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The association between the Yamax Step Counter and the College Alumnus Quesionnaire

Abigail Elaine Geslani
University of Tennessee

To the Graduate Council:

I am submitting herewith a thesis written by Abigail Elaine Geslani entitled "The association between the Yamax Step Counter and the College Alumnus Quesionnaire." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Human Performance and Sport Studies.

David R. Bassett Jr., Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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THE ASSOCIATION BETWEEN THE YAMAX STEP COUNTER AND THE COLLEGE ALUMNUS QUESIONNAIRE

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Abigail Elaine Geslani
May, 2002

DEDICATION

This thesis is dedicated to my parents, Randolph and Edith. For as long as I can remember, you have stressed the importance of my education – something that can never be taken away from me. I would not have come this far without your love, support, and encouragement. You have shown me that anything is possible when you believe in yourself and have faith in God. Mahál Kitá!

your daughter,
Abby

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ABSTRACT

The primary purpose of this study was to examine the association between an electronic pedometer and a physical activity questionniare. Additionally, we sought to examine the percent agreement between two methods of classifying inactive and active individuals. It was hypothesized that individuals who report an energy expenditure greater than 2,000 kilocalories per week on a physical activity questionnaire would take more than 10,000 steps per day as measured by an electronic pedometer. Sixty male subjects between the ages of 19 and 74 years old participated in this study. In order to participate, participants had to be free from any disability preventing him from being ambulatory. Subjects were asked to fill out the College Alumni Questionnaire, which inquired about past and present health and family history, and current physical activity participation. From this questionnaire, a physical activity index was estimated to provide an estimate of weekly energy expenditure. Once the questionnaire was completed, subjects were given a Yamax Digi-Walker SW 200 pedometer. They were instructed to begin wearing the pedometer the next morning, and to wear it for seven consecutive days. Step counts for the seven days were summed and divided by seven to obtain an average step count. Chi-square coefficient of association and a phi coefficient of association were used to determine the relationship and the strength of the relationship between the two thresholds. Results indicated that there was a significant relationship between the two pedometer and questionnaire ($x^2 = 24.76$, $p < 0.0001$ and $\Phi = 0.64$). There was an 80% agreement between the two methods of classifying people according to active and inactive people. This suggests that the 10,000 step goal is an acceptable recommendation for most individuals.

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CHAPTER I

INTRODUCTION

Physical activity influences an individual's health in many ways. A lack of physical activity can negatively impact an individual. Physically active individuals have better serum lipid profiles, improved cardiovascular health, decreased risk of osteoporosis, and better mental health (8, 18, 23, 24, 25, 26, 29, 31, 32, 33, 35, 39). Longitudinal studies have also shown that sedentary people who increase their physical activity demonstrate improvement in health outcomes (24, 35).

The question remains as to how much physical activity is needed for individuals to derive these benefits. The American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC) recommend at least 30 minutes of moderate intensity activity on most, and preferably all, days of the week in order to have benefits on health (36). The problem is how does an individual estimate the amount of physical activity that he/she participates in every day, and how does this measurement translate into the half-hour of moderate intensity activity that is recommended by the ACSM and the CDC. How do we know that the exercise we participate in is sufficient to provide health benefits?

There are many methods of estimating the amount of physical activity an individual performs. These include motion sensors, questionnaires, physical activity recalls, dietary assessments, physiological assessments, and body composition assessments. The most feasible and cost-effective of these are the physical activity questionnaires.

Large-scale, population based studies have shown that there is a relationship between physical activity and risk of coronary heart disease (39). One of the most important studies of this type was the college alumni study, by Paffenbarger (32). He mailed questionnaires to approximately 20,000 male Harvard Alumni and asked questions regarding their current level of physical activity (32, 33, 34, 35). Six to ten years later, he assessed first heart attack through follow-up questionnaires and national death records (which lists causes of death). Researchers first found that those with high levels of activity (physical activity index greater than 2,000 kilocalories/week) had death rates that were one quarter to one third lower than those with lower levels of physical activity. In addition, they found that high levels of energy expenditure were associated with a 10%-20% reduction in the risk of coronary heart disease. They also found that those with low levels of physical activity (< 2,000 kilocalories/week) had a 64% greater risk of fatal heart attacks. This research had significant impact on physical activity recommendations put forth by the ACSM and the CDC (36).

Pedometers are instruments that provide simple, relatively objective measures of physical activity. Their primary use is measurement of walking distance. In recent years, pedometers have gained popularity for their use as a motivational tool. A Japanese researcher, Hatano, has estimated that walking 10,000 steps requires an energy expenditure of 333 kcals for an average Japanese male (15). If this is true, an individual who follows the 10,000 steps per day recommendation will expend greater than 2,000 kcals/week. This level of energy expenditure is supposed to be associated with a reduced risk of cardiovascular disease, according to Paffenbarger's study.

The primary purpose of this study is to examine the association between an electronic pedometer and the College Alumnus Questionnaire. Additionally, we sought to examine the percent agreement between two methods of classifying physically active and inactive people - Hatano's 10,000 steps per day and the Harvard Alumni's 2,000 kilocalories per week. These thresholds are based on two different assessments of physical activity. It is hypothesized that individuals who take more than 10,000 steps per day will report an energy expenditure greater than 2,000 kilocalories per week on the College Alumnus Questionnaire. In addition, it is hypothesized that individuals who take less than 10,000 steps per day will report an energy expenditure less than 2,000 kilocalories per week.

CHAPTER II

REVIEW OF LITERATURE

This review of literature will focus on two methods of categorizing people on the basis of activity levels. One method came from the Harvard Alumni Study of Paffenbarger et al. (32, 33, 34, 35). From this on-going cohort study, an estimated energy expenditure greater than or equal to 2,000 kilocalories per week is associated with a reduced risk of cardiovascular disease. The other method originated in Japan, and it involves the use of an electronic pedometer. It states that individuals should take at least 10,000 steps per day for good health. This review of literature will focus on the two methods of classifying physical activity, their background and methodology. It will also focus on the estimation of physical activity and energy expenditure.

Methods of Estimating Physical Activity and Energy Expenditure

Physical activity has an important role in the health of individuals (8, 24, 34). The effects of physical activity on health have been extensively studied by Paffenbarger et al. (32, 33, 34, 35). Researchers have emphasized that physical activity is an important part of an individual's health. As Hippocrates (42) once said, "All parts of the body which have a function, if used in moderation and exercised in labours in which is accustomed, become thereby healthy, well-developed and age more slowly, but if unused and left idle, they become defective to disease, defective in growth, and age quickly." Although this statement was made many years ago, it still holds true today. A lack of daily physical activity in modern society is an important factor in the etiology of many health problems, such as coronary heart disease and obesity (32, 33, 35, 37).

Casperson's definition of physical activity will be used in this discussion of measures of physical activity. He defined physical activity as "any bodily movement produced by skeletal muscles that results in energy expenditure." (9). Over 20 different methods have been used to assess physical activity and energy expenditure (22). The discussion of the measurement of physical activity is appropriate since physical activity results in energy expenditure. The following section will focus on two instruments used to assess physical activity and estimate energy expenditure – physical activity questionnaires and electronic pedometers.

Physical activity questionnaires

Physical activity questionnaires have been used for many years to determine an individual's physical activity level and energy expenditure. Their primary use is in large populations because they are inexpensive when compared to other methods of estimating energy expenditure. The questionnaires can be self-administered, use an interview process, or a combination of both. It is important that leisure-time, occupational, and household energy expenditure are included in these questionnaires; otherwise energy expenditure could be underestimated in certain populations (32). One should also take into consideration temporal variation (seasonal and yearly) since individuals may exhibit different patterns over time (13). In addition, one should choose study populations carefully since different subpopulations may have different physical activities and habits.

One type of physical activity questionnaire is the Seven-Day Physical Activity Recall. The Seven-Day Physical Activity Recall is an interview-type questionnaire that is given at the end of a one-week period. In a study by Irwin et al. (17), the use of the Seven-Day Physical Activity Recall was compared to doubly labeled water, which is the gold standard for measuring energy expenditure in free-living populations. The researchers found that energy expenditure estimated from the Seven-Day Physical Activity Recall was significantly higher when compared to that from the doubly labeled water (4156 kilocalories/day vs. 1316 kilocalories/day, $p < 0.05$). In addition, increasing age, body mass index, and percentage of body fat were associated with greater overestimations of energy expenditure, although these associations were not found to be significant. The researchers concluded that factors such as age and percent body fat affect the accuracy of the Seven-Day Physical Activity Recall.

Many other physical activity questionnaires are available for use, and are used in various situations (30). For example, the Health Insurance Plan of New York Questionnaire was developed to study coronary heart disease in New York City. The Yale Physical Activity Survey is an interview-style questionnaire that was developed for assessing habitual physical activity in elderly subjects. In addition, the Amsterdam Growth Study Questionnaire was developed for children, and covered the previous three months of physical activity.

One of the most popular physical activity questionnaires is the College Alumnus Questionnaire. Jacobs et al. (19) examined ten commonly used physical activity questionnaires. The researchers studied ten questionnaires in relation to several direct and indirect validation areas, including treadmill exercise performance, concurrent physical activity records, and concurrent four-week physical activity logs. They found that test-retest reliability of two surveys spaced one month apart was high for all questionnaires. The College Alumnus Questionnaire was found to be valid for vigorous activity, and to a lesser extent for light intensity leisure activity. Moderate intensity scores from a four-week physical activity history were not related to reports on the College Alumnus Questionnaire. The measures of cardiorespiratory fitness were only moderately correlated with physical activity reported on the College Alumnus Questionnaire.

