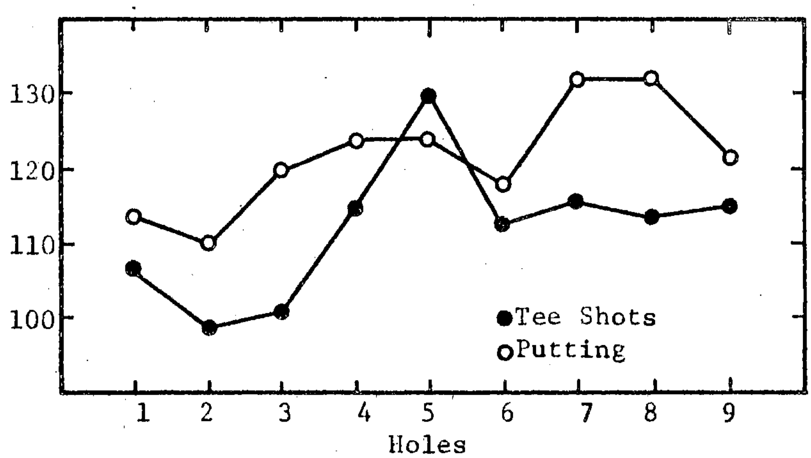

Figure 30. Subject No. VI - Heart Rates During Tee Shots and Putting, Using Pull Cart

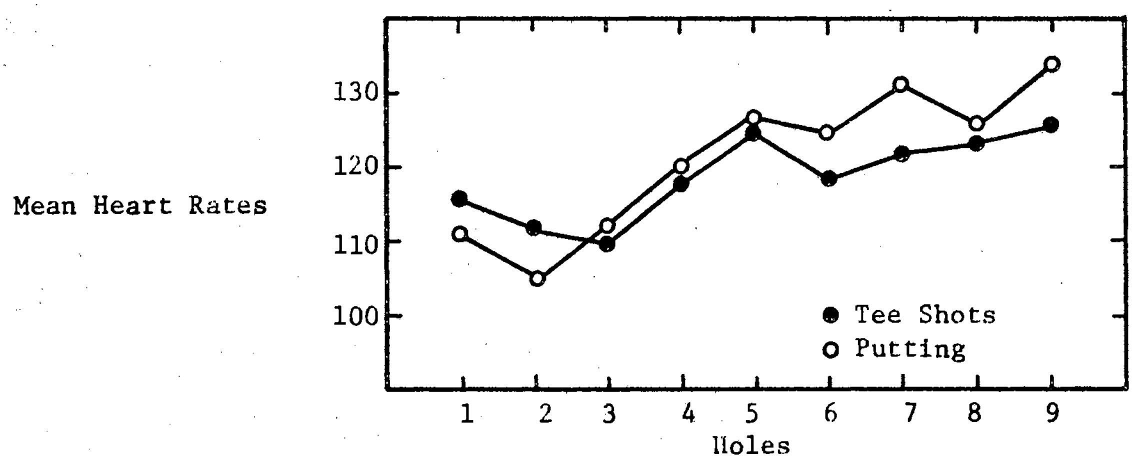

Figure 31. Subject No. VI - Heart Rates During Tee Shots and Putting, Carrying Clubs

Carrying clubs: During nine holes of golf when carrying the clubs, the subject had a mean heart rate of 120.5 and a mean predicted oxygen intake of 1.95 liters per minute. Mean oxygen intake at rest was .410 and the multiple of resting oxygen intake when carrying the clubs was 4.75 liters per minute. His mean heart rate for tee shots for the nine holes was 111.3 and for putting was 123.8. His total score was 37 and he walked a total distance of 3.8 miles. (See Table XII and Figures 29, 30 and 31.)

Analysis of the data of Subject No. VI concludes that the highest heart rate (122.3) occurred during putting and when carrying the clubs. Also, the largest mean predicted oxygen intake occurred when carrying the clubs. The lowest score occurred when riding as well as the lowest mean heart rate and the greatest distance walked (3.8 miles) occurred when using the pull cart.

Subject VII

Relationship of Heart Rate to Oxygen Intake During Treadmill Walking

A fifteen minute reclining resting period was allowed the subject upon his arrival at the physiology laboratory. His resting heart rate was 55 and oxygen intake was .385 liters per minute. His pulmonary ventilation was 3.64 liters per minute and average breaths per minute were 5.2. Following a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0% he averaged 6.1 breaths per minute, his pulmonary ventilation was 8.55 liters per minute and his heart rate was 80 beats per minute. His oxygen intake was .85 liters per minute. After a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 2% he had a mean heart rate of 91 and an oxygen intake of 1.02 liters per minute. He averaged 9 breaths per minute. (See Table XIII and Figure 32.)

Heart Rate and Predicted Oxygen Intake During Golf Rounds

Riding: During nine holes of golf when riding, the subject had a mean heart rate of 82 and a mean predicted oxygen intake of .85 liters per minute. Mean oxygen intake at rest was .385 liters per minute and the multiple of resting oxygen intake when riding was 2.20. His mean heart rate for tee shots was 81.6 and for putting was 82.5. His total score was 47 and he walked a total distance of 2.2 miles. (See Table XIV and Figures 34, 35 and 36.)

With pull cart: During nine holes of golf, using the pull cart, Subject No. VII had a mean heart rate of 89.6 and a mean predicted oxygen intake of 1.00 liters per minute. Mean oxygen intake at rest was .385 liters per minute and the multiple of resting oxygen intake when using a pull cart was 2.59. His mean heart rate for tee shots was 89.1 and for putting was 94.3. His total score was 46 and he walked a total distance of 4.8 miles for the nine holes. (See Table XIV and Figures 34, 35 and 36.)

Carrying clubs: During nine holes of golf, carrying the clubs, Subject No. VII had a mean heart rate of 96.9 and a predicted oxygen intake of 1.13 liters per minute. Mean oxygen intake at rest was .385 liters per minute and the multiple resting oxygen intake when carrying the clubs was 2.93. His mean heart rate for tee shots was 94.3 and for putting was 98.5. His score for the nine holes was 49 and he walked

TABLE XIII

SUBJECT No. VII - RELATIONSHIP OF HEART RATE TO OXYGEN INTAKE DURING TREADMILL WALKING

	Resting	Treadmill 0% Grade: 3.4 Speed	Treadmill 2% Grade: 3.4 Speed
Average Breaths per/min.	5.2	6.1	9
Pulmonary Ventilation L/min.	3.64	8.55	12.35
Heart Rate	55	80	91
Oxygen Intake L/min.	.385	.84	1.02

