ABSTRACT

Hamm, T. M. Marathon performance time in relation to age, physical characteristics, previous running experience, and various training indices of female distance runners. MS in Human Performance, August 1995, 41pp. (M. K. Miller)

The purpose of this study was to determine the correlation between marathon performance time (MPT) and age, physical characteristics, past running experience, and various training indices. One hundred fifty female distance runners, ages 25 to 50 who had completed at least one marathon and resided in the states of Wisconsin or Minnesota were randomly selected by computer through Media Consultation Services and the International Race Network to participate. Eighty-two percent (N = 123) of the questionnaires were returned after 6 weeks. Data were analyzed using descriptive statistics, Pearson product correlations, and stepwise regression analysis. The min per mile pace ran at distances of 10 - 15 miles (P10 - 15; r = .83), min per mile pace from 5 - 10 miles (P5 - 10; r = .81), and fastest mile time (FMT; r = .76) correlated highly to MPT. The following prediction equation for MPT ($r^2 = .77; p < .001$) was established using regression analysis: $\text{MPT} (\text{hr}) = 0.346762 \times (\text{P}10 - 15) - 0.093685 \times (\text{T}5 - 9) + 0.15369 \times (\text{FMT}) + 0.31167$. These findings suggested that 3 training variables will contribute to improved performance times. The pace when running distances of 10 - 15 miles, the number of times per week that distances of 5 - 9 miles are ran (T5 - 9; $r = -0.44$), and the fastest mile time were the variables most predictive of final MPT. Several recommendations were made for future investigation of training indices related to MPT. These included measurement of the max VO2 and on site surveying for a more homogeneous sample of runners.
MARATHON PERFORMANCE TIME IN RELATION TO AGE, PHYSICAL CHARACTERISTICS, PREVIOUS RUNNING EXPERIENCE, AND VARIOUS TRAINING INDICES OF FEMALE DISTANCE RUNNERS

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

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

BY
TRACY M. HAMM
AUGUST 1995
Candidate: Tracy M. Hamm

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

Master of Science in Exercise and Sport Science-Human Performance

The candidate has successfully completed her thesis final oral defense.

Marilyn K. Miller
Thesis Committee Chairperson Signature

William A. Lloyd
Thesis Committee Member Signature

Dennis M. O'Brien
Thesis Committee Member Signature

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

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

Dean of UW-L Graduate Studies
ACKNOWLEDGMENTS

I especially wanted to thank the following people:

Dr. Marilyn K. Miller, my thesis committee chair, for your interest, great ideas, expertise, and for keeping me on schedule.

Dr. Dennis O'Brien, for taking extra time to help me learn and understand ASP.

Dr. William Floyd, for your constructive criticism and encouragement.

My parents and sister, for all your love, encouragement, and support. I could not have done it without you!
# TABLE OF CONTENTS

**ACKNOWLEDGMENTS** ................................................................. iii

**LIST OF TABLES** .................................................................. vii

**LIST OF APPENDICES** .......................................................... viii

**CHAPTER**

I. INTRODUCTION .................................................................. 1

- Purpose of the Study ............................................................ 1
- Need for the Study ............................................................... 1
- Statement of the Problem .................................................... 2
- Hypothesis ........................................................................ 3
- Assumptions ..................................................................... 3
- Delimitations .................................................................... 3
- Limitations ....................................................................... 3
- Definition of Terms ............................................................ 4

II. REVIEW OF RELATED LITERATURE .......................... 5

- Introduction ........................................................................ 5
- Age and Marathon Performance Time .............................. 5
- Physical Characteristics ...................................................... 6
- Height, Weight, and Marathon Performance Time .......... 6
- Body Composition and Marathon Performance Time ....... 6
- Body Mass Index and Marathon Performance Time ........ 7
- Ponderal Index and Marathon Performance Time ............ 8
- Number of Years Training and Marathon Performance Time. 9
# STEPWISE REGRESSION ANALYSIS

## DISCUSSION

- **Age and MPT**
- **Physical Characteristics and MPT**
- **Previous Running Experience and MPT**
- **Training Duration and MPT**
- **Training Intensity and MPT**
- **Training Frequency and MPT**

## REGRESSION ANALYSIS

### V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

- **Summary and Conclusions**
- **Recommendations**

### REFERENCES

### APPENDICES
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Desirable body mass index range in relation to age</td>
<td>8</td>
</tr>
<tr>
<td>2. Descriptive statistics of marathon performance time, age, physical characteristics and previous running experience</td>
<td>19</td>
</tr>
<tr>
<td>3. Mean marathon performance time according to age group</td>
<td>20</td>
</tr>
<tr>
<td>4. Descriptive statistics of various training indices</td>
<td>21</td>
</tr>
<tr>
<td>5. Correlation coefficients (r) and coefficients of determination ($r^2$) between marathon performance time and age, physical characteristics, and past running experience</td>
<td>23</td>
</tr>
<tr>
<td>6. Correlation coefficients (r) and coefficients of determination ($r^2$) between marathon performance time and various training indices</td>
<td>24</td>
</tr>
</tbody>
</table>
#### LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. The Training Questionnaire</td>
<td>36</td>
</tr>
<tr>
<td>B. Cover Letter Requesting Participation</td>
<td>38</td>
</tr>
<tr>
<td>C. Follow-up Letter Requesting Participation</td>
<td>40</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

Marathon running has been growing in popularity over the past few years, especially among females. There are many reasons why more and more adults are participating in long-distance races. It seems that training for endurance events has become socially acceptable due to an increased awareness of exercise for improving health and fitness (Maughan, 1990). Running also helps to relieve stress, control weight, and allows people to meet others who share a common interest (Galloway, 1984). Some choose to train in order to win, while others have the goal of simply completing the challenge of running 26.2 miles. Whatever the reasons or goals, the time needed to train for a marathon is quite demanding and the motivation and dedication to continue very high.

Purpose of the Study

Despite the growing popularity of the marathon and the extensive time needed for preparation, studies regarding training practices and their effectiveness are limited for the female population. The purpose of this study was to determine if marathon performance time (MPT) correlated to age, physical characteristics, past running experience, or various training indices used by adult female marathon runners.

Need for the Study

The need for this study was based on past research conducted in which MPT was correlated to various training indices through data obtained by questionnaires. As indicated by Hagan, Smith, and Gettman (1981), numerous multiple regression equations have correlated MPT with physical characteristics and training indices. The relative
contribution of these factors, as single entities or in combination, is unclear and requires further investigation.

A need was also indicated because the majority of studies that relate MPT to training methods were conducted on males and the data relative to the females' responses to exercise are meager (Helgerud, Ingjer, & Stromme, 1990). Although the responses to exercise and training are basically the same for both sexes, females differ in several ways. According to Fox, Bowers, and Foss (1993) females are on average 3 to 4 inches shorter, 25 to 30 pounds lighter in total body weight, have 10 to 15 pounds more adipose tissue, and 40 to 45 pounds less of lean body mass compared to males. It has also been indicated that females' absolute strength is about two-thirds of males and strength-training programs for females will not cause excessive muscular bulk. Finally, the female has gynecological considerations. Even though mild exercise will not have a significant effect on menstrual disorders, heavy intensive training and competition may induce amenorrhea in female athletes (Dale, Gerlach, Martin, & Alexander, 1979).