In another study, Ainsworth et al. (1) specifically examined the test-retest reliability and the validity of the College Alumnus Questionnaire against various direct and indirect measures of physical activity. Seventy-eight volunteers participated in this study. Participants recorded physical activity for 48 hours prior to each of their visits to the clinic. During the same time period, participants wore an accelerometer and recorded their energy expenditure readings from the accelerometer on their physical activity record form. During each visit, participants completed several questionnaires regarding their physical activity habits and reviewed their activity records with trained interviewers. In addition, participants performed maximal treadmill exercise tests with gas analysis and underwent body composition analysis in order to assess physical fitness. These researchers concluded that the College Alumnus Questionnaire is a moderately good instrument for classifying people according to physical activity status. They found that the questionnaire had acceptable short-term repeatability. However, test-retest reliability decreases when the time between tests is lengthened (30).

Advantages and Disadvantages of Questionnaires

There are a few advantages to using questionnaires to estimate energy expenditure and assess physical activity. The administration of these questionnaires is cost effective.

For the researcher, the use of questionnaires is also time effective, as it does not require a lot of the researcher's time. Physical activity questionnaires, specifically the College Alumnus Questionnaire captures mostly sports and recreational activities (19). Also, physical activity can be assessed over an extended period of time.

However, information from questionnaires regarding physical activity is often used to estimate energy expenditure for given activities (2). The accuracy of this technique is poor, and these tables are usually based on a population of male adults (30). Another limitation of questionnaires is that subjective recall of previous physical activity is best estimated when the time frame is short, such as the previous week or three days (19).

Another disadvantage to using questionnaires to estimate energy expenditure is that accuracy in measuring walking, perhaps the most common type of moderate intensity activity is relatively poor (6). The College Alumnus Questionnaire also underestimates energy expenditure due to the lack of questions regarding lifestyle activity, such as housework or yard work (19). Lastly, the validity and reliability of questionnaires is questionable. Most researchers have found questionnaires to be both reliable and valid (21, 34). However, there is some disagreement because of the lack of appropriate validation schemes as evidenced by Jacobs et al. (19). Investigators studied test-retest reliability, and tried to validate the questionnaires against numerous indirect and direct variables such as treadmill times, body fatness, accelerometer readings, and dietary caloric intake. They concluded that physical activity questionnaires are useful in assessing physical activity, however, there are many important areas of physical activity that are not address in the majority of questionnaires. Therefore, it is difficult to estimate energy expenditure with the use of physical activity questionnaires.

However, questionnaires are still the tool of choice for epidemiologists who research trends in large populations. In these types of studies, stratification of the population is often more important than the quantitative accuracy of the measurement for a given individual. Therefore, questionnaires have shown that an increased physical activity leads to a decrease in all-cause mortality, and an increase in longevity (8, 25, 33).

Electronic pedometers

Pedometers not only provide a measurement of physical activity, but they can also be used as a motivational tool by providing immediate feedback of physical activity. Pedometers are small instruments that are worn on the belt or waistband. They respond to very small amounts of accelerations. Once the acceleration reaches a certain threshold, the unit will register a "count" or step. The counts accumulate, and can be used to estimate distance walked. The distance walked can account for a large amount of caloric expenditure for many individuals (5).

One of the first few studies completed regarding the accuracy of pedometers yielded poor results during walking activities (20). There were several purposes to that study. The researchers wanted to test the reliability of pedometer scores as an indication of actual step rate in walking and running and to examine the effects of different placement positions of the pedometer on the hip. Fifty-eight 12-to18 year old boys were recruited to participate in the study to walk at 2, 4, and 6 km/hr and to run at 6, 8, 10, and 14 km/hr. Actual step rate was counted by an observer, and calculated by taking the number of steps and dividing by the total test time in order to obtain steps/min. It was found that that there was a significant underestimation of steps when walking. However, step counts were more accurate for running. The position of the pedometer made no difference in step counts.

In a similar study (37), researchers wanted to perform a critical evaluation of pedometers for estimating daily physical activity. First, the pedometers were tested for reliability on a carriage with movements in different directions. The researchers found that in order to compare data from different pedometers, the spring tension of the different pedometers had to be adjusted in order to make the different pedometers comparable to each other. Second, researchers performed experiments on a motor driven treadmill with young adult males and children. The researchers found that the pedometer overestimated actual step rate by 0.1-0.3 counts per step during fast walking and fast running. In addition, step rate was significantly underestimated by 0.2-0.7 step counts during slow walking. It was also found that pedometers did not reflect the differences in energy expenditure levels at different speeds very well. Researchers concluded that pedometers might not be a valid indicator of daily physical activity in terms of energy expenditure.

Gayle et al. (12) designed one of the first studies whose purpose was to determine the accuracy of pedometers for measuring distance walked. This study was unique as previous studies investigated the accuracy of pedometers in walking and running. Six different pedometers were tested – three watch-type and three digimeters – on eight male subjects. Each subject walked one mile at a speed of three miles per hour and 0% grade. Four of the six pedometers were worn for each test. Strides per minute were recorded at designated intervals, and this was used in determining the stride length for each individual and assuring consistency in the total number of strides for all walks by the same subject. Researchers concluded that for walks on a carefully calibrated treadmill, steps per minute, as counted by the pedometer, were almost identical within the same walk. These measurements never varied by more than four steps per minute for any two walks by the same subject. However, keep in mind that this study was performed under controlled laboratory conditions and does not apply to less controlled environments.

As time passed, these instruments have become more advanced and have been validated. Bassett et al. (3) provided a significant contribution by testing the validity of electronic pedometers. The purpose of this study was to examine the accuracy of five different pedometers for measuring distance walked and number of steps. Twenty participants were used to examine the accuracy of the various pedometers over a 3.03-mile sidewalk course. Each subject wore two pedometers of the same brand for each trial. The actual steps taken during the course was determined using a hand tally counter. Subjects clicked the counter once for each left foot heel strike, and doubled the final number to give the total number of steps. The Yamax pedometer measured the number of steps and distance to within 1% of actual distance in a field based evaluation.

In addition, ten individuals completed three trials of walking at various speeds on a motor-driven treadmill. All pedometers were worn on the right side of the body. Each trial lasted five minutes. The Yamax was more accurate than the other pedometers at slow-to-moderate walking speeds since no significant differences were found at even the fastest speed.

After the study of Bassett et al. (3), many researchers wanted to know the significance of a pedometer's use in the field of exercise science. Recently, a two-part study was completed in order to evaluate the usefulness of the Yamax Digi-Walker pedometer in quantifying levels of physical activity in a general population (43). Researchers designed a two-part study to test this idea. The first part of the study determined the number of steps required to complete a set distance at different speeds under different conditions. In the second study, researchers wanted to assess physical activity in field conditions. Thirty-one individuals were recruited to participate in both studies.

For the first part of the study, participants complete three, 1.0-mile trials of walking/jogging on both a track and a treadmill. Subjects wore a Digi-Walker pedometer on their right hip, and were asked to walk a 15-minute mile, jog a 10-minute mile, and jog an 8-minute mile. At the end of each mile, the number of steps was recorded. Each subject later repeated the three trials on a motor driven treadmill. In this part of the study, researchers found no significant differences between step counts in track and treadmill conditions.

The second part of the study required participants to wear the Digi-Walker pedometer for two, one-week periods. During the first week, participants wore the pedometer during all waking hours, except for bathing and sleeping. In the second week, participants took the pedometer off during structured or vigorous exercise. During the two-week period, subjects completed a daily log where they recorded the times they woke up and went to bed, and the times the pedometer was put on and taken off. At the end of each week, participants completed a seven-day physical activity recall. Researchers used the activity recall to estimate energy expenditure. Researchers found that there was wide variability among participants. For the first week, participants averaged 11,603 $\pm$ 5,087 steps per day. Participants averaged 8,265 $\pm$ 3,368 steps per day during the second week. Energy expenditure averaged 32.86 kcal/kg/day. Correlations between average step counts and average daily energy expenditure were low (r = 0.34). They concluded that pedometers offer considerable promise for assessing physical activity, but additional work is needed to clarify step patterns across different ages, genders, and occupational classes.

Advantages and Disadvantages of Pedometers

There are a few advantages in using pedometers for research purposes. First, pedometers allow measurement of physical activity with no interruption of daily physical activities. Also, the method is easily applied to a large number of subjects (10). Lastly, the pedometer is an excellent instrument for capturing ubiquitous walking (5).

Despite these advantages, there are many disadvantages. For example, pedometers are most useful when worn on the waistband or belt. This allows measurement of the vertical acceleration of the hip. However, this tends to neglect the work of other body parts, such as the arms (6, 11). Also, pedometers just count the number of steps. Energy expenditure is underestimated by approximately 50% (27) through the pedometer due to the inability to assess non-ambulatory activity, such as swimming or stationary cycling. In addition, they may not account for the increase in energy expenditure during inclined walking or jogging. Lastly, the accuracy of pedometers is sometimes affected by events other than vertical displacement of the hip (20). Therefore, pedometers are good instruments for assessment of walking, but are less accurate in determining energy expenditure.