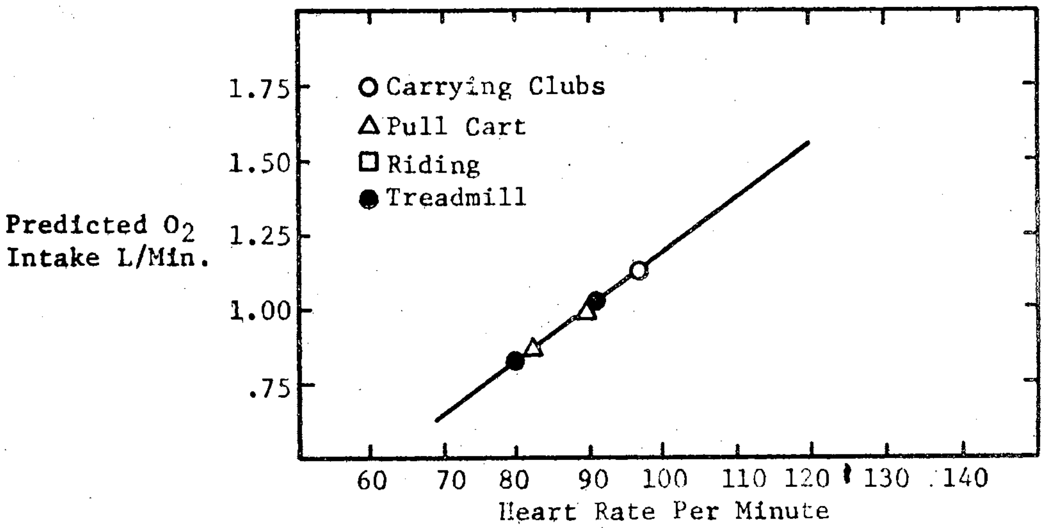

Figure 32. Subject No. VII - Predicted Oxygen Intake

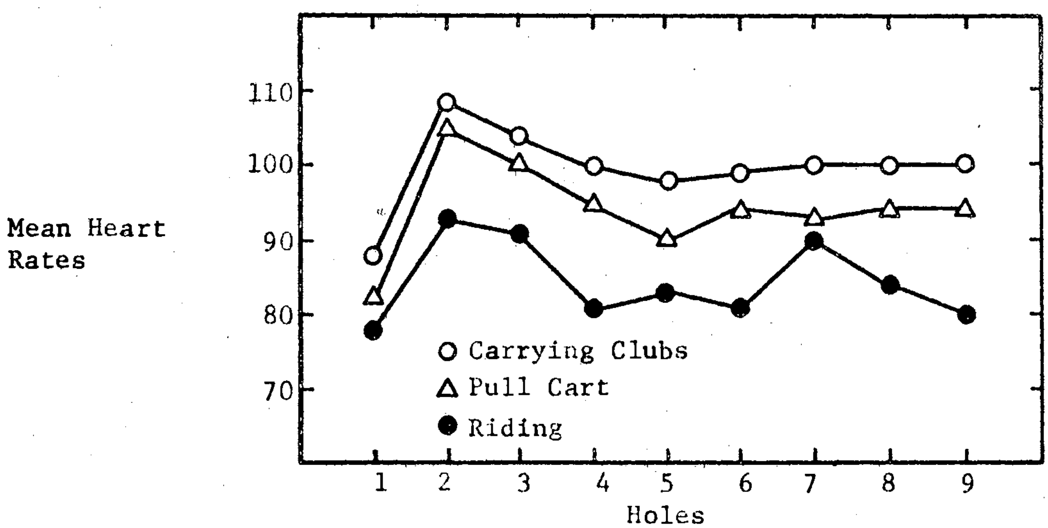

Figure 33. Subject No. VII - Mean Heart Rates By Holes

TABLE XIV

SUBJECT NO. VII

Age	32
Height	5 feet 7 inches
Weight	155 pounds
Regularity of Golf Participation	2 times weekly
Handicap	20
Weight of Golf Bag and Clubs	18 pounds
Oxygen Intake at Rest	.385 L/min.

	Riding	With Pull Cart	Carrying Clubs
Heart Rate Mean during 9 holes	82	89.6	96.9
Heart Rate Mean during Tee Shots	81.6	89.1	98.3
Heart Rate Mean during Putting	82.5	94.3	98.5
Total Score	47	46	49
Total Distance Walked (miles)	2.2	4.8	4.4
Mean Predicted Oxygen Intake (L/min.)	.85	1.00	1.13
Multiple of Resting Oxygen Intake	2.20	2.59	2.93

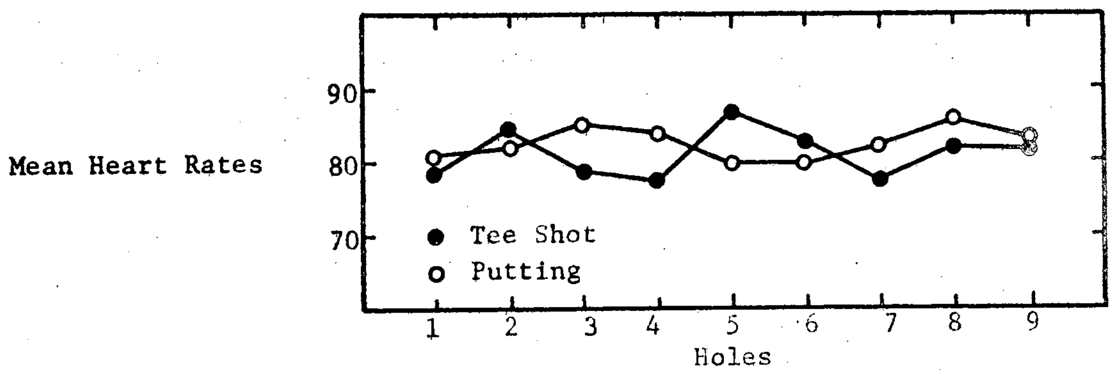

Figure 34. Subject No. VII - Heart Rates During Tee Shots and Putting, Riding

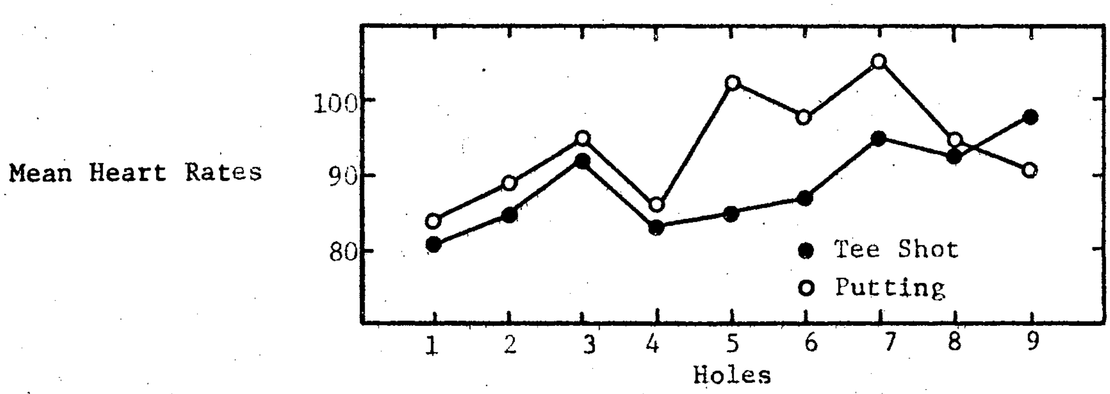

Figure 35. Subject No. VII - Heart Rates During Tee Shots and Putting, Using Pull Cart

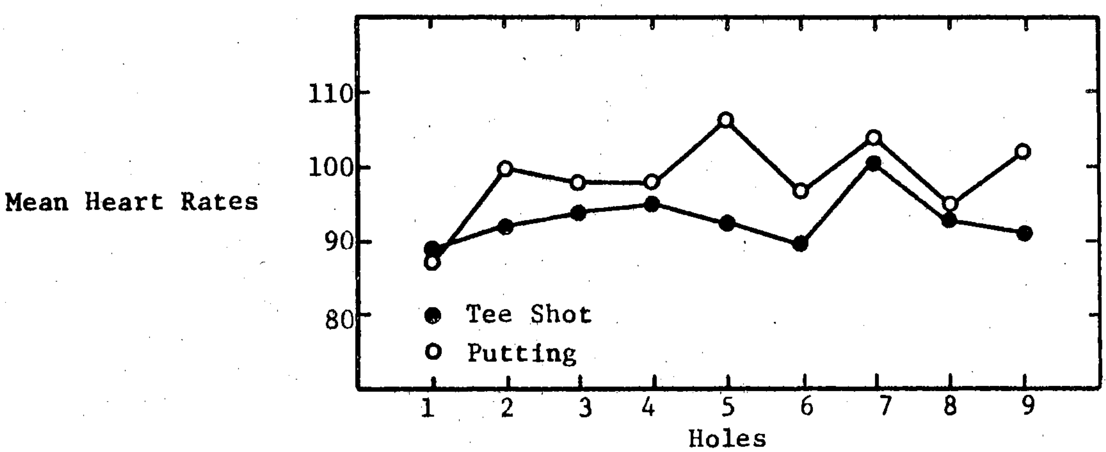

Figure 36. Subject No. VII - Heart Rates During Tee Shots and Putting, Carrying Clubs

a total distance of 4.8 miles for the nine holes. (See Table XIV and Figures 34, 35 and 36.)

