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VALIDITY OF PARTICIPANT RECORDED PEDOMETER STEP LOGS IN FREE-LIVING ADULTS

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Timothy K. Behrens
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VALIDITY OF PARTICIPANT RECORDED PEDOMETER STEP LOGS
IN FREE-LIVING ADULTS

A Dissertation APPROVED FOR THE
DEPARTMENT OF HEALTH AND EXERCISE SCIENCE

BY

Mary K. Dinger, Ph.D.

David A. Fields, Ph.D.

Kristi C. Heesch, Dr. P.H.

Allen Knehans, Ph.D.

Sara K. Vesely, Ph.D.

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Table of Contents

List of Tables

List of Figures

Abstract

PURPOSES: The purposes of this study were to 1) examine the validity of participant recorded pedometer step logs, 2) examine the relationship between steps per day and percent bodyfat (% BF), and 3) examine differences in steps per day by BMI category (< 25 m/kg^2 vs. ≥ 25 kg/m^2). **METHODS:** Participants (N = 89; Male: n = 29, age = 37.97 ± 9.41 years, BMI = 25.87 ± 4.42 kg/m^2, % BF = 21.66 ± 6.21%; Female: n = 60, age = 40.07 ± 10.72, BMI = 24.83 ± 4.72 kg/m^2, % BF = 33.73 ± 8.11%) in this cross-sectional, descriptive study simultaneously wore a sealed pedometer, unsealed pedometer, and Actigraph accelerometer for nine consecutive days. Body composition was assessed via air-displacement plethysmography (BOD POD). Descriptive statistics, tests of equivalence, correlation coefficients, and independent t-tests were calculated. Three conditions were examined for validity: raw Actigraph steps per day (RAW) vs. participant recorded steps per day (PSD), Actigraph steps corrected for vehicular travel (CORRECTED) vs. PSD, and total accumulated steps from the sealed pedometer (SEALED) vs. total accumulated steps from the participant recorded pedometer (PTOT). **RESULTS:** There was a strong correlation between RAW and PSD ($r = 0.88$, $p < 0.0001$). However, RAW and PSD were not equivalent. Similarly, CORRECTED and PSD resulted in a strong correlation ($r = 0.88$, $p < 0.0001$), but they were not equivalent. Comparing SEALED and PTOT indicated a strong correlation ($r = 0.96$, $p < 0.0001$) and equivalence. All correlations for steps per day and % BF were moderate (range: $r = 0.40$ to 0.45). There was a significant difference in steps per day by BMI category in PSD ($p = 0.03$), but not in RAW and CORRECTED. **CONCLUSIONS:** These results indicate 1) acceptable validity for participant recorded pedometer step logs, 2) moderate

relationships between steps per day and % BF, and 3) a significant difference in steps per day by BMI category in PST, but not in RAW and CORRECTED. Future research should attempt to further explain the relationship between Actigraph and pedometer-derived steps.

CHAPTER ONE

INTRODUCTION

Physical inactivity is associated with increased risk of numerous negative health conditions including heart disease (Godsland, Leyva, Walton, Worthington, & Stevenson, 1998; Oguma & Shinoda-Tagawa, 2004; Riedel & Kelsberg, 2004; Yu et al., 2004), hypertension (Hu et al., 2004; McGuire et al., 2004), type 2 diabetes (Knowler et al., 2002), colon cancer (Allgayer, Nicolaus, & Schreiber, 2004; Colditz, Cannuscio, & Frazier, 1997; Martinez et al., 1997), endometrial cancer (Colbert et al., 2003), breast cancer (Colbert et al., 2003; Irwin et al., 2004; Patel, Calle, Bernstein, Wu, & Thun, 2003; Turner, Hayes, & Reul-Hirche, 2004), prostate cancer (Bairati, Larouche, Meyer, Moore, & Fradet, 2000), other cancers (Eyre, Kahn, & Robertson, 2004; McTiernan, Ulrich, Slate, & Potter, 1998), as well as anxiety and depression (Atlantis, Chow, Kirby, & Singh, 2004; Callaghan, 2004; Fukukawa et al., 2004). These conditions associated with physical inactivity, combined with a poor dietary intake, were the cause of an estimated 400,000 deaths per year and accounted for more than 16% of all deaths in the United States in the year 2000 (Mokdad, Marks, Stroup, & Gerberding, 2004). Aside from the physically debilitating effects of chronic disease and psychological disorders, the economic cost of physical inactivity in the United States is, conservatively, between $24 billion (Colditz, 1999) to $76.6 billion per year (Pratt, Macera, & Wang, 2000).

In an effort to stem the tide of physical inactivity and its negative consequences, the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) released a joint position statement on the amount of physical activity necessary to obtain health benefits (Pate et al., 1995). Their recommendation calls for all adults to accumulate at least 30 minutes of moderate intensity physical activity on most, if not all days of the week. Moderate intensity physical activity (MPA) is defined as an intensity that is 3-6 times the energy expended at rest [i.e., metabolic equivalent (MET)], or approximately equal to expending 200 calories in physical activity per day (Pate et al., 1995). Most, if not all days of the week has been interpreted by researchers to be at least 5 days a week (Jones et al., 1998).

In addition to this recommendation, the ACSM released a position statement regarding the amount of physical activity necessary for cardiorespiratory fitness. The vigorous physical activity (VPA) recommendation for cardiorespiratory fitness calls for adults to train aerobically for 3 to 5 days per week, at an intensity of 55%-90% of their maximum heart rate, for 20-60 continuous or intermittent minutes of at least 10 minutes (Pollock et al., 1998). It is stated that the duration component of the VPA recommendation for cardiorespiratory fitness is dependent upon the intensity of the activity performed. That is, the more intense the activity, the less time that is required. Inversely, if the activity is of lesser intensity, then the activity should be performed for longer periods of time (Pollock et al., 1998). The mode of activity should be any aerobic exercise that uses large muscle groups in a rhythmic, continuous nature (Pollock et al., 1998). Examples of VPA for cardiorespiratory fitness include hiking, running, jogging, rowing, stair climbing, swimming, and other endurance games and sports (Pollock et al., 1998).

Unfortunately, even with an abundance of research highlighting the protective effects of regular physical activity, epidemiological evidence suggests that the majority of Americans are not accumulating enough physical activity for health benefits (Casperson, Pereira, & Curran, 2000; Jones et al., 1998; Pratt, Macera, & Blanton, 1999). According to federal surveillance data, approximately 40% of the U.S. population ages 18 and older do not participate in regular leisure time physical activity (Schiller, Coriaty-Nelson, & Barnes, 2004), and only 15% engage in at least 30 minutes of MPA on 5 or more days per week (Schiller et al., 2004). Further, data from the 2002 National Health Interview Survey revealed that over 59% of Americans never participate in VPA lasting longer than 10 minutes (Lethbridge-Cejku, Schiller, & Bernadel, 2004).

Because of statistics such as these, it is essential for researchers and practitioners to develop valid tools for the assessment of physical activity in order to command a more representative picture of the physical activity landscape. Moreover, because of the potential impact that can result from a study using particular instruments or assessments, the validity of an assessment technique is commonly considered its most important attribute (Tudor-Locke, Williams, Reis, & Pluto, 2002). Therefore, to consider an instrument to be a valid tool for assessment, it is important to understand the qualities and limitations of the assessment tool. That is, does the assessment accurately quantify actual, habitual physical activity? To answer this question it is necessary to understand how physical activity is assessed among free-living individuals.

When assessing the behavior of physical activity among free-living individuals, researchers and practitioners can utilize indirect or direct methods. Indirect methods are surrogate markers of physical activity such as body composition, cardiorespiratory fitness, and surveys or questionnaires (Ainsworth, 2000). Direct methods reflect actual bodily movement and/or energy expenditure. Some examples of this are direct calorimetry, doubly labeled water, motion detectors, physiological monitors, physical activity records and logs, and direct observation (Ainsworth, 2000).

Current national physical activity surveillance data are based largely on indirect methods, such as questionnaire data, which have been associated with considerable sources of error (Ainsworth, 2000; Sallis & Saelens, 2000). Some of these errors associated with questionnaires are a dependence on recall, a lack of precision to the activity being recalled (e.g., how intense is a brisk walk?), inconsistent scoring systems that are used to estimate energy expenditure, the general overestimation of self-reported physical activity, and discrepant correlations with varying intensities of physical activity (Ainsworth, 2000; Sallis & Saelens, 2000). However, recent technological advances in direct physical activity assessment, particularly motion detectors, have given researchers and practitioners the ability to reduce these potential sources of error. Motion detectors are devices that directly assess an individual's actual bodily movement. Accelerometers and pedometers are the two most commonly used types of motion detectors for physical activity assessment in laboratory and free-living settings (Ainsworth, 2000; Bassett & Strath, 2002; Welk, 2002).

Accelerometers have been used to monitor and provide a description of physical activity patterns in laboratory and free-living populations (Matthews, Ainsworth, Thompson, & Bassett, 2002; Nichols, Morgan, Chabot, Sallis, & Calfas, 2000; Tudor-Locke, Ainsworth, Thompson, & Matthews, 2002; Welk, 2002; Welk, Schaben, & Morrow, 2004; Westerterp, 1999). Accelerometers provide physical activity data in the form of activity counts that are summed over a user-defined time period. These summed counts are reflective of the frequency, time, and intensity of physical activity over the observed time period. The data derived from accelerometers provide a more accurate picture of an individual's ambulatory physical activity. However, accelerometers are expensive (from $75 to more than $800), and the data management is complex and very time consuming. These limitations make accelerometers impractical for large-scale studies and use among the general population.

Conversely, pedometers are inexpensive ($15-$30) motion detectors that record the number of steps taken over a user-defined time period. They allow for objective and reliable measurement of ambulatory physical activity (Bassett, 2000) and have been employed in epidemiological studies (Bassett, Schneider, & Huntington, 2004; Sequeira, Rickenbach, Wietlisbach, Tullen, & Schutz, 1995). Moreover, because pedometers are relatively low-tech and user-friendly with easy to understand data outputs (i.e., steps), they are increasingly being marketed and employed in interventions as a motivational instrument to increase an individual's physical activity (Leermakers, Dunn, & Blair, 2000; Schnirring, 2001; Tudor-Locke, Myers, Bell, Harris, & Rodger, 2002; Wilde, Sidman, & Corbin, 2001). Importantly, one caveat when most pedometers are utilized for the assessment of physical activity is that it is usually incumbent upon the individual participants to record their steps on step logs in order for researchers and practitioners to accurately assess physical activity patterns. Therein lies the problem; to date, there have not been any studies conducted that have examined the validity of participant recorded step logs. Therefore, the primary purpose of this study is to determine the validity of participant recorded pedometer step logs among free-living adults.

Purposes of Study

1. To examine the validity of participant recorded steps logs among free-living adults.
2. To examine the relationship between body composition and steps per day.
3. To examine the differences in steps per day between healthy weight individuals (BMI < 25 kg/m^2) and those who are overweight/obese (BMI ≥ 25 kg/m^2).
4. To examine whether healthy weight individuals (BMI < 25 kg/m^2) record their total accumulated steps, and steps per day, more accurately than overweight/obese (BMI ≥ 25 kg/m^2) individuals.

Research Questions

1. How valid are participant recorded steps logs among free-living adults?
2. Is there a linear relationship between body composition and steps per day?
3. Is there a significant difference in steps per day between healthy weight individuals (BMI < 25 kg/m^2) and overweight/obese (BMI ≥ 25 kg/m^2) individuals?

4. Do healthy weight individuals (BMI < 25 kg/m^2) record steps per day more accurately than overweight/obese (BMI ≥ 25 kg/m^2) individuals?

Hypotheses

1. Participant recorded steps logs are an accurate representation of the actual daily steps detected by an Actigraph accelerometer with cycle mode enabled.
2. Participant recorded steps logs are an accurate representation of the actual daily steps detected by an Actigraph accelerometer with cycle mode enabled, and corrected for vehicular travel.
3. The total accumulated steps recorded by participants on step logs are an accurate representation of total accumulated steps recorded from a sealed pedometer.
4. There is a strong linear, inverse relationship between steps per day and percent body fat (% BF).
5. Healthy weight individuals (BMI < 25 kg/m^2) take significantly more steps per day than overweight/obese individuals (BMI ≥ 25 kg/m^2).
6. Healthy weight individuals (BMI < 25 kg/m^2) record steps per day more accurately than overweight/obese (BMI ≥ 25 kg/m^2) individuals.

Null Hypotheses

1. Participant recorded steps logs are not an accurate representation of the actual daily steps detected by an Actigraph accelerometer with cycle mode enabled.
2. Participant recorded steps logs are not an accurate representation of the actual daily steps detected by an Actigraph accelerometer with cycle mode enabled, and corrected for vehicular travel.

3. The total accumulated steps recorded by participants on step logs are not an accurate representation of total accumulated steps recorded from a sealed pedometer.
4. There is not a strong linear, inverse relationship, between steps per day and percent body fat (% BF).
5. There is not a significant difference in steps per day between healthy weight individuals (BMI < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2).
6. Healthy weight individuals (BMI < 25 kg/m^2) do not record steps per day more accurately than overweight/obese (BMI ≥ 25 kg/m^2) individuals.

Significance of Study

The data from pedometer steps logs have been used in a variety of different research projects. These projects include methodological reports(Bassett, Cureton, & Ainsworth, 2000; Treuth et al., 2003; Tudor-Locke, Ainsworth et al., 2002) and descriptive examinations (Bassett et al., 2004; McClung, Zahiri, Higa, Amstutz, & Schmalzried, 2000; Sequeira et al., 1995; Thompson, Rakow, & Perdue, 2004; Tudor-Locke et al., 2001; Welk, Differding et al., 2000). Additionally, participant recorded pedometer step logs have been used in intervention studies (Croteau, 2004; DuVall, Dinger, Taylor, & Bemben, 2004; Moreau et al., 2001; Rooney, Smalley, Larson, & Havens, 2003; Sidman, Corbin, & Le Masurier, 2004; Suguira et al., 2002; Tudor-Locke, Myers, Bell, Harris, & Rodger, 2002; Wilde, Sidman, & Corbin, 2001).