Comparison of physical activity questionnaires to pedometers

Previous research compared the use of questionnaires and pedometers to measure physical activities. The researchers completed these studies for various purposes – some to validate the questionnaire and/or the electronic pedometer, some to compare estimations of energy expenditure (5, 27, 38, 41). They will be discussed in this section.

One of the first studies that compared physical activity questionnaires to pedometer measurements was completed by Bassett et al. (5). In this study, the questionnaire used was the College Alumnus Questionnaire developed by Paffenbarger et al (32). The purpose was to investigate the question regarding walking distance on the College Alumnus Questionnaire since measurement of walking behavior is an important concern. Forty-eight men and women participated in this study. The participants filled out the College Alumnus Questionnaire, which included questions on past and present health history and also physical activity. Once the questionnaire was completed, the subjects were given an electronic pedometer. The researchers found that both men and women underreported walking distance on the questionnaire. Men reported walking 1.56 $\pm$ 0.98 km/day on the questionnaire, but actually walked 4.02 $\pm$ 1.56 km/day according to the pedometer ($p = 0.0001$). Women reported 1.3 $\pm$ 1.03 km/day on the questionnaire, while walking 4.32 $\pm$ 1.69 km/day according to the pedometer ($p = 0.0001$).

Tudor-Locke (41) examined concurrent direct measures of physical activity, specifically an activity log and an electronic pedometer. In this study, nine men and women participated in the three day study. All subjects had been diagnosed with diabetes mellitus. The subjects used the Bouchard 3-Day Activity Log and an electronic pedometer for three consecutive days (Thursday, Friday, and Saturday). The activity log for each day was divided into 96 fifteen-minute intervals. Participants were asked to enter a number corresponding to a list of activities that best described their activity during a specified time period. On the first day of the study, subjects reset the pedometer to zero and sealed the pedometer. This blinded the subject to any knowledge of how many steps they were taking. They kept the pedometer sealed for the duration of the study.

Researchers found that the activity log was unable to reflect any changes in walking behavior, which is something that the objective motion sensors were able to detect. Therefore, energy expenditure and physical activity would be significantly underestimated through use of physical activity questionnaires. They concluded that inexpensive pedometers are simple to use, and are capable of detecting increases in physical activity.

The most recent study used women only (27), and the researchers wanted to determine the accuracy of methods that determine physical activity and associated energy expenditure in women in free-living conditions. The study used the following measures of physical activity energy expenditure: 1) the 7-day physical activity recall, 2) the Tritrac accelerometer, 3) a Computer Science and Applications, Inc. accelerometer, and 4) a Yamax pedometer. These methods of estimating energy expenditure were compared to that of doubly labeled water. Subjects chosen were premenopausal and free from any chronic diseases or conditions. The subjects in this study wore a pedometer for seven days, and at the end of this time period participated in a physical activity recall. The researcher found there was a significant difference between energy expenditure from doubly labeled water and energy expenditure from the pedometer. The pedometer underestimated energy expenditure by 59%. The pedometer significantly underestimated non-resting energy expenditure by approximately 50%. On the other hand, there was no significant difference between doubly labeled water and activity recall, although individual differences existed as a function of activity level. Although it was not determined by how much, the 7-Day Physical Activity Recall overestimated energy expenditure for inactive women, while it underestimated it for active women.

Sequeira et al. (38) wanted to determine whether a pedometer was of practical use in assessing physical activity. In addition, they wanted to find the relationship between pedometers and questionnaires, to see how the two compare and whether the pedometer provides useful relevant information.

Four hundred ninety three men and women participated in this weeklong study. Subjects were given a pedometer to wear for one week, and recorded the pedometer readings daily. However, the subjects were told not to reset the pedometer before putting it on the next morning. After seven days, subjects were given a self-administered physical activity questionnaire regarding their daily activity for the past week. They answered questions regarding frequency of sports, number of sweat episodes per week, and leisure time physical activity, which was put categorized in one of three groups: 1) moderate, mainly seated, 2) regular walking, cycling, or gardening, or 3) regular sports training. Activity that might have been performed at work was classified into one of four groups.

The researchers concluded that the pedometer is capable of discriminating between sitting, standing, and moderate effort work categories. In addition, they found that men had more variation in physical activity than women. Men also took more steps per day than women (10,400 $\pm$ 4,700 vs. 8,900 $\pm$ 3,200). Finally, the researchers used a stepwise linear regression model to determine to what extent the questions on physical activity contributed to explain the pedometer results. They found that occupational and leisure time physical activity in men were significant determinants of step counts, while only leisure time physical activity was related to step counts in women.

Considerations for Measurement of Physical Activity

In the previous section, two methods for measuring physical activity were discussed. The focus of this section is methodological considerations in the measurement of physical activity, specifically the duration of the measurement period. Gretebeck and Montoye (13) completed a study that determined how many days a week subjects should be monitored and whether weekdays are significantly different from weekends, and therefore should be treated separately. Thirty male subjects wore one Digimeter waist pedometer, one "Schritte" ankle pedometer, three accelerometers, and a heart rate monitor for seven consecutive days. Subjects also recorded their diet during the same time period. The researchers compared values from the six different instruments, and concluded that a minimum of five or six days of recordings are needed to estimate habitual physical activity. Total daily energy expenditure can be estimated with fewer days of observation.

Categorizing Physical Activity

There are many researchers who study how much physical activity is enough in order to see health benefits. The ACSM and the CDC recommend that every American get at least thirty minutes of physical activity on most, preferably all, days of the week

(36). This statement focuses on cardiovascular (aerobic) type exercises. In this section, the Harvard Alumni Study findings will be discussed. In addition, the Japanese promotion of 10,000 steps per day will be introduced.

Harvard Alumni Study

The Harvard Alumni Study is an on-going study of men who were undergraduates at Harvard University between 1916 and 1950. The purpose of this study is to examine the relationship between physical fitness and all-cause mortality, longevity, and other chronic diseases. The study uses a questionnaire developed by Ralph Paffenbarger et al. (32) to estimate energy expenditure.

From the questionnaire, researchers estimate the physical activity index, a measure of the weekly energy expenditure obtained by summing the reported daily number of flights of stairs climbed, city blocks walked, and sports and recreational activities engaged in during the past year. For each activity, details regarding the frequency and duration of the activity are obtained. Initially, researchers questioned participants on their current health history and physical activity participation in college and after college. Researchers sent follow-up questionnaires to participants in 1988 and 1993. The year of diagnosis for any particular disease was taken as the earliest reported year of diagnosis. Deaths were confirmed by obtaining death certificates from appropriate states. The College Alumnus Questionnaire has been used effectively in illustrating the inverse relationship between leisure-time physical activity and the incidence of obesity and many chronic diseases, such as diabetes and cardiovascular disease (30).

Initially, researchers were interested in whether physical activity could be used as an index of heart attack risk in college alumni (32). The researchers used the information from the college alumni questionnaires to divide the participants into various physical activity categories based on the estimated amount of energy each individual expended in an average week. They found that men with an index below 2,000 kilocalories per week were at a 64% higher risk than those with a higher index. This was based on adult physical activity. Researchers began to wonder if physical activity in college since college has changed, and if so, did it impact physical activity as an adult?

In one of the first studies completed (33), researchers found that death rates were one quarter to one third lower among college alumni expending 2,000 kilocalories or more during exercise per week than less active men. Also, exercise reported as walking stair climbing, and sports were inversely related to mortality, primarily due to cardiovascular causes.

In many of the following studies, researchers wanted to determine whether exercise habits and other personal characteristics were associated with lower rates of death from all causes and from coronary heart disease (24, 35). This time researchers classified subjects according to the intensity of their physical activity – light/non-vigorous activity, moderate-to-vigorous activity, and vigorous activity. They found that vigorous activities were associated with longevity. Although this did not apply to non-vigorous activities, non-vigorous exercise was shown to benefit other aspects of health, such as blood pressure (24). Researchers inferred that beginning moderate-to-vigorous activity later in life is associated with lower rates of death from coronary heart disease in middle-aged and older men (35).

The researchers (39) later updated earlier findings on physical activity and coronary heart disease risk by looking at the quantity, type, and intensity of physical activity. In addition, they assessed whether physical activity impacts the risk of coronary heart disease in the presence of other cardiovascular risk factors. The results of the study indicated that increasing levels of total activities and vigorous activities were associated with a decreased risk of coronary heart disease. Men who expended more than 1,000 kilocalories per week and had only one coronary risk factor had a lower risk of coronary heart disease than those expending less. Also, levels of energy expenditure greater than 2,000 kilocalories per week were associated with a 10%-20% reduction in the risk of coronary heart disease compared to lower levels of energy expenditure.

More recently, researchers (25) wanted to know whether duration of exercise sessions affected coronary heart disease risk in men, assuming the intensity of exercise remained the same. They found that longer duration of exercise sessions predicted a lower risk of coronary heart disease. However, longer exercise sessions did not have a different effect on risk compared with shorter sessions, as long as total energy expenditure was similar. It was concluded that accumulation of shorter sessions of physical activity, as opposed to one continuous session, might reduce risk of coronary heart disease in men.