Analysis of the data of Subject No. VII indicates that the highest heart rate occurred during putting and while carrying the clubs. Also, that the largest mean predicted oxygen intake occurred while carrying the clubs. The lowest score and the greatest distance walked occurred while using the pull cart.

Group Relationships of Heart Rates and Oxygen Consumption at Rest and During Work Levels

Analysis of group data when at rest indicated a mean heart rate of 69 and a mean oxygen intake of .501 liters per minute. After a three minute walk on the treadmill at a speed of 3.4 and 0% grade the mean heart rate was 91 and the mean oxygen intake was 1.10 liters per minute. At a speed of 3.4 and a 2% grade the mean heart rate was 103 and the mean oxygen intake was 1.33 liters per minute. This relationship is shown in Table XV and Figure 37.

<u>Relationship of High and Low Skill Golfers</u>

When carrying the clubs the more skilled golfers (low handicap of 10 and under) had a mean heart rate of 114.3 beats per minute and a mean oxygen intake of 1.31 liters per minute as compared to the low skilled golfers (11 and over) who had a mean heart rate of 102.6 beats per minute and a mean oxygen intake of 1.53 liters per minute. When using the pull cart the more skilled golfers had a mean heart rate of 103.6 beats per minute with an oxygen intake of 1.28 liters per minute as compared to the low skilled golfers' mean heart rate of 97.9 beats per minute and

TABLE XV

MEAN HEART RATES AND OXYGEN INTAKES
AT REST AND DURING WORK LEVELS

Subjects	Resting		0% Grade, 3.4 Speed		2% Grade, 3.4 Speed	
	H.R.	O_2 Intake	H.R.	O_2 Intake	H.R.	O_2 Intake
1	60	.464	72	1.260	84	1.39
2	85	.850	97	1.205	101	1.31
3	78	.299	121	.929	139	1.18
4	66	.474	102	1.190	109	1.50
5	66	.628	75	1.280	98	1.48
6	73	.410	90	1.056	105	1.49
7	55	.385	80	.840	91	1.02
Mean	69	.501	91	1.100	103	1.33

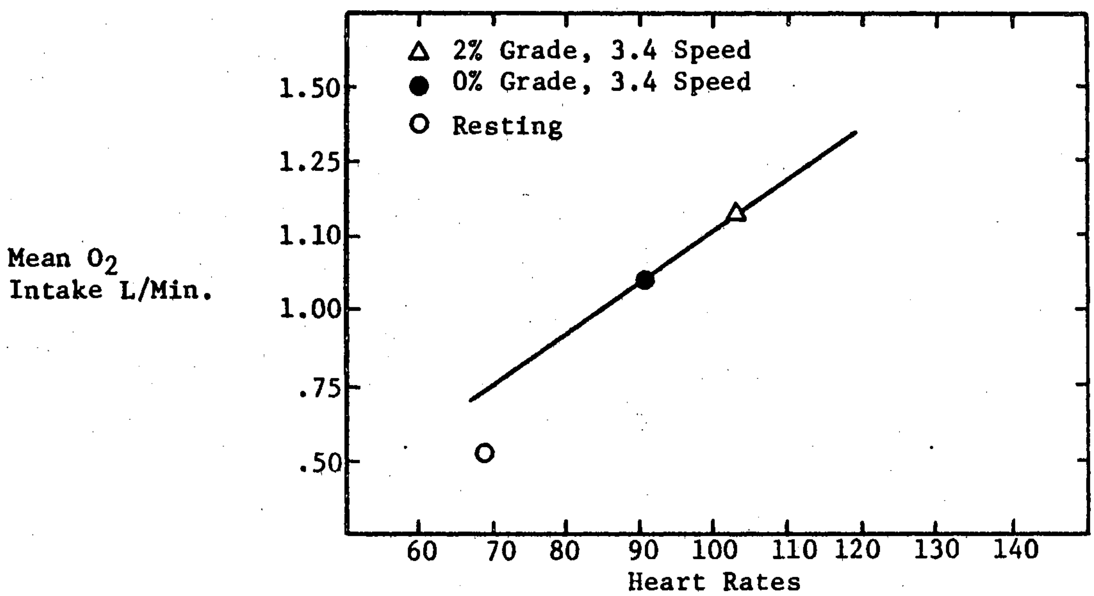

Figure 37. Group Mean Heart Rates and Oxygen Intakes

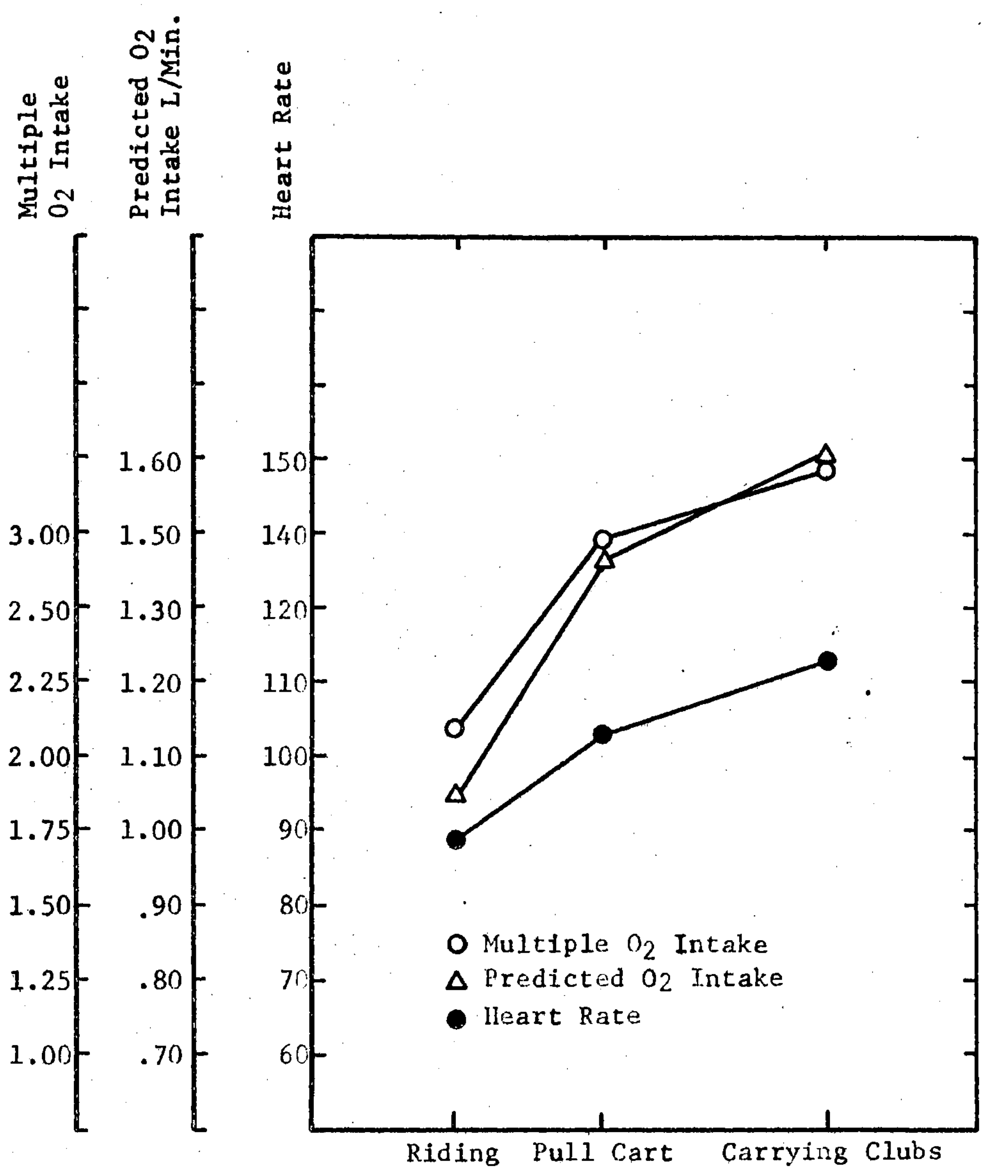

Figure 38. Group Data (N=7)

mean oxygen intake of 1.33 liters per minute. It should be noted that in all three variables the heart rate of the high skill golfer is higher than that of the low skill golfer, but the oxygen intake of the low skill golfer is higher in each variable except when riding the motorized cart. This difference is assumed to be that the high skill golfers take their game more seriously than the low skill golfers. There was very little difference in heart rates and oxygen intakes at rest and when riding in the motorized cart.