**Statement of the Problem**

Despite the growing popularity of the marathon, the majority of studies in which MPT was correlated with age, physical characteristics, previous running experience, and various training indices were primarily conducted on males. Although the number of women participating in endurance events is on the rise, long-distance running was once contraindicated for females because it was thought to be harmful. In 1979, the American College of Sports Medicine developed the following statement in respect to female participation in long-distance events:

It is the opinion of the American College of Sports Medicine that females should not be denied the opportunity to compete in long-distance running. There exists no conclusive scientific or medical evidence that long-distance running is contraindicated for the healthy, trained female athlete. The
American College of Sports Medicine recommends that females be allowed to compete at the national and international level in the same distances in which their male counterparts compete.

Female distance runners are characterized by having large maximal oxygen uptake and low relative body fat content. The challenges of the heat stress of long-distance running or the lower partial pressure of oxygen at altitude seem to be well tolerated by females. The limited data available suggest that females, compared to males, have about the same incidence of orthopedic injuries consequent to endurance training. Disruption of the menstrual cycle is a common problem for female athletes. While it is important to recognize this problem and discover its etiology, no evidence exists to indicate that this is harmful to the female reproductive system (Fox, et al., 1993; p. 400).

Hypothesis

The following null hypotheses were formulated:

There is no significant correlation between MPT and (a) age, (b) physical characteristics (height, weight, body mass index (BMI), and ponderal index (PI), (c) number of years of running experience, (d) training duration, (e) training intensity, or (f) training frequency of female marathon runners.

Assumptions

Assumptions of this study were as follows:

1. The subjects answered the questions truthfully.
2. The randomized group was representative of other female marathon runners.

Delimitations

Several delimitations were placed on this study. The subjects were females from the ages of 25 to 50 who had completed at least one marathon and resided in the states of Wisconsin or Minnesota.

Limitations

The limitations of this study included:

1. The subjects had varying fitness levels.
2. Due to the nature of this study, the maximal oxygen consumption (max VO$_2$), which has been found to be a significant contributor to MPT (Bar-Or, 1975; Hagan, Upton, Duncan, & Gettman, 1987) could not be determined and compared to the other training variables used in this study.

**Definition of Terms**

The following definitions were used in this study:

**Body Mass Index (BMI)** - also known as the Quetelet Index which accounts for differences in body composition by defining the level of adiposity according to the relationship of weight to height and eliminating dependence on frame size. The BMI = weight (in kilograms) / height$^2$ (in meters) (Mahan & Arlin, 1992).

**Maximal Oxygen Consumption (max VO$_2$)** - the maximal rate at which oxygen can be consumed per minute; the power or capacity of the aerobic or oxygen consumption (Fox, et al., 1993).

**Marathon Performance Time (MPT)** - the amount of time needed to run the distance of 26.2 miles.

**Overload Principle** - progressively increasing the intensity of the workouts over the course of the training program (Fox, et al., 1993).

**Ponderal Index (PI)** - a measure of leanness, calculated by dividing height in inches by the cube root of body weight in pounds. The higher the value of this index, the leaner the individual (Slovic, 1977).
CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

The ultimate performance of an athlete is the result of numerous factors. Intrinsic factors, such as genetics, psychology, a person's state of health, the amount of previous training, physical fitness level, the ability to utilize a large fraction of the aerobic capacity for prolonged periods of time, musculoskeletal and orthopedic integrity, nutritional status, and body weight and composition influence one's training capacity and success at completing a marathon. Extrinsic variables including running efficiency, clothing and shoes, course terrain, wind resistance, environmental temperature and humidity, and body fluid loss and replacement also play a role when training and competing (Bar-Or, 1975; Franklin, Forgac, & Hellerstein, 1978). It is important to keep in mind that no single factor, while keeping others constant, can determine athletic performance and that some factors are more influential than others. In this present study, the variables of age, height, weight, BMI, PI, previous running experience, and various training indices were correlated to MPT in randomly selected female marathon runners.

Age and Marathon Performance Time

Age as a factor for prediction of MPT is difficult to isolate, especially among novice and other unaccomplished runners because age does not necessarily reflect experience or training background (Dotan, et al., 1983). Runners today are training at younger ages, whereas in the past runners would train for longer distances only after years of experience at shorter distances (Maughan, 1990). Although it is known that performance declines slowly with increasing age, conflicting evidence on when marathon runners reach their peak has been found. Maughan (1990) has stated that marathon
runners perform their best in their late 30's and early 40's. In contrast, it has been suggested that marathoners reach their peak in their late 20's and into their 30's (Costill, 1979). Subject gender was not identified in either of these studies, which supports that there is a lack of training information for female distance runners.

Physical Characteristics

Height, Weight, and Marathon Performance Time

Hagan et al. (1987) surveyed 35 female marathon runners and found that the correlation between MPT and the variables of height \((r = .16)\) and weight \((r = .49)\) were not significantly high for female novice and experienced distance runners. The mean height of these female subjects was 166.4 cm and the mean weight was 55.1 kg. In contrast, the mean height of female distance runners of national and international caliber was found to be 169.4 cm, the mean weight 57.2 kg, and the average percent of body fat approximately 15.2 %. It is important to note that these runners had also been training for an average of 4.5 years. In addition, the low values in body fat may have been due to genetic factors. It could also be explained by the great mileage being run weekly (Wilmore & Brown, 1974).

Body Composition and Marathon Performance Time

It is well known that excessive body fat is a health hazard and places a person at greater risk for developing chronic disease. It also has many disadvantages for the distance runner (Mahan & Arlin, 1992). A larger body size increases the air resistance to running, which in turn increases or prolongs performance time. In contrast, smaller, leaner runners will have a lower air resistance during running and a faster marathon performance time (Hagan, et al., 1987). An increase in the weight one must carry while running can become a "burden" because it increases the work load without contributing to the success of completing the race (Fox, et al., 1993).
During prolonged exercise, for durations longer than 30 minutes, muscle glycogen stores within some of the slow-twitch muscle fibers become nearly depleted. Severe glycogen depletion, which causes contractile fatigue, occurs even though plenty of free fatty acids and glucose (from the liver) are still available as fuel to the muscle fibers (Fox, et al., 1993). This severe glycogen depletion generally occurs around mile 20 of the 26.2 mile marathon and is known as "hitting the wall" (Galloway, 1984). Although fat is more abundant than the amount of glycogen that can be stored, the body has difficulty mobilizing and utilizing fat as a fuel (Arnold, 1994). It has been estimated that the total amount of fat oxidized during a marathon is very small, amounting to no more than 150 to 200 grams or 1350 to 1800 kcals (Dotan, et al., 1983). Even though longer training runs, particularly those over 20 miles, stimulate fat metabolism at a higher percentage of energy needs and allow the body to use fatty acids more effectively as a fuel source, extra fat stores have not been found to be advantageous for overall running performance.