In the Women's Health Study, Lee et al. (26) used questionnaires to study the relationship between physical activity and coronary heart disease risk in women. Subjects were 39,876 female health professionals from the United States and Puerto Rico. They participated in a double-blind, placebo controlled trial of low dosage aspirin and Vitamin E for primary prevention of cardiovascular disease and cancer. Physical activity was assessed using a questionnaire including questions on time spent on eight different groups of physical activity each week (walking or hiking; jogging, > 10 min/mile; running, < 10 min/mile; bicycling, including stationary machines; aerobic exercise or dance or use of exercise machines; low intensity exercise including yoga, stretching or toning exercises; tennis, squash or racquetball; and lap swimming), usual walking pace, time spent walking per week, and the number of flights of stairs climbed. This questionnaire was similar to that of the College Alumnus Questionnaire.

They found that more active women had a lower body mass index, were less likely to smoke, and had a healthier diet. These women were more likely to use post-menopausal hormones, and prevalence of hypertension, elevated cholesterol, and diabetes mellitus was also lower. Researchers concluded that this particular study indicates that physical activity is associated with lower coronary heart disease rates. In addition, one to one and a half hours of walking per week, regardless of rate, was associated with a 50% reduction in coronary heart disease rates among women who did not exercise vigorously. This is in comparison to women who remained sedentary during the same time period.

<u>10,000 steps per day</u>

The notion of 10,000 steps per day comes from a campaign that is being promoted in Japan (16). This campaign has been proposed by the Japan Manpo Club. The idea is that 10,000 steps a day is sufficient for good health, e.g. cardiovascular risk reduction. The pedometer or "manpokei," which literally means 10,000 step meter, has made a significant contribution to the success of this campaign. The Japanese researcher, Yoshiro Hatano, is the leading researcher in the area of using pedometers for this campaign.

Hatano (15, 16) has proposed that the 10,000 steps a day requirement is equivalent to Paffenbarger's method of classifying active versus inactive individuals ($\geq$ 2,000 kilocalroies/week). Upon analyzing the results of laboratory tests and field measurements of walking activities of Japanese, Hatano has determined that every 30 steps consumes one kilocalorie of energy at a speed of 2.6 miles per hour. This is true for a middle-aged Japanese man who is 65 inches tall and weighs 60 kilograms. At 3.0 miles per hour, one kilocalorie is expended for every 27 steps taken. Based on these findings, walking 10,000 steps would be equivalent to 333 kilocalories at 2.6 miles per hour and 370 kilocalories at 3 miles per hour.

In recent years, several studies have evaluated the effects of walking on mortality and various chronic diseases, such as cardiovascular disease. The Honolulu Heart Study follows men of Japanese ancestry living in Oahu, Hawaii. In this particular study (14), researchers studied the association between walking and mortality in men who were retired and did not smoke. Researchers inquired about distance walked at the baseline examination, which occurred in 1980 or 1982. After the baseline examination, 12 years of follow-up (through the use of questionnaires) were available to assess the relation between distance walked and risk of death, based on comprehensive surveillance of death certificates, hospital admissions, and obituary notices. Results suggested that walking is associated with a lower risk of death among nonsmoking men. More specifically, risk of death can be reduced by 19% when the distance walked each day increased by one mile. Although this study did not involve the use of pedometers, it shows that walking is an effective method for reducing an individual's risk of cardiovascular disease.

Moreau et al. (31) investigated the effects of walking on blood pressure in women with borderline to stage 1 hypertension. Two groups were used in this study - a nonexercising control group and an exercising experimental group. The women were given a Yamax SW-200 pedometer to wear throughout the day for a one- to two- week period prior to the 24-week walking program. This was done in order to determine baseline lifestyle walking. Women in the exercise group were provided with a target number of steps that would lead to a three-kilometer increase in daily walking, which is close to the amount that the ACSM and the CDC recommend. It is specified that 30 minutes of moderate physical activity can be obtained by two miles of brisk walking. Participants assigned to the nonexercising group were asked not to change their daily activity, and wore a pedometer one week each month to document their walking. At baseline, 12 weeks, and 24 weeks, subjects reported to the laboratory after fasting and abstaining from caffeine. During this time, researchers measured resting blood pressure, fasting insulin and glucose, and body composition. Participants completed a three-day dietary food record at baseline, 12 weeks, and 24 weeks. The dietary records were analyzed for dietary composition. Following the study, researchers found that 12 weeks of walking activity (that met the minimum physical activity recommendations) was effective in lowering systolic blood pressure in postmenopausal women, and this was further reduced in the following 12 weeks. It also caused a reduction in body mass of 1.3 kg ($p < 0.05$) in 24 weeks. However, there was no correlation between weight loss and the change in blood pressure.

In a recent study completed in Japan (18), researchers studied the effects of walking 10,000 steps a day or more, regardless of intensity, on blood pressure and autonomic nerve activity in hypertensive individuals compared to normotensive individuals. Subjects were 730, previously sedentary workers in the manufacturing industry. They divided subjects into a hypertensive group that walked 10,000 steps or more a day, a normotensive group that walked 10,000 steps or more per day, and a hypertensive control (sedentary group). The experimental group walked 13,510 $\pm$ 837 steps a day or more over 12 weeks. Pre- and post training measurements included number of steps per day, body mass index, maximal oxygen capacity, blood pressure, heart rate, serum lipid levels, and autonomic nerve activity. Researchers found no significant changes in normotensive participants in 12 weeks. There were, however, significant decreases in systolic and diastolic blood pressure in hypertensive individuals. In addition, maximal oxygen uptake increased significantly in groups walking greater than 10,000 steps per day. Researchers concluded that a recommendation to walk 10,000 steps a day or more leads to an improved exercise capacity and a lowered elevated blood pressure.

In the United States, a recent study was completed using the 10,000 step count as a physical activity target for sedentary women (44). The purpose of this study was threefold. Researchers wanted to 1) determine the daily baseline step count for women, 2) determine step counts for a 30 minute brisk walk, and 3) determine if baseline step counts, plus step counts from 30 minutes of brisk walking, would total 10,000 steps. Thirty-two women were recruited to participate in this study, and 16 wore a Computer Science and Applications accelerometer in addition to the Yamax Digi-Walker 200. Participants wore the activity monitors for a total of four days, and were instructed to take a 30-minute walk on two of the four days. Step counts before and after each walk were recorded. Researchers found that step counts averaged 10,030 ± 2,350 steps when participants took a 30-minute walk, while step counts were approximately 7,220 ± 2,406 steps per day on nonwalking days. The average number of steps for a 30-minute walk was 3,102 steps for day one and 3,105 steps for day two. This study suggests that the target of 10,000 steps per day is easily achievable for sedentary women by taking one 30-minute walk each day.

CHAPTER III

METHODS

Subjects

Sixty male subjects (n = 60) over 20 years of age were recruited from the Knoxville, Tennessee community to participate in this study. The only requirements to participate were that subjects were able to fill out a questionnaire and that they were free from any disabilities that prevented them from walking. Most (83%) of the subjects were college graduates, making the study population similar to that of Paffenbarger et al. (32, 33, 35). This was, however, not a requirement to participate in the study. Prior to participating in the study, the nature of the study was explained to participants, and they were asked to read and sign an informed consent form approved by the University of Tennessee, Knoxville's Institutional Review Board.

Each subject completed a self-administered College Alumnus Questionnaire. Upon completion of the questionnaire, the subject was given an electronic pedometer and was instructed to wear it for the next seven days. Upon completion of the seven-day data collection period, subjects returned their pedometers to the principal investigator.

College Alumnus Questionnaire

Each subject was given a self-administered questionnaire, adapted from the College Alumnus study of Paffenbarger et al. (34). The questionnaire included sections on: (a) background information, (b) past and present health history, and (c) participation in physical activities. Although the original questionnaire was mailed to study participants, we handed it out to the participants and had them fill it out in the presence of the investigator. This slight alteration in the method of administering the questionnaire should not have altered the results.

Estimation of energy expenditure

A physical activity index was computed as the sum of walking, stair-climbing, and "sports, recreation, and other physical activity." Subjects were asked to identify the number of city blocks walked each day, the number of flights of stairs climbed, and the frequency and duration of "sports, recreation, and physical activity" for a typical week. Energy expenditure from blocks walked and flights of stairs climbed was calculated using the formulas developed by Paffenbarger et al. and summarized in Kriska et al. (21, 34).

In previous scoring of the College Alumnus Questionnaire, energy expenditure from stair climbing was estimated using 4 kcal/flight. However, Bassett et al. (4) recently investigated the energy cost of stair climbing and descending on the College Alumni Questionnaire, and found that individuals actually expend approximately 2 kcal/flight of stairs. Thus, the lower figure was used for the purposes of this study.

For each sports and/or recreation activity listed, the estimated level of energy expenditure (METs) was determined from the Compendium of Physical Activity (2). One MET is equivalent to 3.5 ml/kg/min, and it represents an average resting energy expenditure of an average person. The Compendium is a published report that summarizes the energy cost of various activities. Using the subject's weight (in kilograms) and duration of activity (in minutes), the energy cost for each activity was estimated for the week.

The total energy cost for each activity was summed in order to obtain an estimate of energy expenditure for a typical week. After summing the energy cost for physical and/or recreation activity, the energy cost of blocks walked and flights of stairs climbed was added to this value to obtain a total estimated energy expenditure for a typical week.