Low Skill Golfers Handicap 11 and Over

	At Rest		Riding		Using Pull Cart		Carrying Clubs	
	H.R.	O_2 Intake	H.R.	O_2 Intake	H.R.	O_2 Intake	H.R.	O_2 Intake
MEAN	66.0	.566	84.6	1.04	97.9	1.33	102.6	1.53

High Skill Golfers Handicap 10 and Under

	At Rest		Riding		Using Pull Cart		Carrying Clubs	
	H.R.	O_2 Intake	H.R.	O_2 Intake	H.R.	O_2 Intake	H.R.	O_2 Intake
MEAN	70	.467	85.6	1.04	103.6	1.28	114.3	1.31

Group Relationship on Heart Rate and Oxygen Consumption During Golf Rounds

Riding: Analysis of group data of nine holes of golf when riding indicated a mean heart rate of 89.1 and a mean predicted oxygen intake of 1.05 liters per minute. The mean oxygen intake at rest for the group was .501 liters per minute and the multiple of resting oxygen intake was 2.09. Mean heart rates for tee shots and putting were 90.4 and 93.4. The mean score when riding was 41.5 and the mean distance was 1.98 miles. (See Table XVI and Figure 41.)

With pull cart: Analysis of the group data of nine holes of golf when using the pull cart indicated a mean heart rate of 103 and a mean predicted oxygen intake of 1.37 liters per minute. The mean oxygen intake at rest for the group was .501 liters per minute and the multiple of resting oxygen intake was 2.73. Mean heart rate for tee shots was 105.3 and for putting was 108.9. The mean score when using the pull cart was 43.7 and the mean distance walked was 4.58 miles. (See Table XVI and Figure 41.)

Carrying clubs: Analysis of the group data for nine holes of golf when carrying the clubs indicated a mean heart rate of 113.1 and a mean predicted oxygen intake of 1.50 liters per minute. The mean oxygen intake at rest was .501 and the multiple of resting oxygen intake when carrying the clubs was 2.99. Mean heart rates for tee shots was 106.4 and for putting was 111.7. The mean score was 41.5 and the mean distance walked was 4.02 miles. (See Table XVI and Figure 41.)

When riding a motorized cart and carrying the clubs the score was the same (41.5). However, when using the pull cart the score was 42.7, a difference of 2.2. Therefore, there was very little difference in the score in all the variables.

The most consistent high heart rates for putting occurred on hole No. 7. This is a short par 3 hole but has a very sharp uphill grade with a difficult sloping green which probably accounts for the high

TABLE XVI

GROUP DATA (N=7)

	Mean	Standard Deviation
Oxygen Intake at Rest Liters/Min.	.501	.18

	Riding		Pull Cart		Carrying Clubs	
	M	S.D.	M	S.D.	M	S.D.
Heart Rates for 9 holes	89.1	10.6	103	9.2	113.1	8.8
Heart Rates for Tee Shots	90.4	6.46	105.3	10.25	106.4	12.21
Heart Rates for Putting	93.4	8.20	108.9	10.30	111.7	12.74
Predicted Oxygen Intake L/Min.	1.05	.11	1.37	.031	1.50	.11
Multiple of Resting Intake	2.09	.700	2.73	.700	2.99	.800
Calories per Hour	342		411		450	
Calories per Minute	5.2		6.8		7.5	
Oxygen - ml's/kg/minute	8.5		9.1		9.7	
Total Distance Walked	1.98	.35	4.58	.44	4.02	.52
Time in Minutes	96		115		124	
Mean Golf Score	41.5		43.7		41.5	
Mean Weight of Golf Bag in Pounds					24.3	

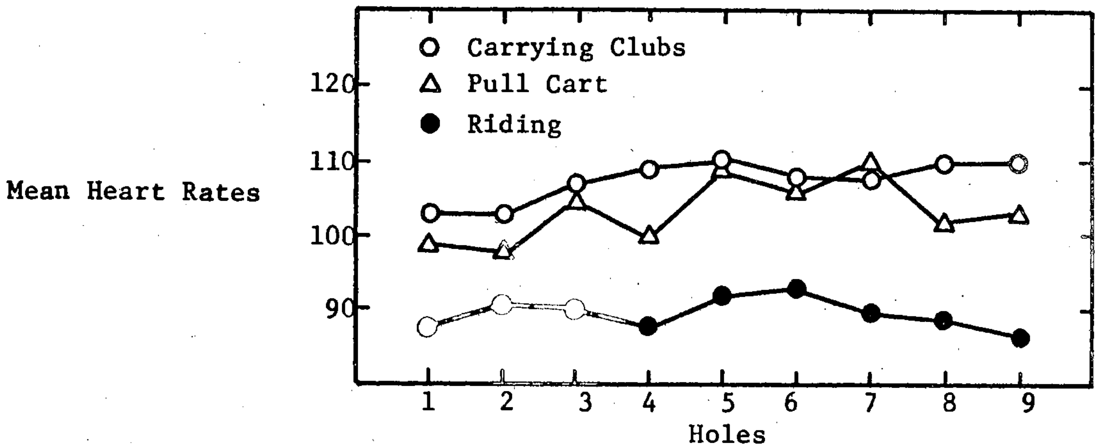

Figure 39. Group Mean Heart Rates on Tee Shots on Each Hole (N=7)