**Body Mass Index and Marathon Performance Time**

Marathon runners come in varying shapes and sizes, particularly among the nonelite. Physical characteristics such as body mass can be determined by the methods of hydrostatic weighing, the BMI (kg $/m^2$), and skinfold measurements. All of these methods have been found to be related to MPT (Hagan, et al., 1987). Florey (1970) collected questionnaire data and found the BMI was the best ratio of weight and height derivatives when correlated to the MPT of women of different sizes.

A BMI score of 20 to 25 is associated with the least risk of early death, and 20 to 27 is the generally accepted range. A score above 27 indicates obesity and increased risk of developing health problems. Age specific guidelines for the BMI have been established and are depicted in Table 1 (Mahan & Arlin, 1992).
Table 1. Desirable body mass index range in relation to age

<table>
<thead>
<tr>
<th>Age group (Yr.)</th>
<th>Desirable body mass index (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 - 24</td>
<td>19 - 24</td>
</tr>
<tr>
<td>25 - 34</td>
<td>20 - 25</td>
</tr>
<tr>
<td>35 - 44</td>
<td>21 - 26</td>
</tr>
<tr>
<td>45 - 54</td>
<td>22 - 27</td>
</tr>
</tbody>
</table>

The correlations reported between MPT and the BMI have not been high. Dotan, et al., (1983) found that MPT correlated (r = .57) with the BMI when compared to other derivatives of weight and height. In this particular study, the 16 marathon runners, gender unidentified, had an average BMI of 21.71 and a mean age of 31.5 years. In a similar study conducted by Hagan, et al. (1987) MPT was correlated to the BMI of novice (r = .52) and experienced female runners (r = .70). The experienced marathoners had ran more than three marathons.

Ponderal Index and Marathon Performance Time

The ponderal index (PI), calculated by dividing the weight in inches by the cube root of body weight in pounds, is a measure of leanness and has also been correlated with MPT in several studies. The higher the PI value, the leaner the individual. Both the BMI and PI have been found to correlate more highly to MPT than weight or height alone (Slovic, 1977). Slovic (1973) noted that faster marathon runners had higher PIs and were leaner than those who finished after them. The average height of the male subjects was similar, but the average weight varied from 137.6 pounds in the 2:31 to 2:45 category to 158.2 pounds in the slowest category. Runners who finished under 3 1/2 hours were
markedly leaner and had average PIs of 13.4, compared to those who finished after them. Runners completing this particular marathon above 4 1/2 hours had PIs of 13.0 or less (Slovic, 1977). In a similar study, which also used male subjects, a mean PI of 13.05 was found in marathon runners (Hagan, et al., 1981). The results of another study conducted by Murray, Zinkgraf, and Shea (1980) found no significant correlation to PI and MPT among 72 male marathon runners. These findings support the conclusions by Fox and colleagues (1993) that an increase in body weight can be a burden in long distance running.

**Number of Years Training and Marathon Performance Time**

The experienced marathoner has an advantage in that he or she can assess and integrate a more effective strategy into the estimation of optimal race pace and probable performance more accurately than the novice. Assessments of a realistic pace is important since poor pace selection may lead to premature fatigue and decreased performance (Franklin, et al., 1978).

A study conducted by Slovic (1977) found that faster runners had considerably more experience in running the marathon than did slower runners. About 12% of those completing the marathon in under 3 hours had not competed in a marathon before, whereas the remaining two-thirds in the slowest category had no prior completions. Slovic (1977) found that 85% of runners who responded to the questionnaire data regarding training and finishing the Trail's End marathon under 2:45 had experience on a college or high school track team. In addition, only half of the runners over 2:45 had experience in high school or college (Slovic, 1973).

Completion of a previous marathon has been associated with a 14- to 19- minute reduction in predicted final time, independent of the runner's training and ability. Runners who had previously finished a marathon also noticed improvements in their
times rather than "getting through". It was suggested that the experience gave the runners greater confidence (Slovic, 1973).

According to Arnold (1994) consistency is a major objective in the early years of a program and moderate mileage of 40 to 60 miles per week should be attempted. After five years of training, some athletes may find their optimum mileage lies in the 70 to 80 miles per week range. Longer mileage can be experimented with and is known to enhance muscular endurance and thought to promote better fat metabolism. As a result, racing can become more frequent. The number of completed races runners can expect is generally thought to be directly proportional to the number of years training and the effectiveness of the preceding preparation period.

**Training Indices**

For marathon runners, major emphasis is often placed on distance while training. The adequacy of distance alone, however, should not be considered as a determinant of performance, since distance is a function of intensity and frequency (Franklin, et al., 1978). A training program should include both aerobic and anaerobic exercise. Athletes can improve their aerobic capacity with endurance training and the anaerobic component with interval training. The primary change induced by training augments the delivery of oxygen to muscles with the increased stroke volume characterized by ventricular enlargement. Oxygen consumption by the muscles is enhanced with training because there is an increased number of mitochondria, respiratory enzymes, and fast-twitch, oxidative glycolytic (Type IIa) muscle fibers (Mahler & Loke, 1985).

Although maximal aerobic power obtained by measuring the max VO2 has been suggested to be the best indicator of marathon performance, training frequency, intensity, and duration prior to the marathon race are also important factors relating to performance (Bar-Or, 1975; Hagan, et al., 1981). These factors have been identified for the male
population, but the relative contributions of these variables are not as well known and require further investigation for the female population.

**Training Duration/Distance**

Faster runners have been found to run considerably more miles than slower runners, regardless of whether the time span under consideration was a month, a week, or the course of a single run (Slovic, 1977). In addition, the greater the length of the longest run, the faster the final MPT was independent of the total or maximum weekly mileage (Slovic, 1973). In a similar study conducted by Hagan, et al. (1987) the correlation between MPT and both mean distance run per week and total workout distance run in 8 weeks prior to a marathon was $r = -.67$ for male runners. A correlation coefficient of $r = -.74$ was found between MPT and total workout distance run and mean distance run per week, respectively for female marathon runners. Dotan, et al., (1983) also found correlation coefficients of $r = .64$ to .69 between training distance and MPT, similar to these other studies.

There is also evidence that marathon performance improved markedly with increases in training volume. Foster, Daniels, and Yarbrough (1977) reported a significant difference in training volume prior to best and second best performances of 12 subjects running more than one marathon during an experimental period. On average, a 15.6 km per week (20%) increase in training volume was associated with a 9.9 minute (5%) improvement in performance. Hagan, et al. (1981) found that a 15.6 km per week increase in running was associated with an increase in marathon performance of 8.8 minutes. These improvements in performances were found in both slow and fast runners, however, the increased training appeared to be more important to the slower runners.

Finally, in an unpublished study reported by Maughan (1990) involving a sample of 468 male marathon runners, all of whom had completed the same race, finishing time
was related to a variety of training indices carried out in 6 months prior to the race. The average weekly training distance \((r = -0.54)\), highest weekly training distance \((r = -0.60)\), and longest single training run \((r = -0.46)\) were correlated with marathon finishing times. Although these results provided some evidence that training volume may be an important factor in marathon performance, survey results need to be interpreted with caution.