Methodological studies have used step logs for information regarding the validity and reliability of pedometers for use in different populations. Based on the data from step logs, Treuth (2003) found that pedometers had low reliability (ICC = 0.08, p = 0.09), but were valid (r = 0.47, p = 0.0001) when more than one day was observed among African-American adolescent females. In another study in adults, Tudor-Locke et al. (2002) found a strong relationship (r = 0.74 – 0.86) between Actigraph accelerometer steps per day and participant-recorded pedometer steps per day, and Bassett and colleagues (2000) found that participant-recorded steps per day from a pedometer were more accurate than the College Alumnus Questionnaire (CAQ) in detecting ambulatory activity in both men (p = 0.0001) and women (p = 0.0001), with both genders under-reporting their ambulatory activity by CAQ.

Further, descriptive studies have utilized participant recorded pedometer step logs to indicate typical steps per day values for different populations (Bassett et al., 2004; Behrens & Dinger, 2003; Sequeira et al., 1995). Bassett and colleagues (2004) used pedometers in an Old-Order Amish community and found that among those studied; the men reported that they accumulated 18,425 ± 4,685 steps per day, while women reported that they accumulated 14,196 ± 4,078 steps per day. These values are higher than what is reported in the general American population due to the working atmosphere in Amish communities. In another large-scale study among Swiss residents, Sequeira and colleagues (1995) found that participants recorded far fewer steps (10,400 ± 4,700 for males and 8,900 ± 3,200 for females), while Behrens and Dinger (2003) found that the college students in their study recorded an accumulated average of 9,932 ± 2,680 steps per day, without gender differences.

Finally, intervention studies have used participant recorded pedometer step logs to measure increases in physical activity (Croteau, 2004; Moreau et al., 2001;

Tudor-Locke, Myers et al., 2002) and to utilize the data to motivate individuals and aid in goal setting to increase physical activity (DuVall et al., 2004; Rooney et al., 2003; Sidman et al., 2004; Wilde et al., 2001). In one study (Sidman et al., 2004), researchers recruited 94 sedentary women to take part in an intervention study using pedometers and participant recorded step logs. The purpose of the study was to examine whether these women accumulated more steps with a directed goal (10,000 steps per day) or with personal step goals. Their findings indicated no difference in step attainment, with the exception of those who had low step values at baseline. One important factor about this study is the fact that participant recorded pedometer step logs were the only physical activity assessment instrument used and the only outcome measure assessed.

The data that are recorded by study participants in steps logs are the primary physical activity data that are collected in a number of studies (Bassett et al., 2004; Croteau, 2004; Moreau et al., 2001; Sidman et al., 2004; Wilde et al., 2001). Moreover, in many cases these data are the outcome measure of the study (Rooney et al., 2003; Swartz, Strath et al., 2003; Tudor-Locke, 2001; Tudor-Locke, Myers et al., 2002; Wilde et al., 2001). If the steps recorded by participants are accurate, then the use of step logs with pedometers is a valid assessment of physical activity. However, if the step logs are flawed due to misrepresentation by the participant, accidental transcription errors, or other events, the data are not valid. As a consequence, any resultant findings and/or conclusions based on that data are also not valid.

Furthermore, because of the continuing popularity of pedometers in research and in the lay press (Anonymous, 2002; Austin & Powers, 2003; de Sa, 2001;

Sansone, 2003; Schnirring, 2001), it is unlikely that the use of pedometers will subside in the near future. Therefore, the validity of participant recorded step logs should be examined.

Delimitations

1. Participants were community-dwelling males and females between 25 and 60 years of age.
2. Adults with physical disabilities that limit ambulatory movement were excluded from the study.
3. Adults with bone or joint problems that could be made worse by a change in their physical activity were excluded from the study.
4. Adults who were currently under a physician's care for a heart condition and had been advised to only participate in physical activity recommended by a doctor were excluded from this study.
5. Adults who were currently taking drugs to control blood pressure or heart conditions were excluded from the study.
6. Those who experienced dizziness or chest pain while participating in physical activity were excluded from the study.
7. Adults with asthma or other respiratory difficulties were excluded from the study.
8. Those with an intense fear of enclosed spaces (claustrophobia) were excluded from the study.
9. Females who were pregnant were not allowed to participate in the study.

10. Individuals that exercised for 45 minutes or more on 5 or more days per week were excluded from participation in the study.
11. Individuals who regularly recorded or logged their physical activity were excluded from participation in the study.
12. All participants were from the Norman and Oklahoma City, Oklahoma metropolitan area.

Limitations

1. The Actigraph is not waterproof; therefore, water activities were not assessed.
2. The pedometer is not waterproof; therefore, water activities were not assessed.
3. The waist-worn Actigraph only captured ambulatory movement.
4. Pedometers only captured ambulatory movement.
5. The participants in this study were volunteers and, therefore, may not have been representative of the general adult population.
6. This study used a descriptive, cross-sectional design; therefore causal relationships cannot be determined.

Assumptions

1. All participants honestly answered the IPAQ questionnaire.
2. All participants honestly recorded their steps per day on the step logs.
3. All participants simultaneously wore the three devices (Actigraph, sealed pedometer, and unsealed pedometer) for the duration of the study.
4. All participants were in a fasted state for their body composition assessment.
5. All participants complied with the study protocol.

Operational Definitions

1. Physical activity – any bodily movement produced by skeletal muscle that results in energy expenditure (Casperson, Powell, & Christenson, 1985). This is operationalized as the raw accelerometer counts per minute, total accelerometer counts per day, and steps from the pedometers and accelerometer.
2. Actigraph accelerometer – a single plane accelerometer that measures and records vertical bodily movement as counts and steps (when in cycle mode) (Manufacturing Technology Incorporated, 2003).
3. Yamax pedometer – a spring-tensioned, electric pedometer that measures and displays vertical bodily movement as steps (Bassett et al., 1996).
4. Percent body fat (% BF) – the relative percentage of body weight that is fat mass (Nieman, 2003).
5. Air-displacement plethysmography – a measurement of body volume based on air-displacement that is used to calculate body density, which in turn, is used to calculate percent fat (Dempster & Aitkens, 1995; McCrory, Gomez, Bernauer, & Mole, 1995).
6. BOD POD – trade name for the commercially available system for assessing body volume via air-displacement plethysmography (Dempster & Aitkens, 1995).
7. Body Mass Index (BMI) – a measure of height for weight used in indicated health status and disease risk (Wagner & Heyward, 1999).

CHAPTER TWO

REVIEW OF LITERATURE

Physical inactivity is one of the leading causes of death and disability in the United States (Mokdad et al., 2004). The inverse relationship between physical activity and overweight and obesity has been well documented (U.S. Department of Health and Human Services, 2001), and as previously mentioned, physical activity is protective against many negative health outcomes including heart disease (Godsland et al., 1998; Oguma & Shinoda-Tagawa, 2004; Yu et al., 2004), hypertension (Hu et al., 2004), diabetes (Knowler et al., 2002), certain cancers (Allgayer et al., 2004; Bairati et al., 2000; Colbert et al., 2003; Patel et al., 2003; Turner et al., 2004), anxiety, and depression (Atlantis et al., 2004; Callaghan, 2004; Fukukawa et al., 2004). The burden of physical inactivity from overweight and obesity, chronic disorders, and psychological disorders, along with the financial costs associated with physical inactivity are burgeoning in American society. In this chapter, these comorbidities of physical activity will be discussed, as well as physical activity assessment techniques that are designed to reduce as much potential error as possible when measuring physical activity patterns in adults.

Physical Inactivity as a Public Health Problem

Epidemiological evidence suggests that the majority of Americans are not accumulating enough physical activity for health benefits (Casperson et al., 2000; Jones et al., 1998; Pratt et al., 1999). According to federal surveillance data, approximately 40% of the U.S. population ages 18 and higher do not participate in regular leisure time physical activity (Schiller et al., 2004). This lack of physical activity, along with poor dietary practices, are responsible for 400,000 deaths annually, accounting for more than 16% of all deaths in the United States in the year 2000 (Mokdad et al., 2004). Poor diet and physical inactivity rank second only to tobacco use as the leading actual cause of death for Americans. If the current trend continues, physical inactivity and poor dietary practices will be the leading cause of actual death in the United States in the near future (Mokdad et al., 2004).

Overweight and Obesity

Although the causes of overweight and obesity are unclear, it is clear that physical activity can play a role in weight management (DiPietro, 1999; Erlichman, Kerbey, & James, 2002; Fogelholm & Kukkonen-Harjula, 2000). Current evidence demonstrates that overweight and obesity is a continuing epidemic in the United States (Mokdad et al., 2001; Mokdad et al., 2004), and as the trend towards overweight and obesity continues, the physical, psychological, and economic consequences continue to increase as well (Mokdad et al., 2001; Mokdad et al., 2004). A question of contention among researchers is, how much physical activity is necessary to prevent weight gain (Saris et al., 2003)?

In a study with previously obese adult women (Schoeller, Shay, & Kushner, 1997), researchers found that the women in their study (n = 32) required much more time in physical activity than was previously thought to effectively manage their weight. Women in this study visited researchers five times over a 12-month period to have their resting metabolic rate, total energy expenditure, and body composition assessed. Physical activity was assessed by 7-day recall and heart rate monitoring. Results indicated that these women required 80 minutes per day of moderate physical activity (MPA) or 35 minutes per day of vigorous physical activity (VPA) added to a sedentary lifestyle to prevent weight gain. This is clearly more than the 30 minutes of MPA recommended by Centers for Disease Control and the American College of Sports Medicine (Pate et al., 1995).

In another study of previously obese individuals (Klem, Wing, McGuire, Seagle, & Hill, 1997), researchers described the practices of those successful in weight loss. The participants in the study (n = 784) were from the National Weight Control Registry (NWCR). They had lost an average of 30 pounds and kept it off for more than 5 years. Analysis of their responses indicated that 71% of women and 79% of men expended at least 1,000 calories per week in physical activity to meet their weight loss goals. This meets the caloric expenditure recommendation of the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) recommendation (Pate et al., 1995), but does not exceed it.

To try and definitively answer the question of how much physical activity is necessary for weight management, the Institute of Medicine (IOM) gathered evidence from studies using the doubly labeled water technique (Brooks, Butte, Rand, Flatt, & Caballero, 2004). Doubly labeled water is a technique that involves adding hydrogen and oxygen isotopes to determine energy expenditure. The concentration of the hydrogen and oxygen isotopes in the body gradually decrease as the individual consumes more unlabeled water and performs daily functions resulting in energy expenditure. The rates of dissolution are then plotted over a pre-determined time frame, and energy expenditure for the individual is calculated based on the regression from the plotted dissolution times (Nagy, 1990).

The IOM's evaluation of the doubly-labeled water studies resulted in a recommendation that in order to prevent weight gain, adults should accumulate at least 60 minutes of MPA a day (Institute of Medicine of the National Academies of Science, 2002). However, their results have come under scrutiny because of the analyses and interpretation of the studies that were reviewed (Blair, LaMonte, & Nichaman, 2004). Accordingly, the Stock Conference consensus statement by the International Association for the Study of Obesity released their own position stand regarding the amount of physical activity necessary for weight management (Saris et al., 2003). The IASO recommendation states that previously obese adults need to accumulate 60-90 minutes of MPA per day and lesser amounts of VPA to prevent weight gain (Saris et al., 2003), and it sharply criticized the IOM for its statements regarding the CDC/ACSM recommendation (Blair et al., 2004).

Most recently, the United States Department of Health and Human Services (DHHS) and the United States Department of Agriculture (USDA) released their own physical activity recommendation (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). This recommendation closely resembles the IOM and IASO recommendations in that it endorses 60 to 90 minutes of MPA on most days of the week to prevent weight gain and aid in weight management. However, it is also inclusive of the CDC/ACSM recommendation (at least 30 minutes of MPA on most days of the week) for the prevention of chronic diseases (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005).

While the latter recommendation does seem to bring the recommendations into a more uniform document, there is still great discrepancy over the appropriate physical activity recommendation for all Americans. These disparate recommendations give credence to the notion that the question of how much physical activity is necessary to prevent weight gain is still in dispute.

Chronic Disorders

Heart Disease and Hypertension

There is a clear link between physical activity and heart disease. Some of the earliest work in physical activity research pointed to the benefits of regular physical activity and exercise in relationship to heart disease (Morris, Heady, Raffle, Roberts, & Parks, 1953). This work was followed by the classic work of Paffenbarger and colleagues (Paffenbarger, Wing, & Hyde, 1978) which demonstrated that physical activity (exerting at least 2,000 calories per week) is an independent risk factor for heart attack in men. In his study, almost 17,000 Harvard alumni males were consulted regarding their physical activity patterns. It was found that those who expended ≥ 2,000 calories per week in physical activity were at a 64% decreased risk to experience a heart attack versus those expending less than 2,000 calories per week in physical activity (Paffenbarger et al., 1978).

In another classic study, leisure time physical activity (LTPA) was examined among U.S. railroad workers (Slattery, Jacobs, & Nichaman, 1989). In this study, railroad workers were followed ≥ 17 years, or until death. Slattery and colleagues found that LTPA was an independent risk factor for heart disease with low active men at a 39% (95% CI: 1.08, 1.79) increased risk of heart disease versus their highly active counterparts (Slattery et al., 1989). Additionally, all cause mortality was higher (RR = 1.32, 95% CI: 1.12, 1.56) among those who were the least active (Slattery et al., 1989).