Electronic Step Counter

Once the questionnaire was completed, subjects were given an electronic step counter (Yamax model DW-200, Yamasa Corporation, Tokyo) and instructed to position it on their belt or waistband in the midline of the right thigh. Step counters (or pedometers) are instruments that respond to very small units of acceleration. Once the acceleration reaches a certain threshold, the unit will register a "count" or step. These instruments have become more advanced in recent years. Bassett et al. (3) found that the Yamax pedometer measured the number of steps and distance to within 1% of actual distance in a field based evaluation.

Because the goal was to determine the how many steps participants took in their everyday lives, they were instructed not to change their level of physical activity during the study. In addition, the following instructions were given:

- The step counter should be worn at all times for 7 consecutive days, except for sleeping and showering.
- We are interested to know how many steps you take each day.
- As soon as you wake up each morning, press the yellow reset button, and record the time of day.
- Put the step counter on your belt or waistband.
- Just before you go to bed each night, please remove the step counter and record the number of steps, time of day, and any physical activity you performed.

Once the subjects returned the step counters and the daily log, the number of steps for the seven day period was summed and divided by seven in order to obtain the average number of steps per day.

Statistical Analysis

First, a graph was constructed from the physical activity index from the College Alumni Questionnaire and the pedometer determined steps per day. The data were also fit with a linear regression line. Statistical analyses were performed using SPSS Base 10.0 for Windows (SPSS Inc, Chicago, IL). A chi-square analysis was used to determine if there was a significant association between the average number steps per day from the pedometer and the kilocalories per week estimated from the College Alumnus Questionnaire. In addition, a phi coefficient of association (Φ) was computed to show the strength of the association. Statistical significance was set at $p = 0.05$ for all statistical analyses.

CHAPTER IV

RESULTS

This study was designed to compare two methods of estimating physical activity - an electronic pedometer and a physical activity questionnaire. Table 1 shows characteristics of the subjects.

Estimation of Energy Expenditure

Subjects reported walking 15 ± 14 blocks per day and an average of climbing 8 ± 8 flights of stairs per day (mean ± SD). In addition, they had a total physical activity index of 2653 ± 2095 kilocalories per week, which includes blocks walked, flights of stairs climbed, and sports, recreation or other physical activity. Table 2 shows the average physical activity index for blocks walked, flights of stairs climbed, and sports, recreation, or other physical activity. Some of the physical activities reported on the College Alumni Questionnaire included lifting weights, running, basketball, and swimming.

Table 1. Subject characteristics (n = 60).

	Mean ± SD	Range
Age (years)	38 ± 14	19-74
Height (cm.)	179.8 ± 6.8	165.1 – 195.0
Weight (kg.)	88.5 ± 20.1	56.8 – 147.7

Table 2. Average reported physical activity index.

	Physical activity index (kcals/week)
Blocks walked	824 ± 801
Flights of stairs climbed	109 ± 105
Sports, recreation, or other physical activity	1720 ± 1755

Step Counts

Participants took 8,385 ± 3,824 steps per day, using the average from seven consecutive days of wearing the electronic pedometer. Average step counts ranged from 1,406 steps per day to 16,818 steps per day. For subjects who reported physical activity on the daily pedometer log, there was an obvious difference between the days they participated in planned physical activity and the days that they did not.

Comparison of pedometer and questionnaire

Figure 1 shows the relationship between average steps per day and weekly energy expenditure from the College Alumni Questionnaire. Pearson's correlation coefficient (r = 0.566) indicated a moderate association between the two estimates of physical activity ($p < 0.0001$). Table 3 shows the chi-square table that was created using SPSS 10.0 for Windows. Chi-square analysis indicated that there was a significant association between the two recommendations ($x^2 = 24.76$, $p < 0.0001$). This analysis also showed that 71% of the men with a physical activity index less than 2,000 kilocalories per week also averaged less than 10,000 steps as reported by the pedometer, and that 95% of men with a physical activity index over 2,000 kilocalories per week averaged more than 10,000 steps per day as evidenced by the pedometer readings.

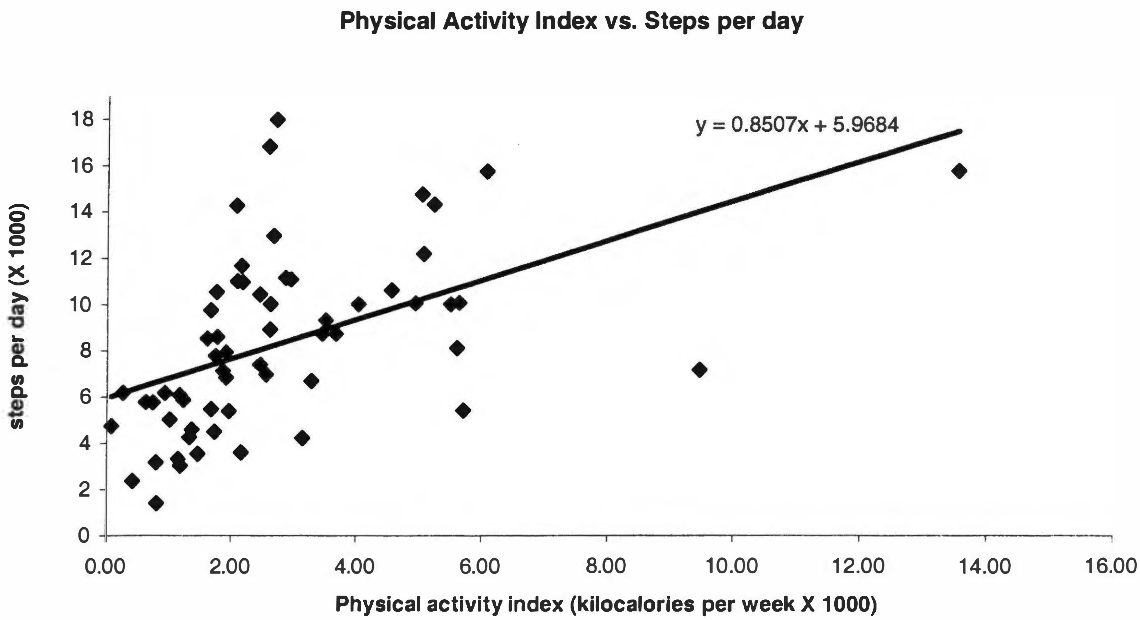

Figure 1. Comparison of step counts to the physical activity index.

Table 3. Chi-square table.

		≥ 10,000 steps?	
		No	Yes
≥ 2,000 kcals per week?	No	27	1
	Yes	11	21

In addition, the phi coefficient of association indicated a moderate association between the two measurements ($\Phi = 0.64$). The percent agreement between these two methods of categorizing active and inactive individuals was 80%.

CHAPTER V

DISCUSSION

The purpose of this study was to examine the association between two methods of estimating physical activity: (1) electronic pedometer and (2) the College Alumnus Questionnaire. In addition we sought to examine the percent agreement between two methods of classifying active and inactive individuals. Hatano's recommendation of 10,000 steps a day is based on the use of an electronic pedometer, while the Harvard Alumni Health Study involved the use of a physical activity questionnaire. Results of this study suggest that there is a significant association between the two measures.

Hatano (15, 16) developed the 10,000 steps per day recommendation based on Paffenbarger's research showing that a physical activity index $\geq$ 2,000 kilocalories/week was associated with a reduced risk of heart attack. Upon analyzing the results of laboratory tests and field measurements of walking activities of Japanese, Hatano has determined that every 30 steps consumes one kilocalorie of energy at a speed of 2.6 miles per hour. This is true for a middle-aged Japanese man who is 65 inches tall and weighs 60 kilograms. At 3.0 miles per hour, one kilocalorie is expended for every 27 steps taken. Based on these findings, walking 10,000 steps would be equivalent to 333 kilocalories at 2.6 miles per hour and 370 kilocalories at 3 miles per hour.

Despite Hatano's reasoning, there are some reasons why these two methods of assessing physical activity might not show close agreement. One is that Hatano's computation was based on walking, but people perform many other types of activity, in addition to walking. The energy expenditure per step widely varies, as for example in running, where it is 2 to 3 times higher. Another factor is that while the College Alumnus Questionnaire captures some walking and stair climbing, it mainly captures vigorous sports and exercise. The pedometer does a better job of capturing ubiquitous ambulatory activity, but it fails to detect activities where there is no vertical movement of the body's center of mass.

Three of the participants who failed to meet the 10,000 step recommendation participated in activities such as lap swimming or stationary cycling, which do not register on the pedometer. When these subjects were excluded from the analysis, it strengthened the association between the two methods of assessing physical activity. Further analysis was done excluding five men who participated in non-ambulatory activity. This analysis showed that 75% of men with a physical activity index less than 2,000 kilocalories per week averaged less than 10,000 steps on the pedometer. The chi-square still showed a significant association between the pedometer and the questionnaire ($x^2 = 26.256$, $p < 0.0001$).

There were 11 subjects who met the 2,000 kilocalories threshold but failed to meet the 10,000 step recommendation. This could be partly explained by the fact that these subjects tended to be heavier, taller men who had an increased caloric cost of weight-bearing activities.