**Training Intensity.**

Of the three training factors, intensity, frequency, and duration, intensity is the most important with respect to ensuring proper overload (Fox, et al., 1993). Intensity training may be implemented into a program by interval training, which breaks race distances into repetitions. It has been suggested that while training, marathoners run one speed workout every other week, completing 11 to 13 repetitions of one mile each, with walking in between, and that the speedwork period should be extended over 12 to 14 weeks (Galloway, 1984).

Interval training has been recommended for improving performance because it seems to significantly improve the max VO\(_2\) which will in turn decrease performance time (Humphreys, 1979). Intensity training will influence biochemical changes, systemic or cardiorespiratory changes, changes in cholesterol and triglyceride levels, blood pressure, heat acclimatization, connective tissue, and body composition (Fox, et al., 1993). Since interval training influences several variables, the max VO\(_2\) cannot be used as the sole contributor to improved or faster performance times. It is also important to note that those with lower aerobic capacities at the beginning of training will see the greatest improvement with intensity training.

In a study conducted on male marathon runners of varying levels of performance, the index of training intensity 8 weeks prior to the marathon was a poorer predictor of performance \((r = 0.20)\) compared with measured max VO\(_2\) \((r = 0.96)\) related to running
speed in the race. Although intensity can be assessed and measured, it is difficult to quantify (Maughan, 1990). On the other hand, correlational data between MPT and the intensity of training used by female distance runners has been found to be significantly higher than that of males. In women, correlation coefficients of $r = .43$ and $r = .63$ have been found between max VO$_2$ and MPT, respectively (Davies & Thompson, 1979; Maughan & Leiper, 1983). Hagan and associates (1987) have found a correlation of $r = .65$ between max VO$_2$ and MPT in women distance runners. Therefore, it has been concluded that max VO$_2$ may only be of moderate importance for female marathon runners.

**Training Frequency**

Prior to engaging in endurance events, runners may find that more frequent and longer training sessions will provide greater fitness benefits. For improvements in aerobic capacity, training should be carried out to at least 3 times per week, however, many experienced runners expect to train on a daily basis, often more than once per day, and for 1 to 3 hours per day (Maughan, 1990). A recommended training frequency for endurance programs ranges from 3 to 7 days per week. One training session per day is also recommended, since two to three workouts per day do not lead to greater performance gains (Fox, et al., 1993).

World-class distance runners usually run twice a day and between 110 and 240 km per week for 45 to 52 weeks per year. For runners who train below these levels and for aspiring marathoners, it has been recommended that they train for at least 3 months at progressively greater weekly distances, up to an average of 80 km per week, to ensure completion of the marathon (Hagan, et al., 1981).

One marathon per year should be attempted in the first two years of training, although several races from 5 to 15 miles may be implemented for experience. Two
Marathons may be ideal within 3 to 5 years of training, although three may be attempted depending on the phasing of the races (Arnold, 1994).

**Consequences of Overtraining**

Training may become an addictive activity, which can lead to almost a preoccupation with running, racing, and/or weight. However, even the most advanced runner should take at least one day off per week, usually before a long-run (Galloway, 1984). Physical symptoms such as sore and aching muscles, tiredness before and after runs, and changes in appetite are early signs of burnout. When long distances or high intensity workouts are completed without adequate time to rest and recover, or too many races are run consecutively, injury and illness can become a consequence (Galloway, 1984). Many injuries are the result of overambitiousness by an athlete trying to do months of work in one month (Squires, 1983). The American College of Sports Medicine (1979) has reported that the incidence of injury due to running is also related to distances run while training, the running surfaces encountered, biomechanics of the back, legs, and feet, and to foot apparel. Eighty percent of all running injuries have found to be the result of training errors. The most common overuse syndromes include stress fractures, chondromalacia, shinsplints, and tendonitis.

**Summary**

It is apparent from this review of literature that many relationships exist between MPT and several of the variables discussed above. Generalizing these findings to the female marathon runner is difficult since the majority of studies were conducted on males. The intent of this study was to study the correlation between MPT and age, physical characteristics, past running experience, and various training indices in female marathon runners.
CHAPTER III

METHODS AND PROCEDURES

Introduction

The purpose of this study was to determine if marathon performance time correlated to age, physical characteristics, past running experience, or various training indices used by female marathon runners from the ages of 25 to 50. The survey instrument, selection of subjects, procedures, and statistical analysis will be discussed in this chapter.

Survey Instrument

Informed consent was obtained by completion of the one page questionnaire (see Appendix A) which consisted of a total of 19 questions, all of which were open-ended. The questionnaire was modeled after those used in previous studies which related MPT to selected training variables (Dotan, et al., 1983; Franklin, et al., 1978; Slovic, 1977).

The questionnaire was designed to collect information about age at the time of the most recent marathon, height and weight, prior running experience, and training indices 4 to 8 weeks prior to competition. This specific time period was indicated to help prevent confusion and allow for less variability of answers based on different training methods used by athletes. In addition, the BMI and PI were calculated from the height and weight data. Although the max VO₂ was not tested, an optional question was included on the questionnaire for those who had been tested in the past.

Subject Selection

The names and addresses of the subjects were obtained from Media Consultation Services of the Burns Computer Service and International Race Network (1995) in
Michigan. One hundred fifty women were randomly selected by computer to participate in this study. Participants were from the states of Minnesota or Wisconsin and aged 25 to 50. Inclusion criteria also required that the subjects had participated in at least one marathon.

In order to obtain a representative sample and help to ensure a response rate of 75 - 90%, the cover letter (see Appendix B) was personalized. Each subject was assigned a number that was used to determine who had responded to the questionnaire and who would need to be sent a follow-up letter (see Appendix C). Subjects were unable to be identified by name or number on the survey and the envelopes which contained their identification number were discarded to ensure confidentiality.

Fifteen female marathon runners from the ages of 20 to 50 and the state of Wisconsin were chosen to participate in a pilot study. Subjects were contacted by telephone and the one page questionnaire was reviewed for content validity.

Procedure

Once the pilot study was conducted, the questionnaire was revised, and the random sample was identified. The random sample of subjects was sent a letter requesting their participation. A copy of the questionnaire was sent along with a self-addressed stamped envelope. After 3 weeks, 91 of the 150 questionnaires were received, for a response rate of 60.7%. A follow-up letter, another questionnaire, and self-addressed stamped envelope were sent to subjects who had not responded after the 3 weeks. A total of 123 out of 150 surveys or 82.0% of the questionnaires were obtained at completion of the study.

Statistical Analysis

A statistical program (ASP) was used for analysis of this study (Blackford, 1992). The mean MPT of each of the following age groups was determined: 25 - 29, 30 - 34,
The means, standard deviations, minimum and maximum values, and ranges of each of the variables derived from the questionnaire were also calculated. This descriptive analysis was performed on the subjects as a group. All variables derived from the questionnaire were analyzed with the exception of max VO₂ because of insufficient data.