In a more recent review of the literature (Riedel & Kelsberg, 2004), MPA was shown to reduce risk of all cause mortality by 34% (95% CI: 0.59, 0.98) and cardiac events by 27% (95% CI: 0,56, 0.96). Further examinations of males and female adults found that, yet again, physical activity is an independent factor for heart disease, while controlling for age, sex, education, smoking, hypertension, diabetes, and BMI (Chen & Millar, 2003). In their study, Chen and Millar (2003) found the odds of those engaging in MPA (OR = 0.46, 95% CI: 0.27, 0.80) being diagnosed with heart disease was significantly less ($p = 0.05$) than those less active. Further, in a meta-analysis of studies with women subjects, a clear dose-response relationship ($p_{trend} < 0.0001$) between physical activity and heart disease was evident (Oguma & Shinoda-Tagawa, 2004).

Not only is mortality and risk of heart disease decreased by physical activity, but also heart function improves. In a randomized controlled study with 269 patients, an experimental group was given an exercise regiment of a 2-hour, twice weekly program for 8 weeks (Yu et al., 2004), while a control group was given conventional care. Results indicated that those in the experimental group experienced improvements in left ventricular function and relaxation patterns ($p < 0.01$). Further, the experimental group's gain in exercise capacity was significantly greater ($p < 0.001$) than that of the control group (Yu et al., 2004). Cleary the literature indicates a strong relationship between regular PA and its protective effects against heart disease.

Similar to the relationship between physical activity and risk reduction of heart disease is that of the relationship between hypertension and physical activity. In a recent study, physical activity was negatively associated with both systolic (R^2 = -2.19 ± 0.14, p = 0.05) and diastolic (R^2 = -0.91 ± 0.13, p = 0.05) blood pressure in men (Godsland et al., 1998). In another study, male and female adults were followed for 11 years and records were taken of physical activity and hypertension during that time (Hu et al., 2004). Results indicated hazard ratios of 1.00, 0.63, and 0.59 for men who were light, moderately, and highly active, respectively ($p_{trend} < 0.001$). Women's hazard ratios were 1.00, 0.82, and 0.71 for light, moderate, and high activity and demonstrated a significant ($p_{trend} = 0.005$) trend (Hu et al., 2004). Therefore, the dose-response relationship was a trend that was evident between both genders and physical activity and the development of hypertension.

Diabetes

The estimated prevalence of diabetes in U.S. adults is 2,900-3,400 per 100,000, and each year there are over 720,000 new cases of diabetes that are diagnosed (Bishop, Zimmerman, & Roesler, 1998). Incredibly, from 1990 to 2000 there was a 49% increase in the number of Americans diagnosed with diabetes (Mokdad et al., 2001). By the year 2050 it is estimated that the number of Americans diagnosed with diabetes will increase by 165% and roughly one-third more will be undiagnosed (Boyle et al., 2001).

In an effort to examine the effects of physical activity on diabetes, researchers randomly assigned 3,234 non-diabetic patients to either a placebo, drug, or lifestyle modification group (Knowler et al., 2002). The lifestyle modification group was asked to participate in 30 minutes of MPA for at least five days per week. After an approximate 3-year follow-up, the lifestyle modification group reduced the incidence of diabetes by 58% (95% CI: 48%, 66%) versus the control (placebo) group. These results even outpaced the drug group, which had a 31% reduction (Knowler et al., 2002).

In another recent large-scale study examining the effects of physical activity and diabetes (Batty, Shipley, Marmot, & Smith, 2002), researchers gathered data from the Whitehall Study, a large database (n = 18,403) made up of male British civil servants between the years of 1967 and 1969. Results from an epidemiological investigation revealed that walking and leisure time physical activity (LTPA) were significantly associated ($p = 0.001$) with decreased mortality from diabetes and comorbidities associated with diabetes (e.g., CHD). Further, when walking pace and LTPA were broken into subgroups (walking pace = slower, faster; LTPA = inactive, moderately active, active) and adjusted for age, there was still a significant decrease in mortality rates when participation in physical activity increased. Results such as these indicate that physical activity can be a useful tool when attempting to decrease diabetes incidence, morbidity, and mortality.

Cancers

Regular, sustained, physical activity reduces the risk of breast and colon cancers, and it also reduces the risk of other cancers as well (Colditz et al., 1997; Eyre et al., 2004). Specifically in women, there is much evidence to suggest that physical activity is protective against breast cancer (Patel et al., 2003) and colon cancer

(Martinez et al., 1997), while in males, regular physical activity is protective against colon cancers (Colditz et al., 1997) and prostate cancers (Bairati et al., 2000).

Not only is physical activity a protective factor in cancer risk reduction, but physical activity can also play a role in improving the quality of life for cancer survivors. In a study examining the effect of physical activity on quality of life in those treated for breast cancer, findings suggested that regular MPA sessions led to reduced fatigue and an improved quality of life (Turner et al., 2004). Findings such as these are indicative that physical activity can play a role not only in cancer risk prevention, but also in treatment of cancer patients during recovery.

Psychological Disorders

In addition to the numerous chronic diseases that are associated with a lack of physical activity, there are also psychological disorders that are associated with decreased physical activity participation. The most common psychological disorders associated with decreased levels of physical activity are anxiety and depression (Callaghan, 2004; DiLorenzo et al., 1999; Weyerer & Kupfer, 1994)**.**

A review of the mental health literature revealed that physical activity and exercise are closely associated with anxiety suppression (Callaghan, 2004). While LTPA led to moderate reductions in anxiety, planned and structured exercise sessions yielded a more beneficial effect on anxiety (Callaghan, 2004). Furthermore, physical activity is beneficial in depression management. In a study examining physical activity and depression (DiLorenzo et al., 1999), researchers found that after a 12-week bicycling regiment, participants reported less depressive symptoms. Moreover, at a 12-month follow-up, participants reported less depression and anxiety did their counterparts who were in the control group (DiLorenzo et al., 1999). Finally, a review of physical activity and psychological health suggested that physical activity, as a counseling method, was more beneficial for controlling psychological health than counseling alone (Weyerer & Kupfer, 1994).

Financial Costs of Physical Inactivity

In addition to obesity, chronic health, and psychological health issues, there are also financial costs related to decreased levels of physical activity. The economic cost of physical inactivity in the United States is, conservatively, between $24 billion (Colditz, 1999) and $76.6 billion per year (Pratt et al., 2000). Add to this other costs that are not as clearly defined, such as the cost of physical activity associated with mental health, and the cost grows even more.

In a study examining the economic costs of physical activity and mental health, researchers (Wang & Brown, 2004) found that physical inactivity is associated with increases in medical costs. They utilized data from the 1987 National Medical Expenditures Survey (n = 12,250) and estimated the expenditures in 2003-dollar amounts. They found that active individuals saved an average of $354 over their inactive counterparts in mental health care. Their study also found, in total, mental health expenditures associated with decreases in physical activity amounted to $38 billion in 2003 dollars.

Physical inactivity is clearly a public health issue that warrants further attention. Approximately 40% of Americans are not active enough to receive health benefits from physical activity (Schiller et al., 2004). This apparent lack of physical activity is ostensibly associated with overweight and obesity. However, it is unclear what other factors are associated with overweight and obesity, and the amount of physical activity necessary to prevent weight gain is also in dispute (Blair et al., 2004). Additionally, numerous lifestyle-related disorders such as heart disease, hypertension, diabetes, some cancers, depression, and anxiety have been associated with decreased physical activity (Pate et al., 1995). The financial consequences of these public health problems amount to an ever-increasingcost of physical inactivity, presently more than $76 billion. To combat these rising costs associated with physical inactivity; public health recommendations for physical activity have been released.

Physical Activity Recommendations

Public health and professional organizations have released position stands and recommendations on the amount of physical activity necessary to offset the rising tide of physical inactivity and its comorbidities. The current public health recommendation is aimed at decreasing sedentarism by encouraging individuals to increase their daily activity in moderate amounts (Pate et al., 1995). Conversely, the position stand by ACSM is aimed at increasing the fitness of individuals by more vigorous exercise (Pollock et al., 1998). Finally, the Institute of Medicine's (IOM) recommendation is intended for those attempting to maintain or lose weight (Blair et al., 2004; Brooks et al., 2004), and the most recent physical activity recommendation from the DHHS and USDA appears to attempt to tie together the different physical activity recommendations(U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005).

CDC/ACSM Moderate Physical Activity Recommendation

The CDC and the ACSM released a joint recommendation in 1995 regarding the amount of physical activity needed for health benefits (Pate et al., 1995). The recommendation states that adults should accumulate at least 30 minutes of MPA on most days of the week (Pate et al., 1995). The three main components of the recommendation are frequency, intensity, and duration. "Most, preferably all, days of the week" has been interpreted by researchers to be at least 5 days a week (Jones et al., 1998). Moderate-intensity physical activity is defined as an intensity that is equal to expending approximately 200 calories in 30 minutes of MPA per day, or 3-6 times the resting metabolic rate (Pate et al., 1995). Some examples of MPA include brisk walking (3-4 MPH), home repair, and house cleaning(Pate et al., 1995) . The duration component of the recommendation has two aspects. First, in order to obtain health benefits, MPA must be performed for a minimum of 30 minutes per day. Second, the 30 minutes of MPA can be accumulated in bouts of at least 8 to 10 minutes (Murphy, Nevill, Nevill, Biddle, & Hardman, 2002) throughout the day.

This recommendation, more commonly known as the MPA recommendation, is based on the evidence that even minimal amounts of physical activity can lead to health benefits (Blair et al., 2004; Pate et al., 1995). Unfortunately, recent empirical evidence suggests that only 15% of Americans participate in at least 30 minutes of MPA on 5 or more days per week in 2002 (Schiller et al., 2004).

ACSM Vigorous Physical Activity Recommendation for Cardiorespiratory Fitness

The ACSM VPA recommendation for cardiorespiratory fitness calls for adults to train aerobically for 3 to 5 days per week, at an intensity of 55%-90% of their maximum heart rate, for 20-60 continuous, or intermittent minutes in bouts of at least 10 minutes (Pollock et al., 1998). The duration component of the VPA recommendation for cardiorespiratory fitness is dependent upon the intensity of the activity performed. That is, the more intense the activity, the less time that is required. Inversely, if the activity is of less intensity, than the activity should be performed for longer periods of time (Pollock et al., 1998). The mode of activity should be any aerobic exercise that uses large muscle groups in a rhythmic, continuous nature (Pollock et al., 1998). Examples of VPA for cardiorespiratory fitness include hiking, running, jogging, rowing, stair climbing, swimming, and other endurance games (Pollock et al., 1998). However, similar to the data reported regarding the MPA recommendation, data from the 2002 National Health Interview Survey revealed that more than 59% of Americans never engage in VPA for cardiorespiratory fitness lasting longer than 10 minutes (Lethbridge-Cejku et al., 2004).

IOM Physical Activity Recommendation

In stark comparison to the MPA recommendation, the IOM physical activity recommendation states that 60 minutes of MPA is necessary to prevent weight gain (Institute of Medicine of the National Academies of Science, 2002). It is important to notice that this recommendation is not based on reducing the risk of chronic disease, but rather the emphasis is on weight management. The frequency, intensity, and modality components of the IOM recommendation are similar to that of the MPA recommendation, with an additional 30 minutes of physical activity necessary for weight management (Brooks et al., 2004). Seemingly obvious, if the majority of

Americans are not meeting the MPA recommendation, then by simple probability, an even greater number are not meeting the IOM recommendation.

DHHS/USDA Physical Activity Recommendation

Seemingly attempting to bind together the disparate physical activity recommendations, the DHHS and USDA physical activity recommendation calls for Americans to accumulate at least 60 minutes of MPA on most days of the week (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). This recommendation also calls for greater amounts of MPA if weight loss is the goal (60 to 90 minutes). However, in contrast to the seemingly similar IOM recommendation, the DHHS/USDA recommendation also compliments the usefulness of the CDC/ACSM recommendation for decreasing and managing the effects of chronic disease. As with the other recommendations, it is clearly evident that the majority of Americans are not meeting this physical activity recommendation.

In summary, there are four primary physical activity recommendations (excluding the IASO Stock Conference report). The CDC/ACSM recommendation calls for Americans to accumulate at least 30 minutes of MPA on most days of the week (Pate et al., 1995). The IOM recommendation is essentially the same as the CDC/ACSM recommendation, with an additional 30 minutes of MPA recommended for weight management (Institute of Medicine of the National Academies of Science, 2002). The VPA recommendation for cardiorespiratory fitness (Pollock et al., 1998) posited by ACSM calls for 20-60 minutes of more intense physical activity than is required by either the CDC/ACSM or IOM recommendation. Finally, the DHHS/USDA recommendation calls for Americans to engage in 60-90 minutes of

MPA on most days of the week, but also recommends lesser amounts of time (i.e., 30 minutes) for chronic disease management (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005).

It is evident that a great number of Americans are not abiding by these physical activity recommendations. However, to answer questions regarding who is and is not meeting physical activity recommendations, it is important to understand how physical activity is assessed in free-living populations. The remainder of this chapter explains physical activity assessment in an effort to examine how physical activity is measured, what the limitations are of differing assessment methods, and in-depth analysis of the particular assessment methods used in this study.

Physical Activity Assessment

It is important for researchers to examine how physical activity is assessed because the type of physical activity assessment is liable to dictate the types of outcomes that are obtained (i.e., frequency, intensity, and duration of physical activity). Many physical activity assessment methods do not ascertain some of the components of physical activity (i.e., frequency, intensity, and duration) in which individuals participate. For instance, the majority of the federal surveillance data indicated above were assessed via questionnaire. This may lead researchers and practitioners to believe inaccurate data as truly reflective of the physical activity landscape. The accurate assessment of physical activity is essential for researchers and practitioners when attempting to evaluate interventions and to have confidence in their results. In fact, many researchers believe that the validity of an assessment tool is commonly considered its most important attribute (Tudor-Locke, Williams et al., 2002). Therefore, it is necessary to examine how physical activity data are assessed.