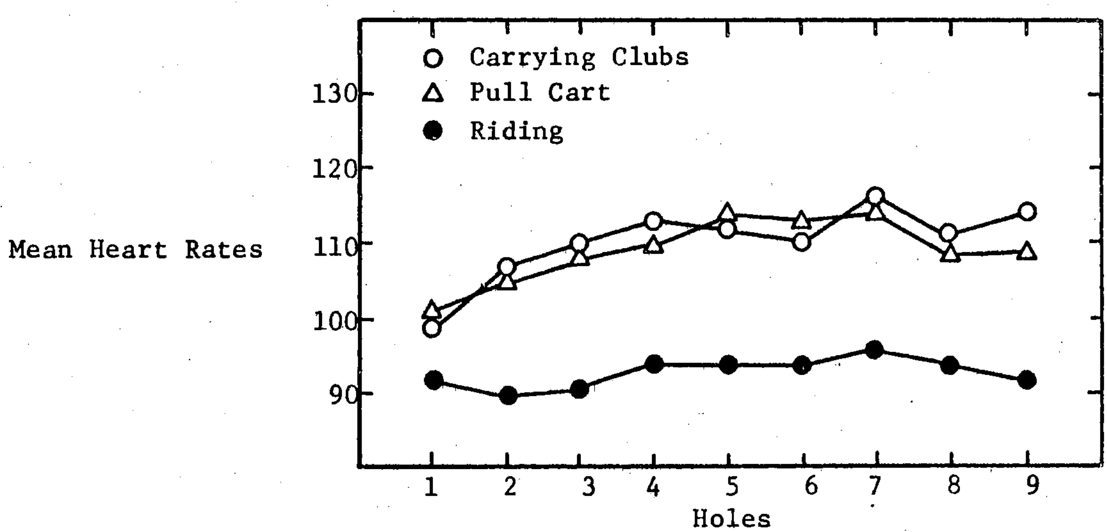

Figure 40. Group Mean Heart Rates on Putting on Each Hole

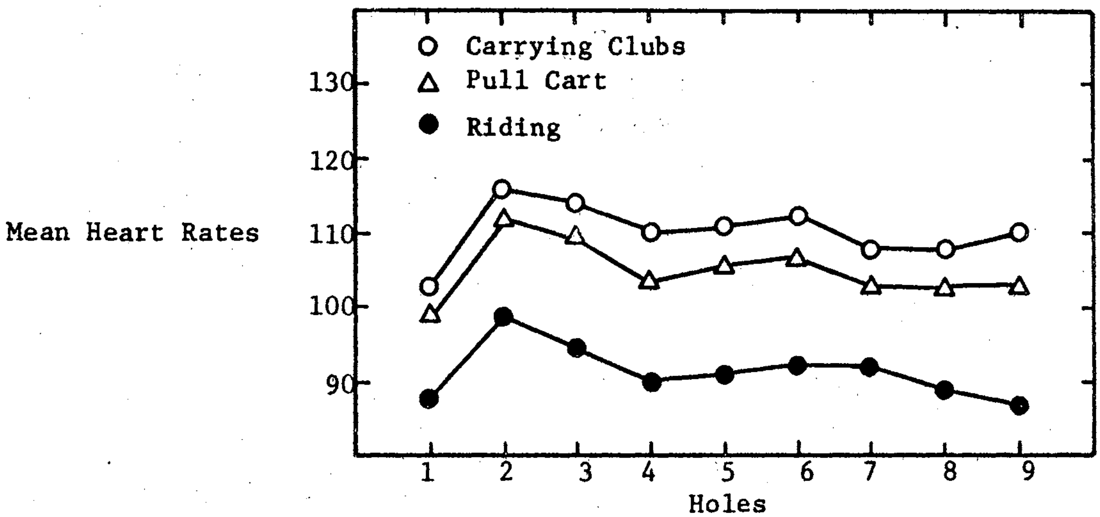

Figure 41. Group Mean Heart Rates on Each Hole (N=7)

heart rates (Figure 40). No relationship was evident on tee shots and holes on any of the variables (Figure 39). Group mean heart rates in all three variables reached a peak on hole No. 2 and then leveled off with a very slight increase on hole No. 6. No relationship was evident with respect to the weight of the bag and clubs when carrying them and the score made.

Discussion

Studies by Christensen,[1] Passmore and Durvin,[2] and Benedict and Cathcart,[3] are in agreement that moderate work requires 5.0 calories per minute or 1.0 liters of oxygen per minute. Very heavy work requires 10 calories per minute or 2.0 liters of oxygen per minute. In classification of activities, golf required 5.0 calories per minute and was classified as light or moderate work. Such activities as canoeing, volleyball, bowling and archery require less calories and oxygen per minute. Tennis requires 8.6 calories per minute and is considered heavy work.

In comparison with these results the writer can conclude that golf participation when riding a motorized cart (5.2 calories per minute or 1.05 liters of oxygen per minute) may be classified as light work, and when using a pull cart (6.8 calories per minute or 1.37 liters of oxygen

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[1] E. H. Christensen, "Physiological Valuation of Work in the Hykroppa Iron Works", Ergonomics Society Symposium on Fatigue, F. W. Floyd and A. Welford (London: H. K. Lewis, 1953), pp. 93-108.

[2] R. Passmore and J.V.G.D. Durvin, "Human Energy Expenditure", Physiological Review, 35:801-839, 1955.

[3] F. G. Benedict and E. P. Cathcart, "Muscular Work", Carnegie Institute of Washington, Publication No. 187, 1913.

per minute) may be considered moderate work. But golf participation when carrying the clubs (7.5 calories per minute or 1.50 liters of oxygen per minute) may be compared to tennis and classified as heavy work.

Skubic and Hodgkins[4] conducted a study dealing with cardiac response to participation in tennis, badminton, golf, archery, and bowling. They found that tennis and badminton proved to be significantly more strenuous than golf, archery and bowling, but none of these required a mean heart rate higher than 106 and were classified as light work. Tennis and badminton were classified as moderate work.

The mean heart rate in this study for golf participation when riding a motorized cart was 89.1, and was 103 when using a pull cart and may be classified as light work in agreement with Skubic and Hodgkins. However, when carrying the clubs it was 113.1 and this may indicate that golf participation when carrying the clubs may be classified as moderate work.

Wells, Balke and Fossan[5] obtained classification of physical work by work capacity test and concluded that a pulse rate of 100 beats per minute was indicative of light work, and 120 beats per minute moderate work. The highest mean heart rate obtained by the writer was when subjects were carrying the clubs which was 113.1 beats per minute. This would place it in the light work classification of Wells and Balke.

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[4]Vera Skubic and Jean Hodgkins, "Cardiac Response to Participation in Selected Individual and Dual Sports as Determined by Telemetry". The Research Quarterly, Vol. 36, No. 3, pp. 316-326, 1965.

[5]J. G. Wells, B. Balke and Von Fossan, "Lactic Acid Accumulation During Work", A Suggested Standardization of Work Classification. Journal of Applied Physiology, 1o:51-55, 1957.

Dr. Kenneth Cooper[6] in his book Aerobics, points out that 7 ml's/kg/min. of oxygen consumed in 14.30 to 20.00 minutes is worth one point toward the 30 points needed per week for physical fitness. He awards 3 points for eighteen holes of golf. He does not say if this is riding a motorized cart, using a pull cart or carrying the clubs. The findings by the writer indicated that oxygen consumption was 8.5 ml's/kg/min. or more for nine holes of each of the three variables. Time spans ranged from one hour and 36 minutes to two hours and four minutes and distance covered from 1.98 miles to 4.5 miles. Using Dr. Cooper's formula, golf participation when riding a motorized cart for nine holes would be worth 4½ points, when using a pull cart would be worth 5½ points, and when carrying the clubs would be worth 6 points.

Subsequently Dr. Cooper had awarded 4½ points for nine holes of golf. Later he reduced it to 3 and finally to 1½ points for nine holes of golf. This conclusion is related to the fact that Dr. Cooper believes that for any exercise to be of benefit, the subject must produce and sustain a heart rate of 150 beats per minute or more. Due to the crowd of weekend golfers or those who may be playing in a foursome, the golfer does not experience a continued activity. This would lower the heart rate and cut down on the energy cost. The writer would agree with Dr. Cooper's allotment of 3 points for eighteen holes of golf if played under normal golf conditions and while riding or pulling a cart. However, it would seem appropriate in light of the findings of this study to give more than 3 (possible 5 or 6) points if the golfer carries his clubs and moves around the course without delay.

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[6] Kenneth H. Cooper, M.D., M.P.H., Major, U.S.A.F. Medical Corps, Aerobics. Bantam Books, Inc., New York, 1968, p. 23.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate by means of electrocardiographic telemetry, the heart rate responses and predict the oxygen intake of subjects during golf participation. This included nine holes of walking and carrying the clubs, walking using a pull cart and riding a motorized cart. To determine these differences the heart rates and oxygen intakes of the subjects were taken at rest, during a three minute walk on the treadmill at a speed of 3.4 m.p.h. and a grade of 0%, and 3.4 m.p.h. and a grade of 2%. This established a linear relationship between heart rate and oxygen intake for moderate activity. The resting ECG, height, weight, barometric pressure and temperature were recorded. Oxygen intake, pulmonary ventilation and breaths per minute were computed.