Pearson product correlations (r) and coefficients of determination (r²) were calculated between MPT and each of the independent variables to further study their interrelationships. The independent variables included: (a) age, (b) physical characteristics (height, weight, BMI, and PI), (c) past running experience (total marathons completed, marathons completed per year, and number of years running distances greater than 5 miles), and (d) training indices (duration, intensity, and frequency). Training duration variables included the longest training run, weeks prior to competition that longest training run was completed, and miles run per week. Training intensity variables consisted of the fastest mile time, pace while running 5 to 10 miles, pace while running 10 to 15 miles, and interval training sessions per week. The frequency of training was analyzed by determining the number of times per week that subjects were running 5 to 9 miles, number of times running 10 to 15 miles per week, and number of times per week engaged in no activity. These training variables were for the time period of 4 to 8 weeks prior to competition.

A stepwise regression analysis was used to determine which combination of variables were the best predictors of MPT. This technique selects variables for a regression equation one at a time until the most useful remaining variable produces no statistically significant increase in multiple correlation. The .05 level of statistical significance was chosen for this particular study.
CHAPTER IV
RESULTS AND DISCUSSION

Introduction

The purpose of this study was to determine the correlation between marathon performance time and age, physical characteristics, previous running experience, and various training indices. One hundred fifty female marathon runners from the ages 25 to 50, who had completed at least one marathon and resided in the states of Wisconsin or Minnesota were randomly selected for this study. Data obtained from the questionnaire were analyzed using descriptive summary statistics, Pearson product correlations, and stepwise regression analysis.

Response to the Questionnaire

Ninety-one of the 150 subjects (61.8%) responded to the questionnaire after 3 weeks. Three weeks after the second mailing a total of 123 questionnaires were returned for a total response rate of 82.0%.

Descriptive Statistics

MPT, Age, Physical Characteristics, and Previous Running Experience

Group means, standard deviations, maximum and minimum values, and ranges for MPT, age, physical characteristics, and previous running experience presented in Table 2.
### Table 2. Descriptive statistics of marathon performance time, age, physical characteristics, and previous running experience

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPT (hrs; N = 122)</td>
<td>4.08</td>
<td>0.67</td>
<td>2.77</td>
<td>6.08</td>
<td>3.32</td>
</tr>
<tr>
<td>Age (yrs; N = 123)</td>
<td>37.77</td>
<td>6.42</td>
<td>26.00</td>
<td>49.00</td>
<td>23.00</td>
</tr>
<tr>
<td>Ht (cm; N = 121)</td>
<td>165.10</td>
<td>5.99</td>
<td>152.40</td>
<td>179.07</td>
<td>26.67</td>
</tr>
<tr>
<td>Wt (kg; N = 122)</td>
<td>57.98</td>
<td>6.62</td>
<td>47.27</td>
<td>77.27</td>
<td>30.00</td>
</tr>
<tr>
<td>BMI (kg/m²; N = 122)</td>
<td>21.31</td>
<td>2.14</td>
<td>17.76</td>
<td>27.64</td>
<td>9.88</td>
</tr>
<tr>
<td>PI (ht/³; N = 122)</td>
<td>12.90</td>
<td>0.48</td>
<td>11.26</td>
<td>13.99</td>
<td>2.73</td>
</tr>
<tr>
<td>TM (N = 122)</td>
<td>8.93</td>
<td>8.49</td>
<td>1.00</td>
<td>55.00</td>
<td>54.00</td>
</tr>
<tr>
<td>MPY (N = 116)</td>
<td>1.52</td>
<td>0.99</td>
<td>0.00</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>YR &gt; 5 (N = 122)</td>
<td>9.93</td>
<td>4.83</td>
<td>2.00</td>
<td>24.00</td>
<td>22.00</td>
</tr>
</tbody>
</table>

**BMI** = Body mass index, **PI** = Ponderal index, **TM** = Total marathons, **MPY** = Marathons per year, and **YR > 5** = Years running distances greater than 5 miles.

As illustrated in Table 2, MPT ranged from 2.77 hr to 6.08 hr. The mean was 4.08 hr and the standard deviation 40 min. Ages ranged from 26 to 49, with a mean of 37.77 years. Of the physical characteristics, the mean height was found to be 165.10 cm, with a standard deviation of 5.99 cm. The shortest subject was 152.4 cm while the tallest was 179.07 cm. The mean weight of the subjects was 57.98 kg and the standard deviation 6.62 kg. The lightest person was 47.27 kg and the heaviest 77.27 kg. The mean BMI was 21.31, the smallest 17.76 and the largest 27.64 kg/m². The mean PI was found to be 12.9 and ranged from 11.26 to 13.99.
Data from previous running experience included total marathons completed (TM), marathons per year (MPY), and the number of years running distances greater than 5 miles (YR > 5). The mean number of total marathons ran was 8.93, with a standard deviation 8.49. The minimum number of marathons ran was 1 and the maximum number was 55 for a range of 54 marathons. The mean number of marathons ran per year was 1.52 with a standard deviation of almost 1 per year (0.99). Some runners did not compete in marathons on a yearly basis due to unsuccessful completion or discontinuation of running. The mean number of years that subjects were running distances greater than 5 miles was 9.93 years (S.D. = 4.83 years).

The mean MPT was also broken down into age categories and is listed in Table 3.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>n</th>
<th>MPT (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 - 29</td>
<td>18</td>
<td>3.97</td>
</tr>
<tr>
<td>30 - 34</td>
<td>25</td>
<td>3.72</td>
</tr>
<tr>
<td>35 - 39</td>
<td>22</td>
<td>4.16</td>
</tr>
<tr>
<td>40 - 44</td>
<td>36</td>
<td>4.29</td>
</tr>
<tr>
<td>45 - 49</td>
<td>22</td>
<td>4.15</td>
</tr>
</tbody>
</table>

As indicated, those aged 30 to 34 had the mean fastest time of 3.72 followed by the 25 to 29 year old age group, with a mean MPT of 3.97 hr. Those in the 40 to 44 year old age category had the mean slowest MPT with a value of 4.29 hr.
Training Indices

Group means, standard deviations, minimum and maximum values, and ranges were calculated for the various training indices used by the female marathon runners. These results are presented in Table 4 and include the training duration, intensity, and frequency variables for the time period of 4 to 8 weeks prior to marathon competition.