Indirect Physical Activity Assessment

Surrogate markers of the behavior of physical activity, commonly referred to as indirect methods, can be used to assess physical activity. Indirect methods include measurement techniques such as body composition, cardiorespiratory fitness, and questionnaires (Ainsworth, 2000). Among indirect assessment techniques, questionnaires are commonly used to measure physical activity. In fact, the majority of national surveillance data are collected via questionnaires.

Even though questionnaires have been widely used, questionnaire data have been associated with considerable sources of error (Ainsworth, 2000; Sallis & Saelens, 2000). Some of the error associated with questionnaires are due to a dependence on recall, a lack of precision to the activity being recalled, inconsistent scoring systems that are used to estimate energy expenditure (Patterson, 2000), the general overestimation of self-reported physical activity, and discrepant correlations with varying intensities of physical activity (Ainsworth, 2000; Sallis & Saelens, 2000).

Although questionnaires do have limitations, they can offer many advantages. Questionnaires are inexpensive (compared to some other assessment methods), unobtrusive, and do not usually require great effort on the part of the participant. Additionally, many questionnaires are simple instruments that can be self-administered. These advantages make questionnaires a valuable tool in physical activity assessment. One questionnaire in particular, the International Physical

Activity Questionnaire (IPAQ), has recently yielded promising results for use as a physical activity assessment tool. Since this is the questionnaire to be used in this study, further discussion of the IPAQ, particularly the IPAQ-short form, will be discussed.

The International Physical Activity Questionnaire

The IPAQ is a recall questionnaire that requires individuals to recall their physical activity over the previous 7 days (Craig et al., 2003). There are four versions of the IPAQ, long and short forms that can be self-administered or interviewer-administered (Craig et al., 2003). The purpose underlying the development of the IPAQ questionnaires is to develop a self-reported measure of physical activity that can be used to compare internationally obtained physical activity data across all domains of physical activity (i.e., LTPA, transportation, occupational, and household). The IPAQ-short form consists of questions concerning the frequency and duration of VPA and MPA, as well as questions regarding the frequency and duration of walking and sitting activity (Craig et al., 2003). The data collected from the administration of the IPAQ can be used to calculate energy expenditure in MET hours per week, and with the body weight of an individual, can be used to calculate energy expenditure in calories per week (Kriska & Casperson, 1997).

Recently, the psychometric properties of the IPAQ short form were examined during the IPAQ 12-country reliability and validity study (Craig et al., 2003). In this study, there were 14 sites in 12 countries (Australia, Brazil, United Kingdom [2 sites], Canada, Finland, Guatemala, the Netherlands, Japan, Portugal, United States [2 sites], South Africa, and Sweden). The sample sizes for each site varied from 28 to 257 participants. The total sample size was 2,300 (Craig et al., 2003).

Test-retest reliability of the IPAQ short form was conducted over a 3 and 7-day period with two individual visits. Spearman correlation coefficients ranged from 0.32 to 0.88 across sites, with a pooled $\rho = 0.76$, 95% CI = 0.73-0.77 for all sites (Craig et al., 2003). The self-administered form was found to have a test-retest reliability $\rho = 0.75$ for all sites, ranging from 0.66 to 0.88 across sites. Concurrent validity was noted to have a pooled $\rho = 0.67$, 95% CI = 0.64-0.70 between long and short forms of the IPAQ. Criterion validity was determined against the Actigraph accelerometer with the short form yielding a pooled $\rho = 0.30$, 95% CI = 0.23-0.36 (Craig et al., 2003). These results from the short form indicate that this instrument shows acceptable validity and reliability.

Direct Physical Activity Assessment

Direct methods of physical activity assessment differ from indirect methods in that instead of being a surrogate marker of physical activity, direct methods reflect actual bodily movement and/or energy expenditure. Some examples of direct physical activity assessment include direct calorimetry, doubly labeled water, motion detectors, physiological monitors, physical activity records and logs, and direct observation (Ainsworth, 2000).

Recently, motion detectors have gained widespread notoriety for their ability to provide a physical activity assessment tool that can eliminate some of the potential sources of error associated with indirect physical activity assessment methods such as questionnaires. The two most common types of motion detectors are accelerometers and pedometers (Bassett & Strath, 2002; Freedson & Miller, 2000; Welk, 2002). Both of these devices can be used to describe an individual's physical activity patterns.

Accelerometers provide more data to researchers and practitioners by accounting for the intensity, duration, and frequency of ambulatory activity (Welk, 2002). However, accelerometers are expensive and the complexity of the data management makes them impractical for large-scale studies and use among the general population. Conversely, pedometers feature an ease of use and user-friendly outputs (i.e., steps taken) that make them more acceptable to the general population (Bassett et al., 1996). Furthermore, pedometers are relatively inexpensive and the data management is much easier for researchers and practitioners to manipulate (Tudor-Locke & Myers, 2001).

Accelerometers

Accelerometers are motion detectors that assess total ambulatory activity; capture frequency, intensity, and duration of activity; and provide an estimate of energy expenditure (Ainsworth, 2000; Bassett, 2000; Westerterp, 1999). Accelerometers can be either uniaxial (i. e., capturing movements only on a single plane), such as the Caltrac and MTI Actigraph (Freedson & Miller, 2000) or triaxial (i.e., capturing movements on all three planes), such as the Tritrac accelerometer (Freedson & Miller, 2000). Of particular interest to the present study is the MTI Actigraph accelerometer (Manufacturing Technology Incorporated, 2003), since that is the accelerometer to be used in this study.

Briefly, the Actigraph (Manufacturing Technology Incorporated, Model 7164; Shalimar, FL) accelerometer is a small, lightweight, personal physical activity measurement and recording system that will be used as one direct measure of subjects' ambulatory physical activity in this study. The Actigraph measures 2 x 1.6 x 0.6 inches, weighs 1.5 ounces, and records accelerations from 0.05-2 G's (Manufacturing Technology Incorporated, 2003). This minute degree of sensitivity allows the Actigraph to record small movements not easily detected by other motion detectors. However, increased sensitivity also decreases the ability of the Actigraph to discriminate between actual ambulatory movement and non-ambulatory movements (i.e., vehicular travel). Still, any vertical movement results in an acceleration that acts on a cantilevered piezoelectric beam and produces a charge that is proportional to the strain. The acceleration signal is filtered by an analog bandpass filter and digitized by an 8-bit A/D converter at a rate of 10 samples per second. Each signal is summed over a user specified interval of time. The Actigraph is initialized and downloaded using a reader interface that is connected to a serial port of a PC compatible computer. Actigraph data are in counts per user-specified time intervals and represent the intensity of the activity during each time period.

Validity

The Actigraph has been used in a variety of studies to monitor and provide a description of physical activity patterns in laboratory and free-living populations (Le Masurier, Lee, & Tudor-Locke, 2004; Le Masurier & Tudor-Locke, 2003; Nichols et al., 2000; Tudor-Locke, Ainsworth et al., 2002; Welk, 2002; Welk et al., 2004; Westerterp, 1999). Validity of Actigraph counts have well documented relationships with energy expenditure, relative VO_2, heart rate, and treadmill speed (Melanson & Freedson, 1995). In their study, Melanson and Freedson monitored heart rate and oxygen consumption in a minute-by-minute process while the Actigraph was secured to the hip of study participants (n = 15). Results indicated criterion validity of r = 0.80 with energy expenditure, r = 0.82 with relative VO_2, r = 0.66 with heart rate, and r = 0.82 with treadmill speed (Melanson & Freedson, 1995).

In an examination of validity for the assessment of MPA in free-living settings, Hendelman and colleagues (2000) had a sample of males and females (n = 25) complete four bouts of walking and other moderate activities (golf, household chores, outdoor chores). They based the accelerometer counts against expired gases from a portable metabolic unit. The results indicated that Actigraph counts were significantly correlated with METs for walking (r = 0.77) and for all moderate activities (r = 0.59).

Reliability

In the most recent study addressing the reliability of the Actigraph, Welk, Schaben, and Morrow (2004) had participants wear an Actigraph while completing three trials of walking on a treadmill at 3 MPH. Participants walked for five minutes and had a 1-minute washout time between each trial. Generalizability Theory was used to quantify the variance between the trials and interclass correlations were calculated. The G value was high for the Actigraph (G = 0.64, SEM = 348) and a strong correlation was recorded (ICC = 0.80). These values indicated a high degree of reliability for the Actigraph.

Cut-points

In addition to the validity of the instrument, the usefulness of Actigraph outputs (counts) is also an important issue. The raw data output by the Actigraph is useful only to those who can interpret the data. If someone were to know the raw counts, the only determination that could be made would be that the higher the counts, the more intense the activity. To explain this issue in relation to METs, Freedson and colleagues attempted to provide cut-points that allow for the determination of time spent in various intensities of physical activity (Freedson, Melanson, & Sirard, 1998). For their study, they recruited 25 males and 25 females to walk/jog on treadmills for three 6-minute bouts at three different speeds: 4.8 km per hour, 6.4 km per hour, and 9.7 km per hour (Freedson et al., 1998). They used the following regression equation for estimating METs from counts per minute: METs = 1.439008 + (0.000795 * counts per minute). This led to a finding that counts per minute equal to or less than 1951 were indicative of light activity (≤ 3 METs). Counts per minute between 1,952-5,724 were considered MPA (3-5.99 METs). Counts per minute between 5,725-9,498 were considered hard (6-8.99 METs), and very hard intensity (≥ 9 METs) were counts per minute greater than 9,499 (Freedson et al., 1998).

Hendelman also examined cut-points in the study mentioned previously (Hendelman, Miller, Baggett, Debold, & Freedson, 2000). They recruited 10 male and 15 female subjects and asked them to walk bouts of self-selected leisurely, comfortable, moderate, and brisk paces. They were then also monitored playing golf and performing indoor and outdoor chores, while during all activities, expired gases were collected (Hendelman et al., 2000). The researchers then reported regression equations for walking [METs = 1.602 + (0.000638 * counts per minute)] and all activities combined [METs = 2.922 + (0.000409 * counts per minute)] (Hendelman et al., 2000). Her examination of cut-points yielded results different from those of Freedson (1998). Hendelman's cut-points were as follows: ≤ 3 METs was equal to or less than 2,191 counts per minute for walking and 191 counts per minute for all activities combined. Moderate activities (3-5.99 METs) were 2,192-6,893 counts per minute for walking and 191-7,524 counts per minute for all activities combined. Hard intensity (6-8.99 METs) was 6,894-11,595 counts per minute for walking and 7,525-14,860 counts per minute for all activities, and very hard intensity (≥ 9 METs) was greater than or equal to 11,596 counts per minute for walking and greater than or equal to 14,861 counts per minute for all activities combined (Hendelman et al., 2000).

Swartz and colleagues (Swartz et al., 2000) completed a study similar to that of Hendelman et al (2000) utilizing moderate activities, but with multiple positions for the Actigraph on the body (wrist, ankle, and hip). In their study, 31 males and 39 females were required to complete one of six activities within the categories of yard work, housework, family care, occupational activity, recreational activity, or physical conditioning activities while wearing a portable indirect calorimetry unit. Their findings yielded a regression equation [METs = 2.606 + (0.0006863 * counts per minute)] which suggested cut-points at less than or equal to 3 METs equal to or less than 574 counts per minute. MET values from 3-5.99 METs (MPA) were between 575-4,944 counts per minute, and hard intensity activities (6-8.99 METs) were equal to 4,945-9,316 counts per minute. Very hard intensity activity (greater than or equal to 9 METs) was greater than or equal to 9,317 counts per minute (Swartz et al., 2000). They also found that the hip placement of the Actigraph explains the majority of the variance when explaining ambulatory physical activity with accelerometers. The ankle and wrist sites were only responsible for an additional 2.7% of the variance in the model (Swartz et al., 2000).

Cycle Mode (Steps)

The Manufacturing Technology Incorporated Actigraph Monitor Model 7164 (Version 2.2; Shalimar, FL) has the option (cycle mode) to determine the number of steps accumulated throughout the day. After the cycle mode is activated, the Actigraph counts the number of cycles in the acceleration signal over a user specified time period. When the Actigraph is worn at the waist, cycle counts approximate the number of steps taken during the time interval (Manufacturing Technology Incorporated, 2003).

The utility of the Actigraph to explain ambulatory movement being well established, there is a significant relationship between accelerometer counts and pedometer steps (Tudor-Locke, Ainsworth et al., 2002). In a study by Tudor-Locke and colleagues (2002), participants (n= 52) wore an Actigraph and a pedometer for seven consecutive days. They found that Actigraph counts per day were correlated with pedometer steps per day ($r = 0.74$, $p < 0.0001$), total counts per day ($r = 0.80$, $p < 0.0001$), and that pedometer steps per day were also correlated ($r = 0.86$, $p < 0.0001$) with Actigraph steps per day (Tudor-Locke, Ainsworth et al., 2002). Further, Bland-Altman plotting demonstrated agreement between the two different measures of steps per day with Actigraphs reporting an average of 1,845 ± 2,116 more steps per day than the pedometer. Tudor-Locke, Ainsworth et al., (2002) therefore suggested that a value of 1,845 steps per day could be used to correct for Actigraph sensitivity to recorded movements that may not actually be ambulatory movement.