Only one subject met the 10,000-step recommendation (10,532 steps/day), but failed to meet the 2,000-kilocalorie threshold. One possible explanation for this is the individual's body size, however, this individual was the average height and weight of the population in this study. Another explanation is that he underestimated his occupational walking. It has been shown in one previous study that walking is underestimated on the College Alumnus Questionnaire (5).

80% of participants in this study reported physical activity other than walking. This shows that there are many activities that an individual can participate in that will register on the pedometer. Examples of these activities are golf, tennis, basketball, and soccer.

Cross-sectional studies have shown that walking, which is one of the most popular forms of moderate activity, is helpful in providing health benefits (14, 28, 31). More specifically, the 10,000-step recommendation is an adequate amount of walking to reduce risk factors associated with coronary heart disease. It has recently been shown to reduce blood pressure in hypertensive patients (18). A recent study found that for every mile a woman walks each day, their risk of mental decline (as measured by the Mini-Mental State Exam) was lowered by 13% (45).

In this study, 2 kilocalories/flight of stairs was used to calculate the physical activity index from the number of flights of stairs climbed. Previously, studies have used 4 kilocalories/flight of stairs. However, Bassett et al. (4) found that the previous energy cost used in the calculation was much higher than the actual energy cost of ascending and descending a flight of stairs. However, even if the correct energy cost had been used in previous studies, this would not have made much of a difference in the actual total physical activity index because stair climbing accounted for approximately 110 kilocalories per week in this study, which accounted for only 4% of the physical activity index.

One question remains: is moderate activity sufficient enough to reduce an individual's risk of heart disease? Research from Paffenbarger et al. (32, 33, 35) suggests that only vigorous activity can help reduce an individual's risk. In a recent re-evaluation of the Harvard Alumni Study, researchers classified subjects according to the intensity of their physical, and concluded that only vigorous activities were associated with increased longevity (24).

However, research indicates that moderate activity, specifically walking, can reduce the risk of coronary heart disease by as much as 50% (14, 18, 26, 28). For instance, the Nurse's Health Study showed that self-reported walking was associated with similar reductions as vigorous exercise in the incidence of coronary heart disease in women (28). Hakim et al. (14) found that walking is associated with a lower risk of death in nonsmoking men. Recently, Lee et al. (26) found that, among women who did no vigorous exercise, walking one hour a week was associated with a 50% reduction in the risk of coronary heart disease. Taken together, these studies strongly suggest that walking (and hence, other forms of moderate intensity physical activity) is cardioprotective.

Future Directions

Future studies comparing the use of questionnaires and pedometers should include data on women. Although men have been used as the subject population in many studies, many current studies are investigating the relationship between physical activity and cardiovascular disease risk in women. For example, the Nurse's Health Study and the Women's Health Study are two on-going cohort studies involving the use of physical activity questionnaires to study the relationship between physical activity and all-cause mortality and disease risk in women (26, 28). In the most recent study (26) researchers found that women who participated in 1 to 1.5 hours per week of walking, regardless of rate, had a 50% reduction in coronary heart disease rates compared with those women who did not report participating in exercise.

Another possibility for future research would be to have an older sample population. In this study, the mean age of the population was approximately 38 years old. This is 10 years less than the mean age of the participants in any of the Harvard alumni (8, 24, 33). As discussed previously, younger participants tend to be more active. More than half the participants in this study reported a physical activity index greater than or equal to 2,000 kilocalories per week. This physical activity index is the "magic number" that Paffenbarger believes will lower cardiovascular disease risk in men (39). However, 2,000 kilocalories per week is not the cut-off that is used in all of the Harvard Alumni Health Studies.

Along those lines, a population with higher levels of occupational activity would be interesting to study. These participants might not participate in exercise or sports, yet still able to exceed the 10,000 step a day recommendation because of their occupations. Such occupations would include postal workers, hotel chambermaids, waiters and waitresses. In this current study 83% of the participants reported participating in at least one other physical activity.

Conclusions

While the current study indicates that 10,000 steps a day cut-off is not always comparable to Paffenbarger's 2,000 kilocalories per week, these two methods of categorizing people into high and low activity groups work well for the majority of people. The percent agreement between these two methods was 80%. This study suggests that the 10,000-step goal is an acceptable physical activity recommendation for most individuals. In addition, an electronic pedometer is a simple, inexpensive method of estimating walking activity. It can help people determine whether or not they are getting sufficient exercise in their day.

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APPENDICES

Appendix A:

(Informed Consent Form)

INFORMED CONSENT

Title: The comparison of the Yamax activity monitor to the College Alumnus Questionniare

Purpose: The purpose of this study is to compare two different methods of measuring physical activity – a questionnaire and an activity monitor.

Procedures:

You will fill out a self-administered questionnaire on physical activity, adapted from Paffenbarger, et al. I will ask you to fill out the college alumni questionnaire in its entirety because I want your responses to be given under the similar conditions to those experienced by the original responders. The other sections of the questionnaire include: (1) background information, (2) past and present health status, and (3) physical activities.

After filling out the questionnaire, you will be given a Yamax activity monitor at the beginning of a one-week period, and will be instructed to wear it during all waking hours, except when in the water or sleeping, for the next seven days. You will be instructed to wear it on the waistband at the level of the hip. The activity monitor should be placed at the mid-line of the right thigh.

Before putting the activity monitor on in the morning, you will make sure that the activity monitor has been re-set, and will also record the time that the activity monitor was placed on the waistband. Every night, before going to sleep, you should record the number of steps on the step counter for that day and note at what time the activity monitor was taken off. The same procedure will be followed for the entire week.

Potential Risks:

The physical risks involved in filling out the physical activity questionnaire and wearing an electronic activity monitor for one week are no greater than those encountered in every day life. There is only a slight chance that you will feel uncomfortable in filling out the college alumni questionnaire.

Use of Information:

The information obtained during all testing will be kept on record for three years, and will be kept strictly confidential. Even if information and results from the study become published, I understand that your individual records will not be released. Only staff working on the study will have access to my records.

Authorization:

I have read, understand, and have been given the opportunity to ask questions about the information provided in this consent form. I have discussed all concerns with the investigator to my satisfaction. I understand that questions are encouraged and may be addressed at any time in the future. Questions may be directed to Abigail Geslani at 865.974.8768 or Dr. David Bassett at 865.974.8766.

I hereby voluntarily and with full knowledge of risks, give my consent to participate in the aforementioned tests and programs within this study. I understand that my participation is voluntary and that I may withdraw from this study at any time without penalty.

____________________________	______________
Signature of Participant	Date
____________________________	______________
Signature of Witness	Date

Appendix B:

(College Alumnus Questionnaire)

College Alumni Questionnaire

Background Information

1. Name: ______________________
2. Age _____
3. Gender (circle one): male female
4. How tall are you? _____________
5. Current weight? ______________
6. How many times in your life have you lost the number of pounds (not due to disease):
   5 lbs: ___ 10 lbs: ___ 15 lbs: ___ 20 lbs: ___ 30 lbs: ___ 40 lbs +: ___

Past and Present Health Status

Has your physician ever told you that you had any of the following?

	Yes	no	year of onset
1. Angina pectoris	___	___	__________
2. Myocardial infarction	___	___	__________
3. Coronary artery bypass or angioplasty	___	___	__________
4. Heart rhythm disturbance	___	___	__________
5. Stroke (CVA or TIA)	___	___	__________
6. Thrombophlebitis	___	___	__________
7. Claudicaton	___	___	__________
8. High blood pressure	___	___	__________
9. Diabetes mellitus	___	___	__________
10. Elevated cholesterol	___	___	__________
11. Chronic bronchitis	___	___	__________
12. Emphysema	___	___	__________
13. Bronchiectasis	___	___	__________
14. Obesity	___	___	__________
15. Gastric ulcer	___	___	__________
16. Duodenal cancer	___	___	__________
17. Gallbladder disease	___	___	__________
18. Cirrhosis	___	___	__________
19. Appendicitis	___	___	__________
20. Ulcerative colitis	___	___	__________
21. Diverticular disease	___	___	__________
22. Kidney stones	___	___	__________
23. Degenerative (osteo)arthritis	___	___	__________
24. Gout	___	___	__________
25. Rheumatoid arthritis	___	___	__________
26. Osteoporosis	___	___	__________

27. Fractures from
    osteoporosis:
    site: wrist ___ ___ __________
    hip ___ ___ __________
    back ___ ___ __________
    other ___ ___ __________
28. Hip replacement ___ ___ __________
29. Cataract ___ ___ __________
30. Glaucoma ___ ___ __________
31. Macular degeneration ___ ___ __________
32. Poliomyelitis ___ ___ __________
33. Recurrent weakness from #32___ ___ __________
34. Multiple sclerosis ___ ___ __________
35. Parkinson's disease ___ ___ __________
36. Depression ___ ___ __________
37. Neurosis ___ ___ __________
38. Psychosis ___ ___ __________
39. Alcoholism ___ ___ __________
40. Benign prostate enlargement
41. Cancer (specify site and year of onset)
    site: _____ year: _____
    site: _____ year: _____
    site: _____ year: _____

How often do you experience (circle one):

Sensation of heart beating(except after exercise):	never	occasionally	frequently
Sense of exhaustion (exept after exercise):	never	occasionally	frequently
Periods of alternating gloom and cheerfulness:	never	occasionally	frequently
Periods of being particularly self-conscious:	never	occasionally	frequently