Table 4. Descriptive statistics of various training indices

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTR (N = 123)</td>
<td>21.48</td>
<td>3.77</td>
<td>10.00</td>
<td>50.00</td>
<td>40.00</td>
</tr>
<tr>
<td>WLTR (N = 123)</td>
<td>2.67</td>
<td>0.78</td>
<td>1.50</td>
<td>7.00</td>
<td>5.50</td>
</tr>
<tr>
<td>MPW (N = 120)</td>
<td>40.72</td>
<td>12.39</td>
<td>10.00</td>
<td>90.00</td>
<td>80.00</td>
</tr>
<tr>
<td>FMT (N = 115)</td>
<td>7.17</td>
<td>1.08</td>
<td>5.13</td>
<td>11.50</td>
<td>6.37</td>
</tr>
<tr>
<td>P5-10 (N = 123)</td>
<td>8.29</td>
<td>1.02</td>
<td>6.00</td>
<td>12.00</td>
<td>6.00</td>
</tr>
<tr>
<td>P10-15 (N = 123)</td>
<td>8.75</td>
<td>1.15</td>
<td>6.75</td>
<td>13.50</td>
<td>6.75</td>
</tr>
<tr>
<td>IPW (N = 120)</td>
<td>0.73</td>
<td>0.68</td>
<td>0.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>5-9W (N = 123)</td>
<td>3.70</td>
<td>1.33</td>
<td>1.00</td>
<td>7.00</td>
<td>6.00</td>
</tr>
<tr>
<td>G10W (N = 123)</td>
<td>1.63</td>
<td>0.70</td>
<td>0.00</td>
<td>3.50</td>
<td>3.50</td>
</tr>
<tr>
<td>NAW (N = 121)</td>
<td>1.20</td>
<td>0.74</td>
<td>0.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

LTR = Longest training run, WLTR = Weeks prior to competition that longest training run is completed, MPW = Miles per week, FMT = Fastest mile time, P5 - 10 = Minute per mile pace while running distances of 5 to 10 miles, P10 - 15 = Minute per mile pace while running distances of 10 to 15 miles, IPW = Intervals per week, 5 - 9W = Number of times per week ran distances of 5 to 9 miles, G10W = Number of times per week ran distances greater than 10 miles, and NAW = Number of times per week engaged in no activity.
The training duration variables consisted of the longest training run (LTR), number of weeks prior to competition that the longest training run was completed (WLTR), and the number of miles run per week (MPW). The longest training run ranged from 10 miles to 50 miles, with a mean of 21.48 miles and a standard deviation of 3.77 miles. The mean number of weeks prior to competition that the longest training run was completed was found to be 2.67, with a standard deviation of less than 1 (0.78). The mean number of miles run per week while training 4 to 8 weeks prior to competition was found to be 40.72. The least number of miles run per week was 10 and the maximum was 90.

The training intensity variables included the fastest mile time (FMT), minute per mile pace when running distances of 5 to 10 miles (P5-10), minute per mile pace while running distances of 10 to 15 miles (P10-15), and number of times per week that subjects engaged in interval training (IPW). The fastest mile time was found to be 5.13 min and the slowest was 11.30 min. The mean fastest mile time was 7.17 min, with a standard deviation of 1.08 min. The mean min per mile pace ran from distances of 5 to 10 miles was 8.29 min. In contrast, the mean min per mile pace ran for distances of 10 to 15 miles was 8.75 min. The number of intervals per week was less than 1 time per week (0.73), with the maximum number of 2 times per week.

The training frequency variables were the number of times per week that the subjects ran distances of 5 to 9 miles (5-9W), the number of times per week subjects ran distances equal to or greater than 10 miles (G10W), and the number of times per week that they engaged in no activity (NAW). The number of times per week that subjects ran distances of 5 to 9 miles was 3.7, with a standard deviation of 1.33. The mean number of times subjects ran distances equal to or greater than 10 miles was 1.63 times per week, with a standard deviation of 0.74. The maximum number of times that distances greater
than 10 miles were run was 3.5 times per week. The mean number of days per week that no activity was done was 1.2 with a minimum of 0, and maximum value of 5.

**Correlation Coefficients and Coefficients of Determination**

**Age, Physical Characteristics, and Previous Running Experience**

Correlation coefficients ($r$) and coefficients of determination ($r^2$) between MPT and age, physical characteristics, and previous running experience are listed in Table 5.

**Table 5.** Correlation coefficients ($r$) and coefficients of determination ($r^2$) between marathon performance time and age, physical characteristics, and past running experience

<table>
<thead>
<tr>
<th>Variable</th>
<th>$r$</th>
<th>$r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.23</td>
<td>0.05</td>
</tr>
<tr>
<td>Height</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Weight</td>
<td>0.43</td>
<td>0.18</td>
</tr>
<tr>
<td>BMI</td>
<td>0.44</td>
<td>0.19</td>
</tr>
<tr>
<td>PI</td>
<td>-0.39</td>
<td>0.15</td>
</tr>
<tr>
<td>TM</td>
<td>-0.19</td>
<td>0.04</td>
</tr>
<tr>
<td>MPY</td>
<td>-0.21</td>
<td>0.04</td>
</tr>
<tr>
<td>YR&gt;5</td>
<td>-0.25</td>
<td>0.06</td>
</tr>
</tbody>
</table>

BMI = Body mass index, PI = Ponderal index, TM = Total marathons, MPY = Marathons per year, and YR > 5 = Years running distances greater than 5 miles; ($p < .05$)

As illustrated, MPT correlated positively with age, height, weight, and the BMI. In contrast, MPT negatively correlated to PI, number of total marathons completed, marathon completed per year, and the number of years running distances greater than 5
miles. Compared to the other four physical characteristics analyzed, the BMI ($r = .44$) correlated to MPT, however the correlation was still rather low. The variables related to past running experience variables all were negatively correlated to MPT.

**Training Indices**

The $r$ and $r^2$ between MPT and various training indices are presented in Table 6.

<p>| Table 6. Correlation coefficients ($r$) and coefficients of determination ($r^2$) between marathon performance time and various training indices |</p>
<table>
<thead>
<tr>
<th>Variable</th>
<th>$r$</th>
<th>$r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTR</td>
<td>-0.16</td>
<td>0.03</td>
</tr>
<tr>
<td>WLTR</td>
<td>-0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>MPW</td>
<td>-0.55</td>
<td>0.30</td>
</tr>
<tr>
<td>FMT</td>
<td>0.75</td>
<td>0.56</td>
</tr>
<tr>
<td>P5-10</td>
<td>0.81</td>
<td>0.66</td>
</tr>
<tr>
<td>P10-15</td>
<td>0.83</td>
<td>0.69</td>
</tr>
<tr>
<td>IPW</td>
<td>-0.33</td>
<td>0.11</td>
</tr>
<tr>
<td>5-9W</td>
<td>-0.44</td>
<td>0.19</td>
</tr>
<tr>
<td>G10W</td>
<td>-0.37</td>
<td>0.14</td>
</tr>
<tr>
<td>NAW</td>
<td>0.38</td>
<td>0.14</td>
</tr>
</tbody>
</table>

LTR = Longest training run, WLTR = Weeks prior to competition that longest training run is completed, FMT = Fastest mile time, MPW = Miles per week, P5 - 10 = Minute per mile pace while running distances of 5 to 10 miles, P10 - 15 = Minute per mile pace while running distances of 10 to 15 miles, IPW = Intervals per week, 5 - 9W = Number of times per week ran distances of 5 to 9 miles, G10W = Number of times per week ran distances greater than 10 miles, and NAW = Number of times per week engaged in no activity; ($p < .05$)
These variables are specifically for the period of 4 to 8 weeks prior to marathon competition. The training duration variables of longest training run, weeks prior to competition that the longest training run was completed, and the miles ran per week all correlated negatively to MPT. The fastest mile time \((r = .75)\), min per mile pace ran from distances ranging from 5 to 10 miles \((r = .81)\), and the min per mile pace ran from distances ranging from 10 to 15 miles \((r = .83)\) were the variables that most highly correlated with MPT. Fifty-six, 66, and 69% of the variance in MPT could be accounted for by the fastest mile time, min per mile pace ran from distances of 5 to 10 miles, and min per mile pace ran from distances of 10 to 15 miles, respectively. The number of intervals per week, the number of times per week subjects ran 5 to 9 miles, the number of times per week subjects ran distances greater than 10 miles, and the number of times per week that subjects did not exercise did not correlate well with MPT \((p < .05)\).