Moreover, a study by Le Masurier and Tudor-Locke (2003) found that vehicular travel caused steps to be registered by the Actigraph that were not registered by pedometers. In this study, 20 participants drove a pre-determined course in a vehicle while wearing both the Actigraph and a pedometer. Steps from the Actigraph and pedometer were then compared to investigate their agreement. Results indicated that the Actigraph counted significantly more steps ($p < 0.05$) than the pedometer (Le Masurier & Tudor-Locke, 2003). Based on this finding, Le Masurier and Tudor-Locke suggested that when comparing Actigraph and pedometer steps per day, one should adjust the Actigraph-derived steps by 12.5 steps for each mile driven during the day to account for differences in instrument sensitivity.

In summary, there are small discrepancies between Actigraph-derived and pedometer-derived steps per day. Although not absolute, the findings by Tudor-Locke, Ainsworth, and colleagues (2002) and Le Masurier and Tudor-Locke (2003) indicate that there are certain correction factors that can be provided to increase agreement from Actigraph and pedometer steps per day. Their findings suggest that pedometers are valid and useful tools that are able to accurately assess ambulatory physical activity in free-living adults to a similar degree of an accelerometer.

Pedometers

Of primary interest in this study is the use of pedometers for physical activity assessment. As previously mentioned, pedometers are inexpensive motion detectors that record the number of steps taken over a user-defined time period. They allow for objective and reliable measurement of ambulatory physical activity (Bassett, 2000) and have been employed in large-scale epidemiological studies (Bassett et al., 2004; Sequeria, Rickenbach, Wietlisbach, Tullen, & Schutz, 1995). Further, pedometers are relatively low-tech, user-friendly, and are increasingly being marketed and employed in interventions as a motivational instrument to increase an individual's physical activity (DuVall et al., 2004; Leermakers et al., 2000; Schnirring, 2001; Tudor-Locke et al., 2002; Wilde et al., 2001).

Validity

In general, it has been found that pedometers are most accurate for assessing steps. They are less accurate at assessing distance and energy expenditure (Crouter, Schneider, Karabulut, & Bassett, 2003). In a review of energy expenditure versus pedometer steps (Tudor-Locke, Williams, Reis, & Pluto, 2002) researchers found that pedometer steps correlated with energy expenditure (median $r = 0.68$) with a range of $r = 0.46$ to $r = 0.88$ among all reports reviewed in their study (studies: $n = 8$). These values were based on studies that estimated energy expenditure with heart rate as well as indirect calorimetry and doubly labeled water. Possible reasons for the lower correlations seen with energy expenditure could be that pedometers measure actual physical movement while energy expenditure is a reflection of gender, age, and body mass in addition to physical movement efficiency.

In addition to energy expenditure, accelerometers and pedometers have been widely used to estimate actual physical movement. As previously mentioned, findings (Bassett, 2000; Tudor-Locke, Ainsworth et al., 2002) indicate that accelerometer and pedometer outputs are highly correlated in the detection of ambulatory movement. In a review of convergent validity with accelerometers and pedometers the correlations from published reports ranged from r = 0.69 (Gardner & Poehlman, 1998) to r = 0.99 (Kilanowski, Consalvi, & Epstein, 1999). The median value of all reported correlations was r = 0.86 (Tudor-Locke, Williams et al., 2002).

Pedometer validity has also been assessed against the criterion measure of direct observation (Kilanowski et al., 1999). In a recent review of pedometer validity citing pedometry against observation, researchers (Tudor-Locke, Williams et al., 2002) found that pedometer steps were positively correlated with time spent performing physical activity. Correlation coefficients for ambulatory activity in children ranged from r = 0.80 for sitting activities to r = 0.97 for recreational activities (Kilanowski et al., 1999). Although these values are high correlations, there have been observational studies (McClung et al., 2000; Shepherd, Toloza, McClung, & Schmalzried, 1999) that suggest validity of pedometers may be compromised in obese individuals (BMI $\geq$ 30 kg/m^2). However, another study examining this potential problem demonstrated that it is not a concern when assessing ambulatory activity (Swartz, Bassett, Moore, Thompson, & Strath, 2003). Future research is needed in this area to be able to answer questions regarding increased abdominal adiposity and pedometer accuracy.

Pedometers have been validated against self-reported physical activity (Bassett et al., 2000). In Bassett, Cureton, and Ainsworth's (2000) study, 48 men and 48 women were recruited to participate. They wore a pedometer and completed the College Alumnus Questionnaire in an attempt to determine which was better at estimating distance walked. Their results indicated a correlation of 0.346 for men and

0.481 for women. However, self-report, as stated previously, is an indirect measure of physical activity with considerable sources of error (Bassett et al., 2000). Because of this error, a recent review paper found that questionnaires correlations' with actual bodily movement (which pedometers detect) are quite low (median correlation: r = 0.33; range r = 0.02 to r = 0.94; Tudor-Locke, Williams et al., 2002). There are various reasons for this wide range. Some of these reasons include the time that physical activity was monitored (e.g., minutes versus days), the intensity of activity (e.g., MPA versus VPA), and the type of activity (e.g., ambulatory, swimming, exercise).

In one of the most recent comparisons of pedometers in free-living conditions Schneider, Crouter, and Bassett (2004) recruited 20 participants (10 male, 10 female) who wore the Yamax Model 200 on their left hip. During the same time frame the participants wore different pedometers for 24-hours each on the right hip (13 different pedometers in total). Their findings indicated the best agreement between the Yamax Model 200 and itself. There was not a significant difference in steps per day between the criterion (Yamax Model 200 worn on left hip) and the test unit (Yamax Model 200 worn on the right hip) with a mean difference of 372 ± 1,685 steps in a 24-hour period (Schneider, Crouter, & Bassett, 2004).

Reliability

It is difficult to obtain test-retest reliability data from a pedometer because of the fluctuations in daily physical activity. It has been suggested that since large daily variations in daily physical activity exist, the data provided by pedometers can actually be more meaningful because they can detect differences in usual, daily, physical activity (Bassett & Strath, 2002). Further, it has been reported that to improve the reliability of pedometer-derived data, sampling periods of longer than one day must be used. This is because data that are collected over a longer time period and then averaged yield a more representative model of actual physical activity (Bassett & Strath, 2002).

This being said, reports have examined the various types and models of pedometers on the market. Generally, reliability of the pedometer depends on the make and model (Bassett et al., 1996; Schneider, Crouter, Lukajic, & Bassett, 2003). Therefore, researchers and practitioners need to be cognizant of the best models and brands necessary to meet their needs (Melanson et al., 2004). In a study examining the reliability of many different brands of pedometers over a 400-meter walk (Schneider et al., 2003), researchers found that 9 of the 10 pedometers tested reported high levels of intramodel reliability, and that the Yamax pedometer similar to the model that will be used in this study, was reported to have exceptional (Cronbach's $\alpha = 0.992$) intramodel reliability (Schneider et al., 2003).

Summary

The psychometric properties of particular physical activity assessment tools or techniques are important issues in physical activity research. The validity of an assessment method allows researchers to evaluate programs, and to have confidence in results obtained with the use of a particular assessment technique. As covered in this section, physical activity can be assessed indirectly or directly (Ainsworth, 2000). Indirect methods are surrogate markers of physical activity and direct methods reflect actual movement and/or energy expenditure (Ainsworth, 2000). Among the most common types of indirect assessment methods are questionnaires. The IPAQ, which is the questionnaire that will be used in this study, has shown promising results in initial examinations of its use in the field (Craig et al., 2003). Motion detectors such as the accelerometers and pedometers, that are to be used in this study, are direct physical activity assessment tools that have been widely used to describe and quantify physical activity in free-living adults. The use of pedometers in the field, as well as their other applications, will be examined in the forthcoming section of this chapter.

Pedometer Applications in the Field

Pedometers have been used in a variety of settings for a range of purposes. Researchers have used pedometers to quantify physical activity in individuals and populations of people (Gardner & Poehlman, 1998; Leenders, Sherman, Nagaraja, & Kien, 2001; Mikami, Mimura, Fujimoto, & Bar-Or, 2003; Scruggs et al., 2003; Tudor-Locke, Ainsworth, Thompson, & Matthews, 2002; Welk, Differding et al., 2000). They have also been used to examine the efficacy of medical interventions (McClung et al., 2000; Schmalzried et al., 1998; Shepherd et al., 1999); they have been used in interventions to increase physical activity (Iwane et al., 2000; Leermakers, Dunn, & Blair, 2000; Tudor-Locke, Myers et al., 2002; Wilde et al., 2001); and they have been utilized as motivational tools (Hatano, 1993; Leermakers et al., 2000; Schnirring, 2001; Tudor-Locke, 2002; Tudor-Locke, Myers et al., 2002; Wilde et al., 2001).

Quantifying Physical Activity with Pedometers

Pedometers allow for physical activity to be assessed with a small, unobtrusive device that is inexpensive and user-friendly. Further, the data (steps) are easy for the layperson to understand. Studies have even used pedometers to quantify physical activity in children. Scruggs and colleagues (2003) used pedometers to quantify physical activity in elementary school physical education (PE) classes. Their goal was to determine a step count per minute that could be used to quantify the amount of time spent in moderate and vigorous physical activity (MVPA) during a PE class. They found that 1,800-1,890 steps were equivalent to 30 minutes of MVPA during a PE class. They concluded that the use of pedometry was an accurate indicator of MVPA and it was a viable method for large-scale surveillance in PE classes.

Pedometers have also been successfully used in adult populations. In a large-scale study of Swiss residents (n = 493), Sequeira and colleagues (1995) used pedometers as a measure of physical activity along with a questionnaire. Participants were stratified by occupational status to examine steps per day, and age was used as a descriptor to examine physical activity differences as age increased. Results indicated that the pedometer was able to accurately distinguish sedentary occupations from more active, and that there was a liner inverse relationship between age and steps per day. During the study period men averaged 10,400 ± 4,700 steps per day and women averaged 8,900 ± 3,200 steps per day (Sequeira et al., 1995).

In another study of an Old-Order Amish community, Bassett (2004) had participants (n = 98; males: n = 53; females: n = 45) wear a pedometer for 7 days and then they completed the IPAQ questionnaire. Results indicated that the men accumulated 18,425 ± 4,685 steps per day and the women accumulated 14,196 ± 4,078 steps per day. Further, his findings suggested that % BF was inversely related to both steps per day (r = -0.356) and to the IPAQ score (r = -0.424). Further, pedometer steps per day were significantly related (r = 0.469) to the overall IPAQ score (Bassett et al., 2004).

In a recent investigation of steps per day in a large population, Tudor-Locke, Ham, Macera, et al. (2004) described the ambulatory physical activity patterns of 209 participants in the southeastern United States. Researchers mailed participants a pedometer that was worn at their waist during all waking hours for 7 consecutive days. Respondents recorded their daily steps on a step log that was mailed back to the researchers. Results of the study indicated that the sample accumulated 5,931 ± 3,664 steps per day, with males accumulating significantly ($p < 0.0001$) more steps (7,192 ± 3,596) than females (5,210 ± 3,518). Moreover, Caucasians accumulated significantly ($p < 0.0001$) more steps (6,628 ± 3,375) than nonwhites (4,792 ± 3,874). Further, participants in the study were more active on weekdays than on weekends and more active at work than when not working.

In a study designed to examine the step patterns of college students, Behrens and Dinger (2004) reported the results of a small (n = 31) preliminary report. Participants wore the pedometer for 7 consecutive days during all waking hours. Their findings indicated that students averaged 9,932 ± 2,680 steps per day. They also found that students were more active on weekdays than on weekends, and that there was not a difference in the total ambulatory activity between males and females.

As previously mentioned, although there have been few representative studies (Bassett et al., 2004; Sequeira et al., 1995) conducted with healthy young adults, empirical data has been collected that suggests normative step values. From a recent review of the literature, healthy young adults can expect to take between 7,000 to 13,000 steps per day, and women's' values would be expected to be less than men's values (Tudor-Locke & Myers, 2001). Older adults who are healthy have an expected daily step count of between 6,000 to 8,500 steps (Tudor-Locke & Myers, 2001). Further, individuals with a disability or chronic disease are obviously less able to perform ambulatory movement. Therefore, the expected step count values for this population are between 3,500 to 5,500 steps per day (Tudor-Locke & Myers, 2001).

Using Pedometers to Motivate and Increase Physical Activity

Another common application of pedometers is to increase physical activity of participants through motivation. Tudor-Locke and colleagues (2002) used pedometers as motivational tools to try and increase the physical activity levels in a group of individuals with type 2 diabetes. They used the social cognitive theory as a theoretical framework to plan an intervention that utilized the feedback from pedometers to let the participants select step goals for each week. This self-selection is a vital component self-efficacy and behavioral capability construct of the social cognitive theory (Bandura, 1997; Baranowski, Perry, & Parcel, 2002) because the ability to self-select increases the individuals' confidence to engage in a particular physical activity pattern. Their results indicated that pedometers could be effectively used to increase physical activity in this population. Average time walking per day increased significantly, and the continuation of walking behavior lasted for many months after the discontinuation of the intervention. Additionally, this increase in walking behavior had a desired effect in the improvements of systolic blood pressure and waist girth.

In order to examine the efficacy of a minimal contact intervention, researchers (DuVall et al., 2004) recruited 50 female volunteers and randomly placed them into 3 groups (pedometer only, pedometer and behavior modification, and standard care). After an eight-week intervention, researchers found that while all three groups did increase their physical activity, there was not a significant difference between any of the groups in time spent in MPA. Although a small sample size limited the generalizability and power of this study, their results may indicate that the pedometer had little effect in increasing physical activity among the study participants.

In another study (Rooney et al., 2003) researchers attempted to increase physical activity among a large group (n = 400) of female employees with pedometers. Their question of interest was whether having the automatic feedback from a pedometer could influence time spent in physical activity in a sample of women. Participants were enrolled in an eight-week walking program where they tried to reach a goal of 10,000 steps per day. The majority of the women increased physical activity self-efficacy, physical activity levels, and physiological gains such as decreased absenteeism and weight loss. Furthermore, the majority (71%) of those enrolled said that they planned on continuing the use of the pedometer after the study ended.