Radio telemetry equipment and a tape recorder were used to record the heart rate responses of the subjects during the three variables of participation, walking with pull cart, walking carrying the clubs, and riding a motorized cart. These records were taken to the physiology laboratory and played from the tape recorder to the physiograph which produced the heart rate readings for each nine holes of golf participation. These heart rate responses were compared with the linear relationship of heart rate and oxygen intake established while walking the treadmill.

The subjects used for this study were six male faculty and staff members of Oklahoma State University and one male professional golfer. No criterion was used in the selection of the subjects, other than that they considered themselves to be weekend golfers. Preliminary studies were made to aid the investigator in developing competence in the use of the equipment. Participation for the study began May 12, 1969 and was concluded June 16, 1969. With exception of one subject, all participation occurred at the same time of day. No attempt was made to control the order in which the three variables of golf participation were played. Each subject was allowed to select his own order of participation.

The heart rates, which were analyzed, were obtained from the tapes of the telemetry system and produced the predicted oxygen intake. The analysis of data gave information with reference to the heart rates and oxygen intakes when riding a motorized cart, walking carrying the clubs, and walking using a pull cart. It also included heart rates and oxygen intakes for putting and tee shots for each of the three variables.

Conclusion

A round of golf will not produce the physiological outcomes that one will get from a program of vigorous endurance running, but it affords many moments of enjoyable recreation. The unexpected triumphs and unpredictable frustrations add much to the life of the middle-aged man. While the real benefits of exercise are not fully understood by the middle-aged man, it is a sincere hope that attitudes will develop to produce self motivation to acquire a personal vigorous exercise program which will undoubtedly improve health and add joy to living.

On the basis of the analysis of data presented in this study, the following conclusions may be reached.

1. Mean heart rate response and mean predicted oxygen intake to the three variables of golf participation was highest when carrying the clubs, (113.1 beats per minute and 1.5 liters of oxygen per minute) and was lowest when riding, (89.1 beats per minute, and 1.05 liters of oxygen per minute).

2. That the greatest mean distance walked occurred when using the pull cart, 4.58 miles for nine holes.

3. Heart rates were higher when putting, than when teeing off or playing from tee to green in all three variables.

4. While carrying the clubs the highly skilled golfers had the highest mean heart rates but the lowest oxygen intake per minute. There was very little difference in heart rates and oxygen intakes at rest, pulling the cart and while riding the motorized cart.

5. When expecting to improve physical fitness to any great extent, golf for the middle-aged sedentary man is not a suitable activity.

6. Golf, as played in this study, was a light activity when riding a motorized cart or using a pull cart, but a moderate activity when carrying the clubs.

Recommendations for Further Study

1. To assess the heart rates and oxygen intakes of professional golfers while on the Professional Golf Association Tour.

2. To study the changes of heart rates and oxygen intakes of sedentary middle-aged men using a prescribed daily walking routine and compare with the results of this study.

3. To determine the energy cost of other sports activities that are popular with the middle-aged man and compare with the results of this study.

4. An investigation of heart rate acceleration and oxygen intake on middle-aged sedentary men participating in golf who smoke at least a pack of cigarettes a day.

5. To study the effects of eighteen holes of golf when riding a motorized cart, using a pull cart and carrying the clubs with reference to oxygen intake and heart rate.

6. To assess the heart rates and oxygen intakes of golf participation in geographical areas conducive to hills and slopes.

7. An investigation to determine the level of physical fitness achieved by golf participation when carrying the clubs over a period of twelve to sixteen weeks when playing two times a week and once on weekends.

8. To determine the energy cost of 18 holes of golf participation when carrying the clubs and play is continuous.

BIBLIOGRAPHY

1. American Medical Association. Exercise and Health - A Point of View. (Bureau of Health Education, 1958), p. 6.

2. Atwater, W. O. and F. G. Benedict. Experiments on the Metabolism of Matter and Energy in the Human Body. U.S.D.A., Office of Experimental Stations, 1903, pp. 1-136.

3. Bailey, D. A. "The Physiological Response of Athletes During All-Out Sports Performance as Monitored by Radio-Telemetry", Progress Report for Fitness and Amateur Sports Research Grant, (Saskatoon, Canada, University of Saskatchewan, November, 1963).

4. Benedict, F. G. and R. D. Milner. Experiments on the Metabolism of Matter and Energy in the Human Body. 1903-1904, U.S.D.A., Office of Experimental Stations, 1907, pp. 1-175.

5. Carpenter, T. M. Tables, Factors, and Fromulae for Computing Respiratory Exchange and Biological Transformations of Energy. (4th Edition, Washington: Carnegie Institute of Washington, 1968), Table 13, p. 104.

6. Cheatum, Billy Ann. Golf. Philadelphia: W. B. Saunders Company, 1969, p. 2.

7. Christensen, E. H. "Physiological Valuation of Work in the Nykroppa Iron Works", Ergonomics Society Symposium on Fatigue, F. W. Floyd and A. Welford. London: H. K. Lewis, 1953, pp. 93-108.

8. Collins, Warren E. Clinical Spirometry. Braintree, Massachusetts: Warren E. Collins, Inc., p. 1.

9. Cooper, Kenneth H., M.C., M.P.H., Major, U.S.A.F. Medical Corps, Aerobics. New York: Bantam Book Company, Inc., 1968.

10. Cureton, T. K. "The Case for Physical Fitness". Think. September, 22-25, 1958.

11. Daniels, F., Jr., J. H. Vanderbil, and C. L. Bommarito. "Energy Cost of Load Carrying on a Treadmill", Fed. Proc. 11:30, 1952.

12. Durvin, J. V. G. D. and V. Makulicis. "The Influence of Grade Exercise on the Oxygen Consumption, Pulmonary Ventilation, and Heart Rate of Young and Elderly Men", Quarterly Journal of Experimental Physiology. 41:442-445, 1956.

13. Fenn, W. O. "Work Against Gravity and Work Due to Velocity Changes in Running; Movement of the Center of Gravity Within the Body and Foot Pressure on the Ground", American Journal of Physiology. 93:433, 1930.

14. "Golf". Teaching Lifetime Sports Skills. The President's Council on Physical Fitness in Cooperation with Lifetime Sports Foundation Fore, Inc., 2020 R Street, N.W., Washington, D. C.

15. Hanson, Dale L. "Cardiac Response to Participation in Little League Baseball Competition as Determined by Telemetry". The Research Quarterly. Vol. 38, 1966, pp. 384-388.

16. Hodgkins, Jean and Vera Skubic. "Cardiac Response to Participation in Selected Individual and Dual Sports as Determined by Telemetry". The Research Quarterly. Vol. 36, No. 3, pp. 316-326, 1965.

17. Hoope, D. D. "The Contribution of the Canadian 5BX Plan to the Physical Fitness of Adult Men", (Unpublished Master's Thesis, College of Education, University of Illinois, Urbana, 1964), pp. 1-78.

18. Hopkins, R. E., Jr. "The Effects of Volleyball and Calisthenics on the Physical Fitness of Adult Men", (Unpublished Master's Thesis, School of Physical Education, University of Illinois, Urbana), pp. 1-85.

19. Howard, G. E., C. S. Blyth, and W. E. Thornton. "A Study of the Continuously Recorded, Telemetered Heart Rate of Track Athletes During Exercise", National Convention of the American Association for Health, Physical Education and Recreation. Washington, D. C., May, 1964.

20. Hunsicker, Paul and Andrew J. Kozar. "A Study of Telemetered Heart Rate During Sports Participation of Young Adult Men", The Journal of Sports Medicine and Physical Fitness. Vol. 3, No. 1, March, 1963, pp. 1-5.