**Stepwise Regression Analysis**

Stepwise regression analysis was used to analyze which combination of variables would be most highly predictive of MPT. The dependent variable was MPT and the independent variables included min per mile pace when running from 10 to 15 miles \((r = .83)\), number of times per week subjects ran distances of 5 to 9 miles \((r = -.44)\), and the fastest mile time \((r = .75)\). A constant was also included in the prediction equation which took the following form:

\[
\text{MPT (hr)} = 0.346762 (P10 - 15) - 0.093685 (TS - 9) + 0.15369(FMT) + 0.31167
\]

The adjusted \(r^2\) for this particular equation was found to be .77, indicating that 77\% of the variance in final MPT could be accounted for by the min per mile pace when running from 10 to 15 miles, number of times per week subjects ran distances of 5 to 9 miles, and the fastest mile time run 4 to 8 weeks prior to competition \((p < .001)\).
Discussion

Age and MPT

The correlation of $r = 0.23$ was found between age and MPT ($N = 123$). A low correlation ($r = .26$) between these two variables was also found in a similar study conducted by Hagan et. al. (1987) for females aged 19 to 54. As explained by Dotan, et al. (1983), age does not necessarily reflect experience and training background. In addition, many distance runners start training specifically for the marathon at younger ages, whereas in the past, runners would run distance only after years of experience at shorter distances.

Previous researchers have also concluded that marathon performance declines with increasing age and runners generally reach their peak in the late 30's and early 40's (Maughan, 1990). In contrast, it has also been suggested that performance peaks in the late 20's and early 30's (Costill, 1979). Ages were not specified for males or females which made it difficult to generalize previous findings to those found for this female population of runners. In this particular study, those aged 30 to 34 had the fastest mean MPT ($n = 25$; 3.72 hr), followed by those aged 25 to 29 ($n = 18$; 3.97 hr). Even though this does not indicate that each individual marathoner reached their peak performance time in their late 20's and early 30's, it does help to support that MPT declines after the age of 34 years. This decline in performance is due to many physiological factors such as a decline in max $VO_2$ and changes in body composition, which will influence one's training capacity and success at completing the marathon.

Physical Characteristics and MPT

Good marathon runners have been typified as being short in stature and low in body weight (Maughan, 1992). International caliber female athletes have been found to be 169.4 cm tall, 57.2 kg, and approximately 15.2% body fat (Wilmore and Brown,
1992). The subjects in this study on average were shorter (166.37 cm) and heavier (57.98 kg). The body composition of the athletes in this study was most likely different from those of a higher caliber, in that the percent body fat was higher. This can only be assumed since body fat composition data were not obtained.

The mean BMI of 21.31 was also in the acceptable range according to standards illustrated in Table 1 (Mahan & Arlin, 1992). The BMI was the best predictor of MPT \( (r = .43) \) compared to the other physical characteristics analyzed. The correlation found in this study was slightly lower \( (r = .52) \) than previously found in novice and experienced female marathon runners (Hagan, et al., 1987). Dotan, et al. (1983) also indicated that BMI correlated \( (r = .57) \) more highly to MPT than height or weight alone, which was supported in this study.

The mean PI (12.9) was within the average range of 12 to 13 which had previously been established. The PI negatively correlated to MPT \( (r = -.39) \), indicating that leaner individuals, those with higher PIs, had faster MPT, however, only 19 and 15% of the variance on final MPT could be explained by the values of one's BMI or PI, respectively. Although the correlations were low, there was some support that a larger body size prolongs performance time (Hagan, et al., 1987). This increase in body size or weight will also increase the work load, which can prolong performance time (Fox et al., 1993).

Previous Running Experience and MPT

Previous running experience was represented by the total marathons ran (mean = 8.93), marathons ran per year (mean = 1.52), and the number of years that subjects were running distances greater than 5 miles (mean = 9.93). These variables all negatively correlated to MPT, although less than 6% of the variance in final MPT could be explained by these variables as single entities. Although it has been suggested that the experienced
marathoner may be able to integrate a more effective strategy for completing marathons (Franklin, et al., 1978), the number of marathons completed in the past, number completed per year, or number of years running distances longer than 5 miles, did not seem to influence final performance time.

**Training Duration and MPT**

The longest training run (r = -.16) and weeks prior to competition that the longest training run was completed (r = -.02) were both poor predictors of final MPT. The miles ran per week (r = -.55) correlated more highly with MPT, but only 30% of the variance in final MPT could be accounted for by weekly mileage. The mean number of miles ran was approximately 40 per week, specifically 4 to 8 weeks prior to competition. In contrast, a study conducted by Hagan, et al. (1987) noted that both novice and experienced female marathoners ran a mean of 51.5 miles per week. The correlation between miles per week and MPT was also higher in that study (r = -.74). In comparing the mileage and the correlation values of past research to the values in this study, it is evident that an increase in training volume can lead to a faster MPT. Although weekly mileage may influence MPT, the training intensity variables were better predictors of final MPT in this study of female distance runners.

**Training Intensity and MPT**

The highest correlations were found between each of the training intensity variables and MPT. The mean fastest mile time (r = .75) was found to be 7.17 min. The min per mile paces ran from 5 to 10 miles (r = .81) and 10 to 15 miles (r = .83) correlated most highly in which 66 and 69% of the variance in final MPT could be explained by the min per mile pace ran from distances of 5 to 10 miles and the min per mile pace ran from distances of 10 to 15 miles, respectively. These results indicate that intensity training is the most important factor in ensuring proper overload (Maughan, 1990). It also can be
implied that intensity training will improve the max VO₂ the most, which has important implications for those wanting to improve their MPT.

**Training Frequency and MPT**

Recommended training frequency for endurance programs ranges from 3 to 7 days per week. The mean number of times that subjects ran distances of 5 to 9 miles per week prior to competition was 3.7 times. The mean number of times they ran greater than 10 miles weekly was 1.63. Subjects did not exercise or engage in any activity for a mean number of 1.2 times per week. The correlations between MPT and the number of times per week that distances of 5 to 9 miles were ran ($r = -0.44$), the number of times per week that distances equal to or greater than 10 miles were ran ($r = -0.37$), and number of times per week that no activity was done ($r = 0.38$) were very low. It was surprising that the number of times that subjects ran distances of 5 to 9 miles on a weekly basis correlated more highly than the frequency of running distances greater than 10 miles weekly. It seems as though longer runs would be more important when training for the 26.2 mile event, however this was not the case with this subject pool. This may indicate that marathoners are running shorter distances at a higher intensity more frequently than they are engaging in runs over 10 miles on a weekly basis. This would explain the higher correlations between MPT and training intensity. Hagan, et al. (1981) recommended an average weekly mileage of 50 miles per week approximately 8 weeks prior to competition to ensure marathon completion.