Finally, Sidman, Corbin, and Le Masurier (2004) used pedometers and step goals to examine how a goal of 10,000 steps per day could influence physical activity. They recruited 92 sedentary women and classified them into low, medium, and high steps according to baseline values. They then assigned them into a control group, self-selected goal group, and a 10,000 steps-goal group. Their findings indicated that those in the low baseline groups accumulated significantly less steps per day than the other groups, but that there was not a difference between the self-selected goal and the 10,000 steps group.

Other Pedometer Uses

Schmalzried et al. (1998) utilized pedometers to standardize wear on artificial joints. Before the use of the pedometer crude measures of time were used to determine the life cycle of a joint replacement. This type of estimation had considerable error in that time cannot factor in physical activity level, or intensity of use, of the replacement joint. They concluded that pedometers offer a quantitative measure of gait cycles that can be used to quantify the lifecycle of a replacement by a more measurable parameter.

Studies such as these indicate that pedometers can be useful in a variety of settings, with a variety of populations, for a variety of reasons. However, some questions still remain. Among these questions are, how many steps are necessary to obtain health benefits? How many steps do people normally take? And, how do we ascertain that these participant-recorded steps are indicative of the actual physical activity among individuals?

Necessary Steps for Health Benefits

Numerous studies have been completed in an attempt to determine how many steps are needed to convey health benefits associated with physical activity and exercise. Since the CDC/ACSM recommendation (Pate et al., 1995) calls for activities to be conducted for a specific time period (i.e., at least 30 minutes), many studies have examined pedometer steps in relationship to time. That is, how many steps are necessary for the accrual of 30 minutes of MPA and the health benefits derived thereof? These studies will be examined as we attempt to determine a proxy step count that can be used as a general recommendation for the American public.

10,000 Steps per day Recommendation

A Japanese researcher, Hatano, was the first to suggest a goal of 10,000 steps per day would lead to better health (Hatano, 1993). Some of his early research with pedometers indicated that walking 10,000 steps per day was equivalent to expending from 336 to 432 calories per day in physical activity (Hatano, 1993). This was thought to roughly correspond with the CDC/ACSM recommendation. Therefore, this recommendation has recently been popularized in the lay press (Anonymous, 2002; Austin & Powers, 2003; Gorman, 2003). Further, scientific studies have examined the 10,000 steps per day recommendation in the light of time accrued when accumulating 10,000 steps(Le Masurier, Sidman, & Corbin, 2003; Tudor -Locke, Ainsworth et al., 2002; Welk, Differding et al., 2000; Wilde et al., 2001).

Researchers (Welk, Differding et al., 2000) found that walking or running a mile requires roughly 1,300 to 2,000 steps, depending on anthropometric differences. Using a mean value of 1,935 steps per mile and a walking speed of 4 miles per hour [which meets the definition of MPA; 3-6 METs(Pate et al., 1995)], the authors of the study concluded that approximately 3,800 to 4,000 steps would be equal to 30 minutes of MPA. However, the authors were also cautious to note that many people will accumulate many steps that are at an intensity that is too light to be beneficial. Therefore, they suggested that even though 3,800 to 4,000 steps are of scientific value, actual target values for the population should be set higher. Combining the baseline values for their population (7,439 ± 3,797 steps) plus the observed step value for 30 minutes of MPA (3,800 – 4,000 steps) yields a result similar to the 10,000 step per day recommendation suggested by Hatano (1993).

A study conducted with females (Wilde et al., 2001) found that 3,102 to 3,105 steps were necessary to accomplish 30 minutes of ambulatory MPA. Moreover, those who completed a 30-minute walk were more likely to achieve a goal of 10,000 steps per day. This study was the first to answer a vital question regarding the use of pedometers by the general population: How many total steps should be accrued throughout the day to achieve the health benefits associated with 30 minutes of MPA? The findings of Wilde (2001) suggested that if a person were to achieve 10,000 steps per day, they would also receive the health benefits associated with MPA.

In an effort to explore this question in greater detail, Tudor-Locke and colleagues (2002) conducted a study with accelerometers and pedometers to examine how many steps throughout the day were necessary to include both a baseline value and 30 minutes of accumulated MPA. Their data were collected on total accumulation of steps by all intensities of physical activity including light activity, MPA, and VPA. After breaking the data into pedometer-determined quartiles, they found that 8,064 $\pm$ 766 steps of accumulated activity were equivalent to 32.7 $\pm$ 14.4 minutes per day of MPA. Although these findings do not seem to agree with the 10,000 steps recommendation, they nonetheless convey health benefits with fewer than 10,000 steps.

Similarly, researchers (Behrens, Hawkins, & Dinger, In press) examining this issue in a sample of college students found that those meeting the MPA recommendation were significantly more likely to be accumulating 10,000 steps per day. In their study, Behrens, Hawkins, & Dinger (In press) had participants (N = 36) wear a pedometer and accelerometer for 7 consecutive days. Researchers then compared time in physical activity of at least MPA to average steps per day. Findings indicated that when participants were meeting the MPA recommendation, they were also most likely accumulating at least 10,000 steps per day.

The 10,000 steps per day recommendation has also been found to aid in physiological outcomes such as blood pressure and sympathetic nerve activity (Iwane et al., 2000). Researchers designed an intervention with factory workers in which the workers were given a 10,000 step per day goal. Results from this study indicated that walking 13,510 ± 847 steps per day for 12 weeks led to significant decreases in systolic and diastolic blood pressure, sympathetic nerve activity, and BMI. Additionally, increases in VO_2 were observed (Iwane et al., 2000).

Not only is the 10,000 steps recommendation useful for helping to attain physiological outcomes, it is also useful for attaining psychological outcomes. Employees in a work site were encouraged to buy a pedometer and participate in a walking intervention (Rooney et al., 2003). After an eight week intervention, employees reported physiological changes in body weight and increased energy, and psychological changes in increased self-esteem and self efficacy (Rooney et al., 2003).

Although the literature base is still unclear as to the appropriateness of a 10,000 steps per day recommendation, Tudor-Locke and Bassett (2004) have recently published a pedometer step indices that can be used to quantify step values as to their approximate standing against the CDC/ACSM physical activity recommendation (Tudor-Locke & Bassett, 2004). Their synthesis of the literature regarding steps per day indicates that a person accumulating 10,000 steps per day can be considered active and most likely meeting the CDC/ACSM physical activity recommendation. They also state that persons accumulating less than 5,000 steps per day can be considered sedentary, and that those accumulating greater than 12,500 steps per day can be considered highly active individuals (Tudor-Locke & Bassett, 2004). However, it must be mentioned that their estimations are based on a literature base that is highly fragmented with few large-scale studies describing the step patterns of large groups. It is therefore necessary to use these indices with caution until more research can add credibility to their findings.

Using Participant-Recorded Step Logs to Quantify Physical Activity

Methodological studies have used step logs for information regarding the validity and reliability of pedometers for use in different populations. Based on the data from step logs, Treuth (2003) found that pedometers had low test-retest reliability (ICC = 0.08, $p = 0.09$), but were valid ($r = 0.47$, $p = 0.0001$) when more than one day was observed among African-American adolescent females. Further, Tudor-Locke, Ainsworth, et al. (2002) found a strong relationship between Actigraph steps per day and participant recorded steps per day ($r = 0.86$), and Bassett and colleagues (2000) found that participant-recorded steps per day from a pedometer were more accurate than the College Alumnus Questionnaire (CAQ) in detecting ambulatory activity in both men ($p = 0.0001$) and women ($p = 0.0001$).

Descriptive studies have utilized participant-recorded pedometer step logs to indicate typical step per day values for different populations (Bassett et al., 2004; Behrens & Dinger, 2003; Sequeira et al., 1995), and intervention studies have used participant-recorded pedometer step logs to measure increases in physical activity (Croteau, 2004; Moreau et al., 2001; Tudor-Locke, Myers et al., 2002) and to utilize the data to motivate individuals and aid in goal setting to increase physical activity (DuVall et al., 2004; Rooney et al., 2003; Sidman et al., 2004; Wilde et al., 2001).

Therein lies the problem. As the popularity of pedometers continues to grow in the mainstream media and in research circles, the use of participant recorded pedometer step logs will also continue to increase. To date, the validity of these step logs has not been examined. Therefore, it is incumbent upon researchers to fill this gap in the literature.

Summary

There is a clear relationship between physical activity and negative health consequences (Pate et al., 1995). In an effort to stem the tide of physical inactivity among Americans and the comorbidities that accompany physical inactivity, the CDC, ACSM, and IOM have released recommendations on the amount of physical activity necessary for certain health benefits and improved cardiorespiratory fitness. However, many Americans are still not meeting these physical activity recommendations.

Importantly, these recommendations have largely been assessed by indirect methods, namely questionnaires, which have been associated with numerous sources of potential error (Ainsworth, 2000; Patterson, 2000; Sallis & Saelens, 2000). New technological advancements in physical activity assessment through motion detectors have allowed researchers and practitioners to accurately assess physical activity without some of the sources of error common to questionnaires. This accurate physical activity assessment is necessary for evaluation of intervention effectiveness and to give confidence in study results.

The use of pedometers as a physical activity assessment tool continues to increase in popularity both in research and in the mainstream media. However, many studies and interventions use participant-recorded pedometer step logs for their physical activity data. If the steps recorded by participants are accurate, then the use of step logs with pedometers is a valid assessment of physical activity. However, if step logs are flawed due to misrepresentation by the participant, accidental transcription errors, or other events, the data are not valid. As a consequence, any resultant findings and/or conclusions based on that data are also not valid. Therefore, the examination of participant recorded pedometer step logs is an essential area for study.

CHAPTER THREE

METHODOLOGY

The primary purpose of this study was to examine the validity of participant recorded step logs in free-living adults. Secondary purposes of this study were to a) examine the relationship between accelerometer detected and participant recorded steps per day, b) to examine the differences in steps per day between those with acceptable and overweight/obese BMI's, c) to examine the relationship between body composition and steps per day, and d) to examine whether healthy weight individuals recorded their steps more accurately than overweight/obese individuals. The specific processes and procedures for accomplishing these tasks will be presented in this chapter.

Participants

After approval from the Institutional Review Board at the University of Oklahoma – Norman Campus, male and female participants were recruited from the Norman and Oklahoma City, Oklahoma metropolitan areas. Participants were between 25 and 60 years of age. Further, participants reported not being claustrophobic, not having asthma or other respiratory problems, and being free of physical limitations affecting their ambulatory activity. Additionally, participants that had physical conditions that could be made worse by a change in physical activity (i.e., bone or joint problems, currently taking medications to control blood pressure or heart conditions, those currently under a physicians care for heart conditions and were advised not to undergo physical activity unless recommended by a doctor, and those who were dizzy, lost their balance, or experienced chest pain as a result of physical activity) and pregnant women were excluded from the study. Furthermore, participants were not regular, vigorous exercisers that exercised 5 or more days per week for at least 45 minutes per day, or those who regularly recorded their physical activity in training logs or physical activity diaries. All participants completed the informed consent prior to participation in the study.

Recruitment

Participants were recruited by mass emails, flyers, television advertisements, and by word of mouth. Specifically, the University of Oklahoma – Norman campus and the University of Oklahoma – Health Science Center campus received mass emails alerting individuals of the study (Appendix A). Flyers (Appendix B) were placed on both campuses in high traffic areas, as well as other well-traveled areas around the aforementioned metropolitan area. Television announcements regarding the study were placed on the university public access channel (Channel 22) (Appendix A).

Experimental Design

This was a cross-sectional, descriptive study with volunteers from the community. The independent variables (IV) in this study were the steps recorded from the sealed pedometer and the Actigraph, BMI, gender, and % BF. The dependent variable (DV) was steps per day that were recorded by the participants.

Instruments/Measures

Demographic Questionnaire

The demographic questionnaire was used to assess age, gender, race/ethnicity, level of formal education, occupational status, and household income. The demographic questionnaire is located in appendix C.

PAR-Q

The PAR-Q is a medical screening questionnaire for use among individuals aged 15 to 69 years. It was used as a pre-screening questionnaire to determine participant eligibility in this study. The PAR-Q is located in appendix D.

Height

Height was assessed using a wall-mounted stadiometer (Accu-Hite Wall Stadiometer, Seca Corp., Hanover, MD) in the Human Body Composition Lab. Briefly, participants were asked to stand with heels together, without shoes, with the back as straight as possible, with their heels, shoulders, and head touching the wall. Participants were asked to look straight ahead, inhale deeply, and hold the breath while the headboard was brought to rest upon the highest point of the head (Nieman, 2003). Measurements were taken to the nearest 1/8 of an inch.

Weight

Weight was assessed via the BOD POD. As part of the BOD POD procedures, participants stepped on an electric scale that assesses body weight in kilograms and pounds. The scale was calibrated (within 1/100 gram) to 40 kg before each testing day to ensure correct calibration. Weight was recorded to the nearest 0.1 kilogram.

Anthropometric assessment

Hip and waist measurements were assessed before the BOD POD procedure in the Human Body Composition Lab. A tension-loaded Gullick tape measure was used to assess anthropometric values. The hip measurement was taken at the largest circumference of the hip-buttocks area while the participant was standing (Nieman, 2003). The waist measurement was taken at the smallest circumference below the rib cage and above the umbilicus. If a "smallest" area did not exist, measurements were taken at the navel (Nieman, 2003). All measurements were taken from the right side of the participants. The waist to hip ratio (WHR) was calculated by dividing the waist circumference by the hip circumference. All measurements were recorded in centimeters.