21. Karpovich, Peter V. Physiology of Muscular Activity. 6th Edition, London and Philadelphia: W. B. Saunders Company, 1965, p. 66.

22. Knuttgen, H. G. "Oxygen Uptake and Pulse Rate While Running with Undetermined and Determined Stride Lengths at Different Speeds", Acta Physiology, Scandiva, 52:366, 1961.

23. Kozar, Andrew J. "Telemetered Heart Rates Recorded During Gymnastic Routine", The Research Quarterly, Vol. 34, No. 1, pp. 102-106, 1963.

24. Kristufek, C. J. "Effects of Endurance Training on an Adult Subject", (Unpublished Master's Thesis, School of Physical Education, University of Illinois, Urbana, 1951), pp. 1-87.

25. Malhotra, M. S., J. Gupta, and P. M. Rai. "Pulse Count as a Measure of Energy Expenditure", Journal of Applied Physiology, Vol. 18, p. 994, 1963.

26. Miller, Kenneth D. Physical Education Activities for College Men and Women. Dubuque, Iowa: Wm. C. Brown Company, 1963.

27. Orban, W.A.R. "Heart Rate Response to Interval Running Using Radio Telemetry", Journal of Sports Medicine and Physical Fitness, 3:252-253, December, 1963.

28. Passmore, R. and J. V. Durvin. "Human Energy Expenditure", Physiological Review, 35:801, 1955.

29. Pohndorf, R. H. "Improvement in Physical Fitness of Two Middle-Aged Adults", (Unpublished Ph.D. Thesis, College of Physical Education, University of Illinois, Urbana, 1957), pp. 1-94.

30. Raab, W. "Prevention of Degenerative Heart Disease by Physical Activity", Quest. Monograph III, December, 1964, p. 19.

31. Ralston, H. J. "Comparison of Energy Expenditure During Treadmill Walking and Floor Walking", Journal of Applied Physiology. 15:1156, 1960.

32. Rose, K. D. and F. L. Dunn. "A Study of Heart Function in Athletes by Telemetered Electro Cardiography", Proceedings 5th Annual Conference on the Medical Aspects of Sports. American Medical Association, December, 1963.

33. Rozenblat, V. V. "Heart Rate in Man During Natural Muscular Activity (data obtained by dynamic radio telemetry)". Federation Preceeding. (Translation Supplement), 22:1766, July, 1963.

34. Sargent, R. M. "Relation Between Oxygen Requirement and Speed in Running", Proc. Royal Society of London, B, 100:10, 1926.

35. "Should Your Youngster Adopt Golf as a Major Sport?" Golf. Vol. II, No. 3, March, 1959, p. 48.

36. Skubic, Vera and Jane Hilgendorf. "Anticipatory, Exercise, and Recovery Heart Rates of Girls as Affected by Four Running Events", Journal of Applied Physiology, Vol. 19, pp. 853-856, 1964.

37. Vannier, Maryhelen and Holley Beth Poindexter. Physical Activities for College Women. Philadelphia: W. B. Saunders Co., 1966, p. 101.

38. Vasilena, V. V. "Analyse Telemetrique de la frequence cardiaque dans la course sur differentes distances", Revue de l'education physique, Vol. III:25-30, January, 1963.

39. Wells, J. G., B. Balke, and Von Fossan. "Lactic Acid Accumulation During Work", A Suggested Standardization of Work Classification. Journal of Applied Physiology, 10:51-55, 1957.

40. White, Paul D. "Today's Health News", Today's Health. 39:9, 1961.

41. Wolbers, C. P. "The Effects of Volleyball on the Physical Fitness of Adult Men". (Unpublished Master's Thesis, School of Physical Education, University of Illinois, Urbana, 1949), pp. 1-103.

APPENDIX

TABLE XVII

MEAN HEART RATES BY HOLES ON THREE VARIABLES

Riding

Holes	1	2	3	4	5	6	7	8	9
Heart Rates	88	99.5	96.6	90.4	91.4	92.1	92	89.5	98.6

With Pull Cart

Holes	1	2	3	4	5	6	7	8	9
Heart Rates	112.8	110.2	104.8	106.5	107.7	103.9	103.5	103.5	103.5

Carrying Clubs

Holes	1	2	3	4	5	6	7	8	9
Heart Rates	103	116	114	110	111.4	112.3	108.5	108.5	110.1

TABLE XVIII

MEAN HEART RATES ON TEE SHOTS BY HOLES - RIDING

	Subject	1	2	3	4	5	6	7	M
	1	94	84.6	84.6	82.3	79.6	115.3	79.3	88.5
	2	97	90	87.6	86.3	78	114	85	91.1
H	3	96.3	88.3	92	92	76.3	111.3	79	90.7
O	4	97.6	92	90.3	84.3	78	99.3	78	88.5
L	5	96.3	91	93.6	83.6	78	118.6	87	92.5
E	6	91	94.6	90	87.3	77	131.3	83.6	93.5
S	7	96.3	86.6	87.6	83.3	80.6	121.3	78	90.5
	8	92	81.3	88.6	84.6	79.3	119.3	82	89.1
	9	92.3	78	87.6	84.3	77.6	119	82.6	88.7
	Mean (N=7)	94.7	87.4	89.1	85.3	78.2	116.6	81.6	

TABLE XIX

MEAN HEART RATES ON PUTTING BY HOLES - RIDING

	Subject	1	2	3	4	5	6	7	M
	1	89.3	94.3	93.3	85.6	85	121.6	79	92.6
	2	91.6	88.3	90.6	89.3	78	116	82.6	90.9
H	3	94.6	87.6	94.3	88	81	107.6	85.3	91.2
O	4	99	86.6	92	88.3	80.3	131	84.3	94.5
L	5	103.6	93	96	82	81	126.3	80.6	94.6
E	6	97.6	99.3	89.6	85	82	125.6	80	94.1
S	7	118	94.6	90.3	80.3	78	131	82.3	96.3
	8	98.3	84.3	93.6	87	81.3	131.3	86.3	94.5
	9	99.6	82	90	89.3	78.6	124	82.6	92.3
	Mean (N=7)	99	90	92	86	80.5	123.8	82.5	

TABLE XX

MEAN HEART RATES ON TEE SHOTS BY
HOLES - WITH PULL CART

	Subject	1	2	3	4	5	6	7	M
	1	92.3	110.6	102.6	94.3	107.6	107.6	81	99.4
	2	86	112.6	112.6	91.6	101	99	85	98.2
H	3	94.3	135.6	113.6	95.6	107	101	92	105.5
O	4	98	93.3	117.6	92.3	99.3	115.3	84.3	100.1
L	5	98.3	131.3	117.3	98	108.6	103	85.6	109.8
E	6	97	122	113.6	110.3	102.6	113.3	87.3	106.5
S	7	98	125.6	115.6	111.6	104.3	116.3	95.6	110.1
	8	101.3	85.6	109.3	111.6	102	114.3	93.6	102.5
	9	92.3	111	109	107.6	103.3	105.6	98.3	103.8
Mean (N=7)		95.3	114.1	112.3	101.8	103.9	111.3	89.1	

TABLE XXI

MEAN HEART RATES ON PUTTING BY
HOLES - WITH PULL CART

	Subject	1	2	3	4	5	6	7	M
	1	88.3	111.3	115	90.6	106.6	114.6	84	101.4
	2	91	132.6	115.3	97.6	100	110.6	89.3	105.2
H	3	91.6	127	118	101.6	102	120.6	95.6	108
O	4	99	127.6	126.6	106	103	124.3	86.6	110.4
L	5	103.6	127	130	107.6	108.6	124.6	102.6	114.8
E	6	104.6	126.6	122.3	117.3	110	118.3	98.6	113.9
S	7	97.3	119.6	121.3	118	110.3	132.6	105.6	114.9
	8	99.6	113.3	113	114	100	132.6	95.3	109.6
	9	99.6	113	119	115.6	106.3	122.6	91.6	109.7
Mean (N=7)		97.1	122	120	107.5	105.2	122.3	94.3	