Current Medications

___ No regular medication
___ Aspirin, 2+ times/week (e.g. Anacin, Bufferin, Alka-Seltzer)
___ Other anti-inflammatory drugs, 2+ times/week (e.g. Advil, Motrin)
___ Acetaminophen, 2+ times/week (e.g. Tylenol)
___ Antibiotics. Please list name(s) and dose(s):

____
____

___ Other prescription medications. Please give name(s) and dose(s):

____
____
____

Family History

Father's health history

a. Age (if alive) _____ or b. Age at death _______ c. Cause of death _______

Mother's health history

a. Age (if alive) _____ or b. Age at death _______ c. Cause of death _______

Sibling(s) health history

How many children did your parents have (excluding adopted children)? ______

Did any of your sibling(s) have cancer? Yes No

Sibling	Site

Physical activities

1. How many city blocks or their equivalent do you regularly walk each day? ________ blocks/day (12 blocks=1mile)
2. What is your usual pace of walking? (Please circle one)
   a. Casual or strolling (less than 2mph)
   b. Average or normal (2-3mph)
   c. Fairly brisk (3-4 mph)
   d. Brisk or striding (4mph or faster)
3. How many flights of stairs do you climb up each day? (1 flight = 10 steps) _____flights/day
4. List any sports or recreation you have actively participated in during a typical week. Please include only the time you were physically active (i.e. actual playing time in jogging, bicycling, swimming, brisk walking, gardening, carpentry, calisthenics, etc.).

Sport, recreation, or other physical activity	#times/week	duration of event
a.______________________________	__________	______________
b. ______________________________	__________	______________
c. ______________________________	__________	______________
d. ______________________________	__________	______________

5. At least once a week, do you engage in regular activity akin to brisk walking, jogging, bicycling, swimming, etc. long enough to work up a sweat, get your heart rate thumping, or get out of breath.
   a. No, why not? ________________
   b. Yes, number of times a week _________
   Activity ______________________

6. On a usual weekday and a weekend day, how much time do you spend on the following activities? Total for each day should add up to 24 hours.

	Usual weekday day (hours/day)	Usual weekend day (hours/day)
vigorous activity(digging in the garden, strenuous sports, jogging, aerobic dance, sustained swimming, brisk walking, heavy carpentry, bicycling on hills, etc.)		
moderate activity (housework, light sports, regular walking, golf, yard work, lawn mowing, light carpentry, painting, repairing, ballroom dance, bicycling on level ground, etc.)		
light activity (office work, driving a car, strolling, personal care, standing with little motion, etc.)		
sitting activity (eating, reading, desk work, watching TV, listening to radio, etc.)		
sleeping or reclining		

Appendix C:

(Pedometer Log)

DAILY PEDOMETER LOG

	Date		Physical activity
1		Time on: Time off: # steps:	Duration: Type:
2		Time on: Time off: # steps:	Duration: Type:
3		Time on: Time off: # steps:	Duration: Type:
4		Time on: Time off: # steps:	Duration: Type:
5		Time on: Time off: # steps:	Duration: Type:
6		Time on: Time off: # steps:	Duration: Type:
7		Time on: Time off: # steps:	Duration: Type:

Instructions:

1. The pedometer should be worn at all times for 7 consecutive days, except for sleeping and showering.
2. We are interested to know how many steps you take each day.
3. As soon as you wake up each morning, press the yellow reset button, and record the time of day.
4. Put the pedometer on your belt or waistband.
5. Just before you go to bed each night, please remove the pedometer and record the number of steps, time of day, and any physical activity you performed.

Appendix D

(Calculation of physical activity index)

For blocks walked per day, the following equation was used:

blocks walked /day X 8 kcal/block X 7 days/week = # kcals/week

For stairs climbed, the energy expenditure was estimated using the following:

flights climbed/day X 2 kcal/flight X 7 days/week = # kcals/week

:For each activity listed, the following equation was used:

MET level for activity X 3.5 ml/kg/min X body weight (kg) ÷ 1000 ml X 4.8 kcal/L X # times/week = # kcals/week for activity

Appendix E

(Raw subject data: College Alumni Questionnaire)

Table 4. Raw subject data for basic subject characteristics.

			Subject's Weight	
Subject	Age	Height	lbs.	kg.
1	59	170.2	125.0	56.8
2	54	175.3	224.0	101.8
3	28	175.3	174.0	79.1
4	54	187	325.0	147.7
5	40	172.7	155.0	70.5
6	38	180.3	167.0	75.9
7	26	177.8	192.0	87.3
8	26	182.9	175.0	79.5
9	27	180.3	216.0	98.2
10	23	167.6	145.0	65.9
11	25	185.42	149.0	67.7
12	20	176.53	160.0	72.7
13	22	185.4	205.0	93.2
14	25	182.9	148.0	67.3
15	20	185.4	162.0	73.6
16	38	177.8	155.0	70.5
17	25	187	167.0	75.9
18	19	180.3	160.0	72.7
19	31	175.26	175.0	79.5
20	20	180.3	180.0	81.8
21	29	182.9	231.0	105.0
22	73	180.3	202.0	91.8
23	74	180.3	170.0	77.3
24	53	177.8	188.0	85.5
25	39	182.9	245.0	111.4
26	49	180.3	196.0	89.1
27	33	180.3	285.0	129.5
28	56	182.9	180.0	81.8
29	48	172.7	157.0	71.4
30	25	172.7	140.0	63.6
31	57	172.7	168.0	76.4
32	35	175.3	135.0	61.4
33	40	193	312.0	141.8
34	50	182.9	180.0	81.8
35	31	185.4	215.0	97.7
36	25	180.3	185.0	84.1
37	30	167.6	180.0	81.8
38	59	172.7	170.0	77.3
39	56	167.6	174.0	79.1
40	32	177.8	230.0	104.5
41	36	180.3	198.0	90.0
42	32	180.3	155.0	70.5

Table 4 continued.

43	25	182.9	150.0	68.2
44	37	180.3	220.0	100.0
45	51	167.6	223.0	101.4
46	48	188.0	240.0	109
47	29	182.9	250.0	113.6
48	62	172.7	174.0	79.1
49	38	188.0	214.0	97.3
50	31	165.1	135.0	61.4
51	37	185.4	190.0	86.4
52	28	190.5	290.0	131.8
53	32	177.8	198.0	90.0
54	24	190.5	230.0	104.5
55	30	195.6	210.0	95.5
56	45	172.7	185.0	84.1
57	33	172.7	210.0	95.5
58	38	182.9	250.0	113.6
59	49	193.0	285.0	129.5
60	53	180.3	182.0	82.7

Table 5. Raw subject data for blocks walked and stairs climbed.

Subject	Number of Blocks	Number of Calories (kcal)	Flight of Stairs	Number of Calories (kcal)
1	2	112	10	140
2	36	2016	0	0
3	36	2016	20	280
4	0	0	0	0
5	12	672	8	112
6	6	336	5	70
7	12	672	4	56
8	12	672	20	280
9	0	0	10	140
10	12	672	10	140
11	48	2688	3	42
12	36	2016	4	56
13	24	1344	10	140
14	2	112	3	42
15	48	2688	10	140
16	36	2016	3	42
17	24	1344	5	70
18	36	2016	20	280
19	50	2800	10	140
20	10	560	6	84
21	24	1344	0	0
22	6	336	6	84
23	6	336	15	210
24	24	1344	1	14
25	36	2016	10	140
26	12	672	2	28
27	15	840	10	140
28	5	280	3	42
29	6	336	10	140
30	5	280	30	420
31	12	672	10	140
32	4	224	10	140
33	1	56	8	112
34	0	0	10	140
35	3	168	3	42
36	24	1344	5	70
37	4	224	14	196
38	6	336	5	70
39	1	56	10	140
40	12	672	2	28
41	16	896	2	28
42	0	0	20	280

Table 5 continued.

43	4	224	3	42
44	1	56	3	42
45	5	280	4	56
46	0	0	3	42
47	36	2016	4	56
48	2	112	0	0
49	36	2016	40	560
50	18	1008	3	42
51	12	672	20	280
52	20	1120	5	70
53	0	0	8	112
54	12	672	7	98
55	36	2016	2	56
56	12	672	1	14
57	18	1008	10	140
58	0	0	5	70
59	1	56	0	0
60	6	336	0	0

Table 6. Raw subject data for subjects reporting at least one activity.