International Physical Activity Questionnaire (IPAQ) – Short Form

The short form of the IPAQ is a 7-item questionnaire that assesses physical activity over the previous 7 days. It inquires about vigorous, moderate, and walking activity, as well as time sitting. There is both a frequency and duration component so that MET hours per week can be calculated, and with the participant's body weight, caloric expenditure in kcals per week can also be calculated (Kriska & Casperson, 1997). Validity and reliability of the IPAQ-short form were examined in a 12-country study (Craig et al., 2003) with 2,300 individuals. Test-retest reliability was acceptable (ρ_{pooled} = 0.76, 95% CI: 0.73-0.77). Criterion validity, determined against the Actigraph accelerometer, was moderate (N= 781, ρ_{pooled} = 0.30, 95% CI = 0.23-0.36) (Craig et al., 2003). In this study, the IPAQ instrument was self-administered on the initial visit and on the return visit. Data from the IPAQ were used as a descriptive measure of physical activity among the study participants. The IPAQ is located in appendix E.

Mileage questionnaire

Le Masurier and Tudor-Locke (2003) published a standard correction factor of 12.5 steps per mile traveled in a vehicle for Actigraph-derived steps when comparing to pedometer steps, due to the sensitivity differences of the devices. The Mileage questionnaire was utilized in an attempt to determine the usual vehicular travel of each study participant. The participants were asked to recall approximately how many miles were traveled in a vehicle for each of the days while they were participating in the study. These mileage data were used to determine the total correction per individual that was needed when comparing Actigraph derived steps with pedometer steps (Le Masurier et al., 2004; Le Masurier & Tudor-Locke, 2003). The Mileage questionnaire is located in appendix F.

Accelerometer

Total ambulatory activity counts and steps per day were determined by the Manufacturing Technology Incorporated Actigraph 7164 accelerometer (Version 2.2; Manufacturing Technology Incorporated, 2003). This is a small, lightweight accelerometer that detects vertical accelerations. These accelerations displace a piezoelectric plate that create a signal relative to the force generated (~ 0.05 to 2 G’s) that is filtered and quantified via an 8-bit analog converter every 10 seconds. The signals are then summed over a user-defined time period. The Actigraph is initialized and downloaded to a PC using a reader interface and produces an output of activity counts. When cycle mode is initialized, the Actigraph accesses each sample of the accelerometer signal using the summed magnitude mode and cycle counts to determine the number of steps (Manufacturing Technology Incorporated, 2003).

Research has indicated a high correlation (r = 0.88) between activity counts and steady state oxygen consumption (Hendelman et al., 2000), and another study found that Actigraph outputs were not significantly different from measured METs (Welk, Blair, Wood, Jones, & Thompson, 2000). Further, regarding steps recorded in cycle mode, there is a high correlation between pedometer steps per day and Actigraph steps per day (Tudor-Locke, Ainsworth et al., 2002), and it has recently been suggested that Actigraph-determined steps be used as a criterion measure when counting steps (Le Masurier et al., 2004).

Pedometer

The Yamax model 200 pedometer is a small, lightweight device that records physical activity as steps over a user-defined time period (usually steps per day). This pedometer detects vertical accelerations of ≥ 0.35 G's that force a cantilevered arm into motion (Crouter et al., 2003). With each vertical acceleration, the arm touches an electric plate that records each "step". These steps are automatically displayed in a digital screen that users can observe at any time during the day. The Yamax 200 is a valid measure of ambulatory physical activity (Bassett et al., 1996) and has been utilized in numerous studies (Behrens & Dinger, 2003; Croteau, 2004; Le Masurier et al., 2003; Moreau et al., 2001; Rooney et al., 2003; Sidman et al., 2004; Wilde et al., 2001).

Air displacement plethysmography (BOD POD)

The BOD POD is a dual chambered fiberglass plethysmograph that assesses body volume by measuring pressure changes within a closed chamber (Fields, Goran, & McCrory, 2002; Dempster & Aitkens, 1995; McCrory, Gomez, et al., 1995). The BOD POD has been validated against hydrostatic weighing and dual x-ray absorbimetry (DXA) for determining %BF among adults with acceptable results (Fields et al., 2002). Reliability of the BOD POD for determining %BF has also been well documented with an acceptable coefficient of variation among adults (from 1.7%-4.5% within the same day and 2.0%-2.3% between days; Fields et al., 2002). Briefly, participants wore a swimsuit and a swim cap (cap was provided by the laboratory), and remove all jewelry so that isothermal air is reduced. Participants then entered the BOD POD and a measure of air displacement is taken. Following this, thoracic gas volume (V_{TG}) is measured via a small breathing tube inside the chamber. Body volume is calculated using V_{TG} and surface area artifact (SAA) [SAA (L) = k (L/cm^2) X BSA cm^2] where k is a constant from the manufacturer and BSA is body surface area calculated from body weight and height. The body volume is then measured Vb_{corr} (L) = Vb_{raw} (L) – SAA (L) + 40% V_{TG} (L), where Vb_{corr} is the body volume that has been corrected for V_{TG} and SAA. When body mass (M) and Vb_{corr} have been calculated, body density is calculated as $D_b = M/Vb_{corr}$. This is then used in the Siri (Siri, 1956) 2-compartment model [% fat = (495/body density) – 450] to yield % BF estimates (Fields et al., 2002).

Procedures

Initial Visit

During the initial visit, participants reported to the Physical Activity Assessment Lab at their appointed time. Participants were led to a table where they were asked to read and sign the informed consent (Appendix H), HIPAA form (Appendix I), and the PAR-Q (Appendix D). Additionally, participants were asked to complete a demographic questionnaire (Appendix C) and the IPAQ (Appendix E). After this they were led into a quiet, private area where they were fitted for a belt, given an Actigraph in a pouch that fits on the belt, given a sealed pedometer, an unsealed pedometer, and a log sheet for the Actigraph and pedometer. They then received instruction as to the use of this equipment.

Specifically, participants were told that the Actigraph (in the pouch) should be worn over the right iliac crest and the pedometers should be worn at the waist, over the midline of each thigh. The sealed pedometer should rest over the left thigh and the unsealed pedometer will be over the right thigh. Participants were instructed to wear all the devices simultaneously during all waking hours for 7 consecutive days, excluding water activities. This time frame accounts for 90% reliability of capturing MPA, VPA, and physical inactivity (Matthews et al., 2002). Participants were then instructed in the use of the log sheet (Appendix G). For each day, participants wrote the time that the devices were put on and taken off. Additionally, the Actigraph log required participants to record number of hours worked and if they participated in any exercise or sports during the day. The pedometer log had spaces for time worn throughout the day and total steps. Participants were instructed to record their steps from the unsealed pedometer at the end of each day and to press the "reset" button so that the unsealed pedometer is zeroed out for the next day. Both logs (Actigraph and pedometer) have a "comments" section where participants made small notes if the devices were taken off during waking hours (e.g., to swim, shower, bathe, or other circumstance where the devices may be damaged).

Participants were instructed that all of the equipment must be worn at the same time and recorded on the log provided. The participants were then instructed on the use of the Mileage questionnaire (Appendix F). Briefly, participants were told to record their daily mileage traveled in an automobile on the log and to return the log upon during return visit. They were also told that upon their return visit, they should have fasted for the previous 4 hours. Further, in an effort to maintain the equality of wear time, participants were instructed to continue to wear the devices during all waking hours until they met with the researchers again at their follow-up appointment.

Final Visit

For the final visit, participants came to the Human Body Composition Lab at their appointed time after one week of wearing the devices. During this visit, the participants were seated at a table where they turned in the Actigraph, belt, pouch, sealed pedometer, unsealed pedometer, the Mileage questionnaire, and log sheet. They then completed the IPAQ questionnaire. After the completion of the questionnaire, each participant was asked to change into a swimsuit. Swimsuits were essential to maintain the integrity of the testing condition (Fields et al., 2000). After changing, each individual had his or her hip and waist measurements assessed. A tension-loaded tape measure was used to assess hip and waist measurements. The hip measurement was taken at the largest circumference of the hip-buttocks area while the participant was standing (Nieman, 2003). The waist measurement was taken at the smallest circumference below the rib cage and above the umbilicus. If a “smallest” area did not exist, measurements were taken at the navel (Nieman, 2003). All measurements were taken from the right side of the participant. After this, participants had their height and weight assessed. Height was assessed using a wall-mounted stadiometer. Participants were asked to stand with heels together, without shoes, with the back as straight as possible, with their heels, shoulders, and head touching the wall. Participants were asked to look straight ahead, inhale deeply, and hold the breath while the headboard was brought to rest upon the highest point of the head (Nieman, 2003). Weight was assessed via the BOD POD electric scale. As part of the BOD POD procedures, participants stepped on an electric scale that assessed body weight in kilograms and pounds.

After these assessments, the BOD POD procedure took place. The procedure was explained to the participants, and they were asked if they had any questions. After questions had been answered, participants were asked to enter the BOD POD. There were 2 to 3 short (50-second) assessments performed to determine body volume. The outer chamber of the BOD POD was opened during each interval. Finally, participants were asked to breathe normally into a small tube, and to give 3 small “puffs” into the tube when prompted by the tester. This procedure took approximately another 50 seconds. After this, the door was opened, and the participants were allowed to change into their normal clothes.

After participants changed their clothes, the researcher(s) thanked the participants for their involvement in the study and acknowledged that their involvement in the study was complete. Each participant who completed the study was immediately given the results of his/her body composition and a brief explanation of its meaning. Within one week thereafter, each participant was mailed or emailed the results of their physical activity assessment. All data were collected between September 2004 and November 2004 from participants in three different cohorts.

Data Reduction

Actigraph data were downloaded with the manufacturer's software (Manufacturing Technology Inc., 2003) and reduced with SAS, version 8.1 (SAS Institute Inc., 2000). Each participant must have worn the Actigraph for at least 12 hours on 5 of 7 days to remain in the analysis. To account for this, minute-by-minute counts were summed over each hour. These hour data were summed over each 24-hour period. Any 24 period with more than 12 hours of zero counts indicated that the device was not worn enough during that day and the data for that day was considered insufficient. Participants could have no more than two insufficient days to remain in the analysis. Also, steps per day were calculated using the cycle mode of the Actigraph. As mentioned earlier, Actigraph-derived steps are highly representative of actual ambulatory activity and recent research has suggested that the Actigraph steps should be used as a criterion when possible for assessing steps per day (Le Masurier et al., 2004). Moreover, as previously mentioned, a correction factor of 12.5 Actigraph-derived steps per mile traveled in a vehicle was applied that incorporates the correction for vehicular travel during the study days due to the sensitivity of the Actigraph in comparison with the pedometer (Le Masurier et al., 2004; Le Masurier & Tudor-Locke, 2003).

Steps from the sealed pedometer were recorded upon the return of all equipment to the lab. Steps from the sealed pedometer were recorded as accumulated total steps over the study period (i.e., 8 consecutive days; Table 1). The steps from the log sheets turned in by each participant (from the participant recorded pedometer) were entered by study day, and then summed over the entire study period (Table 1).

According to recent research (Schneider et al., 2004), the Yamax model 200 has a difference of 372 steps per 24-hour period when worn simultaneously on right and left hips. The participants in this study wore the devices for 7 full days and two half days. The two half days were combined into one full day, yielding a total of 8 days in the study. Therefore, an equivalence value of 2,976 steps was used to determine equivalence over the entire study period (372 steps per day X 8 days = 2,976 steps) between sealed and unsealed pedometers. Total accumulated steps were combined over the entire study period, as is depicted in Table 1.

Similarly, when comparing Actigraph-derived steps per day with that of the participant recorded steps per day by test of equivalence, a standard for equivalence between Actigraph-derived and pedometer steps per day was needed. There has been only one study to report a mean difference between Actigraph and pedometer steps per day (Tudor-Locke, Ainsworth et al., 2002), and no studies, to my knowledge, have attempted to define the equivalent number of steps with an Actigraph and a pedometer. In their study, Tudor-Locke, Ainsworth, and colleagues (2002) found that

Actigraphs detected significantly more steps per day than pedometers (1,845 ± 2,116 steps). Based on their findings, 1,845 steps were used as the equivalent measure when equivalence was examined between the Actigraph steps per day and the participant recorded steps per day.

Total accumulated steps were derived from study days 1 through 9. The orientation day (day 1) and the final day of the study (day 9) were both half days. Therefore, days 1 and 9 were merged into one full day, resulting in 8 total study days of data (2 half days from days 1 and 9, plus the additional 7 full days from study days 2 through 8). Step per day values were derived from study days 2 through 8. This is depicted in Table 1.

Table 1. Study Days Used for Analyses

Step Condition	**Study Day**								
	1*	2	3	4	5	6	7	8	9*
Sealed	X	X	X	X	X	X	X	X	X
Participant Recorded	X	XY	XY	XY	XY	XY	XY	XY	X
RAW		Y	Y	Y	Y	Y	Y	Y	
CORRECTED		Y	Y	Y	Y	Y	Y	Y	

X = Total accumulated steps, Y = Steps per day.
* = Study days 1 & 9 were half-days that were merged together to form one study day for analyses.

Statistical Analyses

All statistical analyses were completed using SAS, version 8.1 (SAS Institute Inc., 2000). Descriptive statistics were calculated for all demographic, dependent, and independent variables. One-way ANOVA was employed to determine whether there were significant differences in the dependent variables by cohort. Steps did not differ by cohort for the participant-recorded pedometer (F[6,82] = 0.42, p = 0.86), raw (uncorrected for mileage) Actigraph-derived steps per day (F[6,82] = 0.63, p = 0.71), or corrected Actigraph steps per day (F[6,82] = 0.63, p = 0.71). Further, independent t-tests were employed to explore any possible gender differences in the dependent variables. Results from this investigation revealed that there were no significant differences by gender for the participant-recorded pedometer (t[87] = -0.17, p = 0.86), raw (uncorrected for mileage) Actigraph-derived steps per day (t[87] = 1.0, p = 0.32), or corrected Actigraph steps per day (t[87] = 0.94, p = 0.35).