TABLE XXII

MEAN HEART RATES ON TEE SHOTS BY
HOLES - CARRYING CLUBS

	Subject	1	2	3	4	5	6	7	M
	1	99	110.6	110.3	94.6	106.6	116.6	89.6	103.9
	2	107	96.6	108.6	101	107	112	92.6	103.5
H	3	110.6	102	113	96.6	105.6	110	94.3	104.5
O	4	118	109	120	99	108.6	118	95	109.6
L	5	116.6	115	118.3	110.3	104	125	93	110.3
E	6	112	100.3	117.3	103	98	119.3	90	105.7
S	7	103.6	118.6	115.6	103.6	99.6	122.3	101	109.1
	8	108.3	113.3	114.6	115.6	102.3	124.6	94	110.3
	9	107.3	112	109.3	119.5	105.3	126.3	91	110.1
Mean	(N=7)	109.1	108.6	114.1	104.7	104.1	119.1	94.3	

TABLE XXIII

RELATIONSHIP OF MEAN HEART RATES ON PUTTING
BY HOLES - CARRYING CLUBS

	Subject	1	2	3	4	5	6	7	M
	1	101.3	103	110.3	71	109	111	88	99
	2	111	105.3	104.3	105.6	109	105	100.3	105.8
H	3	117	103	114.3	107.6	117.3	111.6	96.6	109.6
O	4	120	114.3	116.6	105	121	119	96.6	113.2
L	5	115.3	128.6	126.6	113.6	107.3	124	106.6	113.1
E	6	110	117.6	122.3	111.6	100.6	125	97.3	110.6
S	7	115.3	111.6	119.3	117.3	107.6	131.6	104.6	115.4
	8	105.3	111	119	118	109	126.3	94.3	111.8
	9	116.3	115.6	106	118.6	107.3	134	102.6	114.3
Mean	(N=7)	112.3	112.2	115.4	107.5	109.8	120.9	98.5	

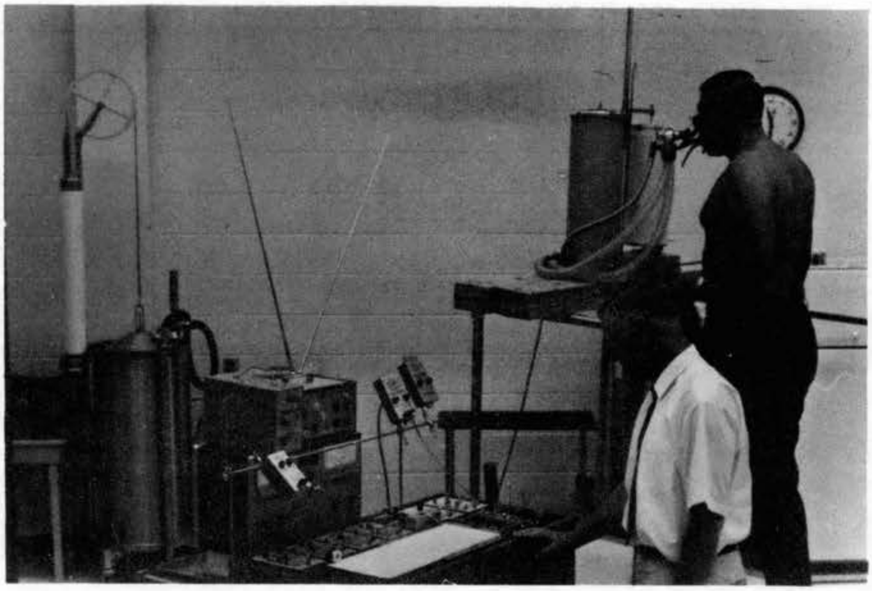

Figure 42. Heart Rate and Oxygen Consumption Recorded During a Treadmill Walk

Figure 43. Heart Rate and Oxygen Consumption Recorded During Bicycle Pedalling

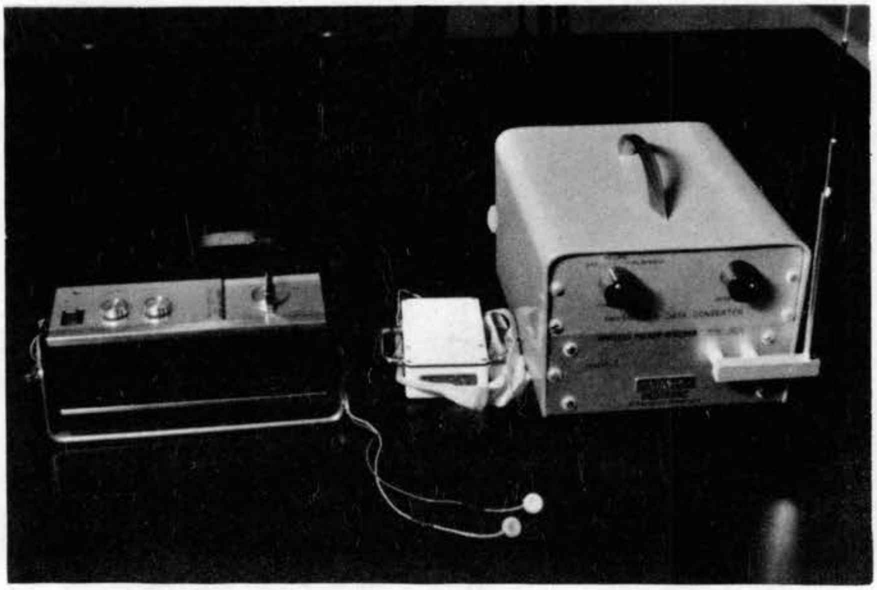

Figure 44. Transistorized Tape Recorder, Transmitter and F. M. Receiver and Amplifier

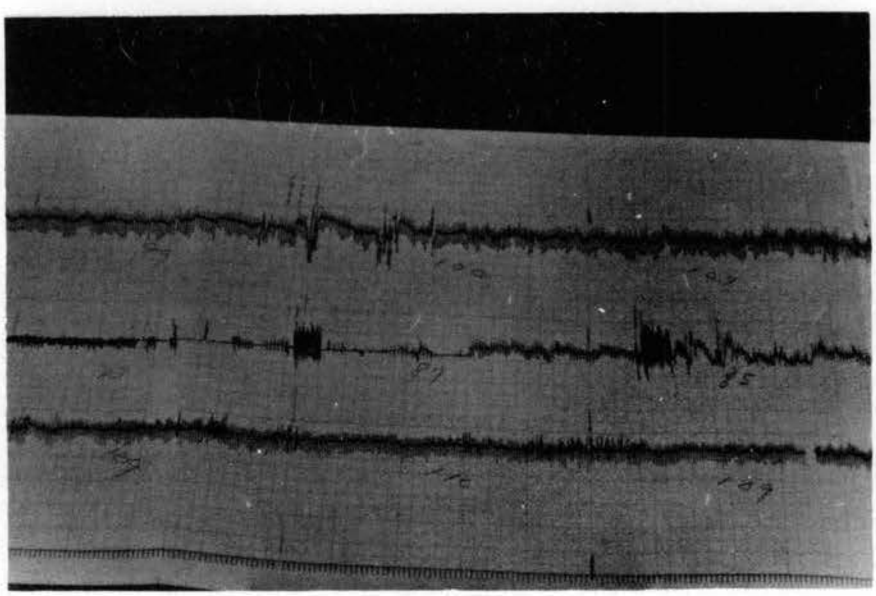

Figure 45. Recorded Heart Rates from Tapes Through Physiolograph of Three Variables of Golf Participation

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