Activity #1					
Subject	Activity	METS	# times weeks	Duration (min)	per week (kcals)
2	weights	3	2	60	615.80
3	gym	5.5	3	120	2630.88
4	gym	5.5	2	120	3276.00
5	carpentry	6	2	120	1704.44
6	H2O aer.teach	4	14	30	2142.46
7	walking	2.5	2	30	219.93
8	b-ball	6	1	180	1443.27
9	walk/jog	6	2	30	593.80
10	jogging	7	2	45	697.58
11	weights	3	3	60	614.42
13	golf	4.5	2	180	2536.04
14	bike	4	4	90	1627.46
15	b-ball	6	1	90	668.03
17	b-ball	6	1	45	344.32
18	gym	5.5	3	90	1814.40
19	jogging	7	5	20	935.45
20	soccer	7	2	30	577.31
21	walking	2.5	7	20	617.40
23	walking	2.5	5	15	243.41
26	walking	2.5	4	30	449.02
27	walking	3	5	45	1469.05
29	yardwork	5	1	120	824.73
29	weights	3	2	20	143.87
30	bike	7	2	60	898.04
32	weights	3	3	45	417.52
33	lap swim	7	2	45	1501.00
34	tennis	7	2	60	1154.62
35	kickbox	7	3	60	2068.69
36	b-ball	6	1	60	508.58
37	weights	3	3	60	742.25
38	bike	7	3	40	1090.47
39	gym	5.5	3	45	986.58
40	jogging	7	4	10	491.78
42	b-ball	6	1	60	426.11
43	running	8	4	30	1099.64
44	weights	3	3	60	907.20
45	gym	5.5	2	60	1123.92
46	lap swim	7	4	25	1282.91
47	volleyball	4	1	60	458.18
48	gym	5.5	3	75	1644.30

Table 6 continued.

50	weights	3	3	45	417.52
51	running	8	5	30	1741.09
52	b-ball	6	3	60	2391.71
53	weights	3	3	40	544.32
54	weights	3	3	60	948.44
55	bike	7	4	60	2694.11
56	walking	3.3	3	30	419.58
57	weights	3	2	60	0.00
59	gym	5.5	3	30	1795.50
60	gym	5.5	2	30	458.64

Table 7. Raw subject data for subjects reporting a second activity.

Activity #2					
Subject	Activity	METS	# times weeks	Duration (min)	per week (kcals)
2	aerobics	6.5	1	45	500.33
5	walk/jog	6	3	45	958.75
8	gym	5.5	5	90	3307.50
10	weights	3	3	45	448.45
11	bike	4	5	90	2048.07
13	jogging	7	4	20	876.65
14	hiking	6	2	30	406.87
17	gym	5.5	4	60	1683.36
18	b-ball	6	2	90	1319.56
19	weights	3	5	60	1202.73
21	bike	7	6	20	1481.76
23	calisthenics	8	3	30	934.69
26	weights	3	3	60	808.23
32	bike	7	3	45	974.21
34	walk	3.3	2	60	544.32
35	weights	3	3	60	886.58
36	volleyball	4	2	60	678.11
38	weights	3	3	20	233.67
40	weights	3	3	45	711.33
42	walking	3.3	2	30	234.36
43	hiking	7	2	40	641.45
47	golf	4.5	1	180	1546.36
50	bike	7	3	20	432.98
52	walking	3.3	2	30	438.48
53	jogging	7	3	30	952.56
54	jogging	7	2	15	368.84
55	b-ball	6	2	45	865.96
56	aerobics	5	2	45	635.73
57	racquetball	7	2	50	1122.55

Table 8. Raw subject data for subjects reporting a third activity.

Activity #3					
Subject	Activity	METS	# times weeks	Duration (min)	per week (kcals)
5	aq. exer	4	1	45	213.05
10	bike	7	3	30	697.58
11	rock cl.	11	2	240	6007.68
13	weights	3	2	30	281.78
14	rock cl.	7	3	20	474.68
18	running	8	2	30	586.47
21	calisthenics	8	6	20	1693.44
32	walking	3.3	2	60	408.24
34	Nordic	7	2	40	769.75
35	jogging	7	4	30	1379.13
42	weights	3	1	60	213.05
43	rock cl.	7	4	60	1924.36
47	cardio	5.5	3	45	1417.50
53	bike	7	2	25	529.20
54	sprints	10	1	20	351.27

Table 9. Raw subject data for subjects reporting a fourth activity.

Activity #4					
Subject	Activity	METS	# times weeks	Duration (min)	per week (kcals)
11	jog	7	3	90	2150.48
13	walking	5	2	3	46.96
42	tennis	7	1	60	497.13

Appendix F

(Raw subject data: Pedometer logs)

Table 10. Raw subject data for steps taken per day.

AVERAGE STEPS/DAY								
Subject	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
1	7867	4901	7799	5839	5470	7952	3435	6180
2	2476	5138	4509	5578	4549	3370	4001	4232
3	7346	9794	8911	10346	10899	9386	13784	10067
4	7556	11313	1912	7857	5197	2212	10851	6700
5	9930	6065	11145	8753	8115	11575	5636	8746
6	9123	7652	5285	8963	2740	7369	7682	6973
7	8276	8047	3100	9100	5150	8361	8223	7180
8	7289	5270	2178	3368	6178	6495	7289	5438
9	7449	6048	7143	3412	2535	6411	7371	5767
10	10043	14028	10758	9211	19005	11250	16500	12971
11	15481	21205	10077	27880	6484	7386	21940	15779
12	7230	6296	14987	6020	16576	12324	13621	11008
13	12446	22503	21408	14752	13836	11098	4293	14334
14	6672	7701	10023	14384	16735	10546	11560	11089
15	9166	9043	8414	8674	12345	8132	9481	9322
16	9931	18322	10562	10676	13233	17926	19217	14267
17	5011	11045	5680	11021	8421	8490	11550	8745
18	16482	14024	13581	18276	17794	11663	18430	15750
19	10082	9836	17526	9260	10950	16200	11632	12212
20	1969	3951	8944	4108	9342	8009	4802	5875
21	7676	11213	7150	7217	7480	8862	7257	8122
22	2382	3541	1522	2834	773	3233	2384	2381
23	3211	5249	4361	4241	4621	5572	4229	4498
24	736	5292	6523	6980	3850	5240	3557	4597
25	3662	3250	4122	2725	4370	3712	3272	3588
26	3085	4717	6272	5738	6293	5515	6090	5387
27	7772	3251	9427	9531	5970	7243	8607	7400
28	2981	4835	5862	3310	1508	2554	2197	3321
29	5528	8675	3193	7612	7037	3866	4486	5771
30	6351	8888	4892	6244	8405	8217	16698	8528
31	2679	1900	693	600	1875	1053	1043	1406
32	10023	10795	11790	10385	11725	10025	12025	10967
33	5759	8505	3209	4117	8770	3012	4904	5468
34	9280	11720	11552	9424	10830	10994	6372	10025
35	11770	13881	13309	3361	8306	11665	12164	10637
36	10410	7152	6734	7751	12037	10592	7733	8916
37	9065	7047	10773	1741	2012	6648	5301	6084
38	9199	9193	7866	10578	4818	9255	3558	7781
39	3359	4023	2169	1053	4387	3337	2927	3036
40	7729	5996	8360	6609	4461	4652	9997	6829
41	8007	8844	10528	8971	5068	845	884	6164
42	17848	5692	5772	9507	6909	14533	7984	9749

Table 10 continued.

43	9440	24300	17203	11300	11020	14072	1600	14762
44	7231	7747	5168	3539	1712	5160	4653	5030
45	2625	4866	5305	2478	2907	2335	4184	3529
46	7865	4035	3699	2455	3042	3282	5424	4257
47	8772	9567	9004	11137	13466	8156	10063	10024
48	8910	9055	9926	10093	7893	3636	10666	8597
49	14056	11269	14138	22343	21801	22504	11617	16818
50	8469	10075	8463	7563	8295	5208	7496	7938
51	8781	8620	38906	17891	16891	18899	15791	17968
52	15099	15639	2005	10299	10958	10974	5168	10020
53	11131	12128	17893	11297	8415	10282	10596	11677
54	8516	11107	9827	10525	12768	11694	8765	10457
55	10003	11708	9498	7400	10615	10452	10943	10088
56	2904	12163	10287	13768	12504	11332	10767	10532
57	4044	10146	8439	14414	14678	15382	11027	11161
58	4429	5426	1095	4486	5203	4359	8242	4749
59	2946	7542	2576	5152	12979	8967	9686	7121
60	2675	829	712	5186	3849	4964	3992	3172

VITA

Abigail Elaine Geslani was born in Buffalo, New York on September 26, 1977. She was raised in Fort Myers, Florida where she attended St. Francis Xavier Catholic School and Bishop Verot Catholic High School. In August 1995, she enrolled as a student at the University of Florida in Gainesville. During her sophomore year, she was inducted into Phi Eta Sigma and Golden Key National Honor Societies. She was on the Dean's List during her last two years and was on the President's Honor Roll for two semesters. As part of her academic program, Abigail was a fitness instructor, and later a fitness supervisor, at Living Well, the university wellness program for faculty and staff. She served as President of the Reid-Yulee-Mallory Area. During her last semester at the University of Florida, she worked as an intern at the Center for Exercise Science within the College of Health and Human Performance. In May 1999, Abigail graduated from the University of Florida with highest honors with a B.S. in Exercise and Sport Sciences. After graduation, she was employed as a fitness specialist for the Wellness Centers of Cape Coral. In August 2000, she began graduate school at the University of Tennessee in Knoxville. She served as a graduate teaching associate for two years in the Physical Education Activity Program. In addition to teaching physical education classes, she was an exercise leader for the Center for Physical Activity and Health, and assisted with research testing in the Applied Physiology Laboratory. She also completed an internship with the Baptist Hospital Cardiac Rehabilitation Program. Outside of school, Abigail was employed part-time as a fitness instructor for the Jump Start Program at Associated Therapeutics. She is graduating with a M.S. in Human Performance and Sport Studies with a concentration in Exercise Physiology in May 2002.