**Regression Analysis**

Previously multiple regression equations have been developed using a variety of training factors to predict MPT. These equations however, were specifically for male marathon runners. Hagan et al. (1981) suggested that age, max VO₂, total number of workouts, and total workout distance gave the best prediction for MPT ($r^2 = .71$). In
contrast, Hagan, et al. (1987) indicated that for females, the distance run per day and workout pace were the most powerful predictors of MPT ($r^2 = .68$). Davies and Thompson (1979) reported an $r^2$ value of .99 when max VO$_2$ and percent max VO$_2$ utilized during the run were used to predict MPT, while Foster (1983) found that max VO$_2$ alone predicted MPT with an $r^2$ value of .91. The range in variance has been attributed to the time over which the training variables were collected.

In this particular study, the min per mile pace when running distances 10 to 15 miles, the number of times per week subjects ran 5 to 9 miles, and the fastest mile time 4 to 8 weeks prior to competition were selected by a stepwise regression analysis and an $r^2$ value of .77 was obtained ($p < .001$). Although the $r^2$ value for this equation was not as high as those which used max VO$_2$, the derived MPT prediction equation can be utilized since many runners do not know their max VO$_2$ value. It is also important to note that regression equations are general predictors of performance and not specific indicators of success.
CHAPTER V
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

The purpose of this study was to determine the correlation between MPT and age, physical characteristics, previous running experience, and various training indices. One hundred twenty-three randomly selected females aged 25 to 50, from the states of Wisconsin and Minnesota completed the one page questionnaire for a total response rate of 82.0%. The names and addresses of the subjects were obtained from Media Consultation Services of the Burns Computer Service and International Race Network. Data were analyzed using descriptive statistics, Pearson product correlations and stepwise regression analysis.

Each correlation coefficient was statistically significant at the .05 level. The variables that correlated most highly to MPT were the min per mile pace when running distances of 10 to 15 miles \( r = .83 \), min per mile pace when running distances of 5 to 10 miles \( r = .81 \), and the fastest mile time \( r = .76 \) 4 to 8 weeks prior to competition. Age, physical characteristics, previous running experience, training duration, and training frequency were also correlated to MPT, but the correlations were much lower.

A prediction equation for MPT was established for female runners using stepwise regression analysis. The min per mile pace when running distances of 10 to 15 miles \( r = .83 \), the number of times per week that distances of 5 to 9 miles were ran \( r = -.44 \), and the fastest mile time \( r = .75 \) were the variables selected for this analysis. The percent of variance in MPT explained by this equation was 77% \( p < .001 \). This indicates that 23% of the variation in MPT could not be accounted for by the min per mile pace ran from distances ranging from 10 to 15 miles, the number of times per week
that subjects ran distances of 5 to 9 miles and the fastest mile time. Although this was lower than many of the equations established for males in which the max \( V_\text{O}_2 \) was utilized, it can be a useful and practical tool to predict final MPT based on one's training regimen 4 to 8 weeks prior to competition.

**Recommendations**

The following recommendations, which are modifications of this study, have been made for future study:

1. In addition to collecting the questionnaire data, also include laboratory testing. Maximal oxygen consumption (max \( V_\text{O}_2 \)) has been found to correlate highly with MPT in the past and by implementing this test, additional MPT prediction equations may be established for females. Also include hydrostatic weighing and/or skinfold measurements for a better assessment of physical characteristics such as body fat/lean body mass ratio.

2. Conduct a comparative study between males and females. Compare the correlation coefficients between the two groups to determine if some training variables are more predictive of MPT than others.

3. Expand the questionnaire to include more training variables and/or investigate if the goals and motives of distance runners correlate to MPT.

4. Survey the top 20% of marathon finishers at the race site. This may provide a more homogeneous sample with a narrower spread of performance times.
REFERENCES


APPENDIX A

THE TRAINING QUESTIONNAIRE
THE TRAINING QUESTIONNAIRE
Please write your answers in the blanks provided.

1. What is your birthdate? ____________________________

2. What is your height? _______ feet _______ inches

3. What is your weight? _______ pounds

4. What was the month and year of your most recent marathon? __________________

5. What was the finishing time of your most recent marathon? __________________

6. How many total marathons have you completed? ____________

7. On average, how many marathons do you complete per year? ____________

8. How many years have you been running distances greater than 5 miles? ____________

9. How long is your longest training run, in miles, prior to running a marathon? ____________

10. How many weeks prior to a marathon do you complete your longest training run? ____________

Please base your answers to the following questions as if you were 4-8 weeks from competing in a marathon.

11. What is your fastest mile time? ____________

12. What is your pace (min./mile), when running 5-10 miles? ____________

13. What pace do your run (min./mile), when running 10-15 miles? ____________

14. How many miles do you average per week? ____________

15. How many times per week do you run intervals, such as multiple 880s or a mile at greater than 90% of your best effort with walking or slow jogging in between intervals? ____________

16. How many days per week do you run distances ranging from 5 to 9 miles? ____________

17. When training, how many days per week do you run distances equal to or greater than 10 miles? ____________

18. What is the average number of days per week that you do not engage in any type of exercise? ____________

19. (OPTIONAL) If you have ever had your VO2max tested, what was it and when did you have it done? VO2max ____________ Year tested ____________
APPENDIX B

COVER LETTER REQUESTING PARTICIPATION
Dear

Congratulations on completion of your most recent marathon! I hope that you met the goals you set out to accomplish. I ran The Twin Cities Marathon in October of 1994, and even though I set a personal record, I still have considerable room for improvement. I have done some research of various training methods which can help to improve performance. However, the research involving marathon preparation and performance is limited for women.

Which brings me to the reason why I am writing this letter. I am interested in determining what methods you use to train for marathons. Several experienced female marathon runners from the states of Wisconsin and Minnesota were randomly selected to complete the enclosed questionnaire. Your name was obtained through the Burns Computer Service and International Race Network. I plan to use the data from the questionnaire to determine if any correlation exists between marathon performance time and training methods, physical data, age, or prior running experience.

Please take 10 minutes out of your busy schedule within the next week to complete the enclosed questionnaire. It is painless, your answers will be confidential, and you will be making a significant contribution to women's training studies. Thank you!

Sincerely,

Tracy M. Hamm, R.D.
Human Performance

Enclosures: 1
APPENDIX C

FOLLOW-UP LETTER REQUESTING PARTICIPATION
Date

Dear

I sent a questionnaire to you several weeks ago regarding your marathon training methods and have not received your response. I understand that you may not have had time to complete the questionnaire, but your input is very important because only a few women were contacted. In addition, your responses can help make a significant contribution to women's training studies.

For your convenience I have included another copy of the questionnaire. Please take 10 minutes out of your day to complete the survey. If you would like I can send you a copy of the results (please indicate this on the training questionnaire). I also want to reassure you that your answers will be kept strictly confidential.

Thank you for your cooperation.

Sincerely,

Tracy M. Hamm, R.D.
Human Performance

Enclosures: 1