To examine if significant equivalence existed between the a) sealed pedometer and participant-recorded steps from the unsealed pedometer, b) uncorrected Actigraph (RAW) and participant-recorded pedometers, and c) corrected Actigraph (CORRECTED) and participant-recorded pedometers, a test of equivalence was utilized. Traditional significance testing only examines whether there are significant differences between items; it says nothing about the similarity, or equivalence, between items. In this study, the equivalence between comparisons [i.e., the a) sealed pedometer and participant-recorded steps from the unsealed pedometer, b) RAW and participant-recorded pedometers, and c) CORRECTED and participant-recorded pedometers] was a key component of the analysis. A test of equivalence utilizes two 1-sided *t*-tests to determine equivalence. In order for measures to be significantly equivalent three things must occur. First, the 1-sided *t*-tests must both be significant. Second, the direction of significance must be in the correct direction (i.e., the test statistic in this case must both be negative due to the set-up of the difference variables). Third, the ninety-five percent confidence intervals (95% CI) of the test statistic must fall within the 95% confidence intervals of the equivalent values. In this study the equivalent values were from –2,976 to 2,976 for the total accumulated steps for the entire study period (e.g., sealed versus participant recorded), and from –1,845 to 1,845 steps per day for the step per day comparisons.

To explain the validity of the data in more detail, Pearson product moment correlation coefficients were also calculated for a) participant-recorded steps and sealed pedometer steps, b) RAW and participant-recorded pedometers, and c) CORRECTED and participant-recorded pedometers. Additionally, to explore agreement among the different methods of assessing steps per day, Bland-Altman plots were utilized to examine participant recorded total accumulated steps and total accumulated steps from the sealed pedometer, RAW and participant-recorded steps per day, and CORRECTED and participant recorded steps per day.

To examine the relationship between % BF and steps per day, Pearson product moment correlation coefficients were calculated between % BF and steps per day as derived from the participant logs and the Actigraph. Further, an independent *t*-test was utilized to examine significant differences in steps per day between healthy weight individuals (BMI: < 25 kg/m^2) and overweight/obese individuals (BMI: ≥ 25 kg/m^2). Independent *t*-tests were also used to examine whether healthy weight individuals (BMI: < 25 kg/m^2) recorded the total accumulated steps, and steps per day, more accurately that overweight/obese (BMI: ≥ 25 kg/m^2) individuals.

Because the validity of participant recorded pedometer step logs was the central interest in this study, power calculations for sample size were deduced from the primary question. A small pilot study was conducted with 5 participants in an attempt to determine an equivalent value of steps per day between pedometers worn on right and left hips. Participants wore a sealed and unsealed pedometer on opposite sides of the hips (sealed pedometer on left hip and unsealed on the right hip) for 24 hours. The mean difference in step counts between the two pedometers was 107.14 steps per day. Based on this small convenience sample, initial data indicated that a mean difference of 750 steps would be considered equivalent over 7 days (107 steps per day X 7 days). Using this criteria, a preliminary investigation of statistical power revealed that 70 participants were needed to test for equivalence with power ≥ 0.80, alpha = 0.05, estimated standard deviation of 2,000 steps, and an expected equivalence of 750 steps (Hintze, 2001). Because a non-compliance rate of ~20% was expected, an additional 20% were recruited to participate in the study. This yielded a necessary sample size of 88 participants. All statistical analyses were conducted with $\alpha = 0.05$ level of significance for two tailed tests and $\alpha = 0.1$ for one-tailed tests.

CHAPTER FOUR

RESULTS

There is strong evidence to suggest that physical activity is protective against numerous chronic diseases (Bauman, 2004). In spite of the clear evidence indicating the effectiveness of physical activity in this respect, many Americans are still not active enough to accrue the health benefits derived from physical activity (Lethbridge-Cejku et al., 2004; Schiller et al., 2004). In an effort to stem the increasing incidence of mortality and morbidity due to physical inactivity, governmental and scientific bodies have established physical activity guidelines (Institute of Medicine of the National Academies of Science, 2002; Pate et al., 1995; Pollock et al., 1998). Unfortunately, national surveillance data indicates that although the physical activity guidelines are in place, the majority of Americans are still not accruing enough physical activity into their daily lives (Lethbridge-Cejku et al., 2004; Schiller et al., 2004).

Based on these discouraging statistics, many recent physical activity interventions have used pedometers either as a motivational (Croteau, 2004; DuVall et al., 2004; Rooney et al., 2003; Sidman et al., 2004) or measurement tool (Bassett et al., 2004; Bassett & Strath, 2002; Behrens & Dinger, 2003; Tudor-Locke, Williams et al., 2002; Tudor-Locke, 2002; Tudor-Locke, Myers et al., 2002), or both. In most of these studies it is incumbent upon individuals to record the amount of daily steps taken. To date, there have been no studies that have attempted to examine the validity of these participant recorded step logs. Without proper assessment of the psychometric properties of these step logs, little can be determined about the efficacy of step per day-based findings. Therefore, the primary purpose of this study was to examine the validity of participant recorded pedometer step logs. Secondary purposes of this study were to a) examine the relationship between steps per day and percent body fat (%BF), b) to examine whether steps per day differed between individuals with healthy weight (BMI < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2), and c) to examine whether healthy weight (BMI < 25 kg/m^2) individuals record their total accumulated steps, and steps per day more accurately than overweight/obese individuals (BMI ≥ 25 kg/m^2).

The results of this study are presented in the following order: participant characteristics, validity of participant recorded pedometer step logs, relationship between steps per day and % BF, examination of steps per day by BMI, and accuracy of pedometer step logs by BMI category.

Participant Characteristics

The participants in this study were all community-dwelling adults living in the Norman and Oklahoma City, Oklahoma metropolitan area. There were 114 individuals who initially participated in the study. Five participants did not complete the study, resulting in their exclusion from data analysis. Of the remaining 109 participants, 20 individuals did not adhere to the *a priori* inclusion criteria of wearing the devices for a minimum of 12 hours on at least 5 of 7 days. This resulted in a sample of 89 participants that remained for final analyses. A conservative preliminary sample size analysis indicated the need for 70 participants. The actual value for equivalence used in the analysis (2,976 steps) was much higher than originally postulated (750 steps). Therefore, the 89 participants in this study exceeded the number of participants needed to achieve ≥ 0.80 power.

The 89 participants in the final sample wore the devices 6.77 ± 0.53 days for 16.19 ± 1.05 hours per day. These values represent actual wear time as 67.45% of a 24-hour period. Assuming 8-hours for sleeping, these participants wore the Actigraph for all (> 100%) waking hours, and for 97% of the 7-day period. These values far surpass the *a priori* inclusion criteria of at least 12 hours per day for at least 5 of 7 days, and suggest that these 89 participants strictly adhered to the study protocol.

There were no significant differences between male and female participants for age or BMI. However, there were significant differences between males and females for height (t[87] = 11.72, $p < 0.0001$), weight (t[87] = 5.33, $p < 0.0001$), waist to hip ratio (t[87] = 8.47, $p < 0.0001$), and % BF (t[87] = 0.07, $p < 0.0001$). A description of the participants' physical characteristics can be found in Table 2.

Table 2. Physical Characteristics of the Total Sample and by Gender

Variable	**Total Sample N = 89**	**Female n = 60**	**Male n = 29**
Age	39.4 ± 10.3	40.1 ± 10.7	37.9 ± 9.4
Height (inches)	66.9 ± 3.8	64.9 ± 2.3	71.2 ± 2.5*
Weight (pounds)	161.3 ± 36.1	148.9 ± 29.2	186.9 ± 35.9*
Waist to Hip Ratio	0.8 ± 0.1	0.9 ± 0.1	0.8 ± 0.1*
BMI (kg/m^2)	25.2 ± 4.6	24.8 ± 4.7	25.9 ± 4.4
Percent Bodyfat	29.8 ± 9.4	33.7 ± 8.1	21.7 ± 6.2*

Note: Values presented as means ± SD, * ($p < 0.0001$) females compared to males.

Socio-Demographic Characteristics

The great majority of the participants (82.1%) reported Caucasian ethnicity/race. Participants also reported being highly educated (57.3% with graduate/professional schooling), gainfully employed (85.4%), and having varying occupations. A description of the participants' socio-demographic characteristics is located in Table 3.

Table 3. Socio-Demographic Characteristics by Total Sample and Gender

Variable	**Total Sample N = 89**	**Female n = 60**	**Male n = 29**
Race/Ethnicity			
Caucasian	73 (82.1%)	47 (78.3%)	26 (89.7%)
Non-Caucasian	16 (17.9%)	13 (21.7%)	3 (10.3%)
Educational Attainment			
Grade 12/GED or Some College	10 (11.2%)	7 (11.7%)	3 (10.3%)
College Graduate	28 (31.5%)	18 (30.0%)	10 (34.5%)
Graduate/ Professional School	51 (57.3%)	35 (58.3%)	16 (55.2%)
Employment			
Employed for wages	76 (85.4%)	51 (85.0%)	25 (86.2%)
Other	13 (15.6%)	9 (15.0%)	4 (13.8%)
Household Income			
$10,001 - $25,000/ Don't Know	8 (9.1%)	5 (8.5%)	3 (10.4%)
$25,001 - $35,000	9 (10.2%)	5 (8.5%)	4 (13.8%)
$35,001 - $50,000	16 (18.2%)	13 (22.0%)	3 (10.3%)
$50,001 - $75,000	23 (26.1%)	13 (22.0%)	10 (34.5%)
More than $75,000	32 (36.4%)	23 (39.0%)	9 (31.0%)

Note: Values for categorical variables presented as frequency (%)

Time in Physical Activity

Self-reported physical activity from the International Physical Activity Questionnaire (IPAQ) – Short Form and time spent in different intensities of physical activity from the Actigraph were used to describe participants' physical activity. The IPAQ was used to indirectly assess the physical activity of the participants to use as a descriptive variable. Participant responses on the IPAQ-Short form indicated participation in 107.8 ± 145.3 minutes of vigorous physical activity (VPA), 111.3 ± 173.4 minutes of moderate physical activity (MPA), and 199.3 ± 217.5 minutes of walking for the week the devices were worn. These self-reported values were much higher than what was determined from the Actigraph, and because these data were not normally distributed, the description of the data presented in Table 4 includes mean values as well as quartiles of each variable.

Actigraph-derived time in physical activity was also used as a physical activity descriptor for the sample. Time in physical activity for the sample consisted of 5.1 ± 8.6 minutes of VPA and 34.9 ± 16.7 minutes in MPA. The only Actigraph-derived gender differences were observed for time in light activity (F[1] = 5.76, p = 0.02) and moderate activity (F[1] = 4.47, p = 0.04), with males being more active than females. Since male and female physical activity patterns were generally similar, the data presented in Tables 5, 6, and 7 are presented as the total sample. Further, because the VPA data was not normally distributed, minutes in MPA and VPA presented in Table 4 are presented with median values and quartiles.

Table 4. Minutes per Day Spent in Physical Activity by IPAQ and Actigraph

Variable	Mean	SD	Median	Min	Max	Q1	Q3
VPA							
IPAQ	107.8	145.3	60	0	840	0	160
Actigraph	5.1	8.6	0.8	0	38.1	0	6.1
MPA							
IPAQ	111.3	173.4	60	0	840	0	120
Actigraph	34.9	16.7	32.7	5.2	88.4	22.4	43.5

Total Accumulated Steps

Both sealed and participant-recorded pedometers were used to assess total accumulated steps over 8 days after checking for normality of the data. Since these data were approximately normally distributed, mean differences are reported. Median values and quartiles are also provided to describe the variables in greater detail. There was no significant difference between total accumulated steps over the 8-day period from the sealed and participant recorded pedometers ($t[88] = 1.03$, $p = 0.31$). Additionally, there was not a significant difference by gender for total accumulated steps from the sealed pedometer ($t[88] = 0.09$, $p = 0.77$) or participant-recorded pedometer ($t[88] = 0.02$, $p = 0.89$; Table 5).

Table 5. Total Accumulated Steps for the Study Period

Accumulated Steps/Week	Mean	SD	Median	Min	Max	Q1	Q3
Sealed	71,348.8	25,713.8	68,384	9,673	129,931	51,334	86,659
Participant Recorded	72,171.7	26,902.1	67,734	5,139	135,916	54,318	86,423

Mean Steps per Day

In addition to the accumulation of steps over the 8-day study period from the sealed and participant recorded pedometers, mean steps per day were also calculated from the Actigraph and participant recorded pedometer. There were 9 days of wear in the study with study days 2 though 8 being full days. Average Actigraph steps per day and participant recorded steps per day were calculated for the 7 full days of the study (Table 1). Actigraph steps per day that were uncorrected for vehicular travel (RAW) and Actigraph steps per day that were corrected for vehicular travel (CORRECTED) were determined by obtaining a mean value for each (Table 6). Participants traveled an average of 288.96 ± 192.95 miles during the 7 full days of the study. This led to an average correction factor of 3,612 steps for the difference between RAW and CORRECTED (e.g., 288.96 X 12.5 = 3,612). Mean steps per day did not differ by gender for RAW ($t[87] = 1.0$, $p = 0.32$), CORRECTED ($t[87] = 0.94$, $p = 0.35$), or participant recorded steps per day ($t[87] = 0.17$, $p = 0.86$). Again, these data were normally distributed. Mean, median, and quartiles steps per day from RAW, CORRECTED, and participant recorded conditions are located in Table 6.

Table 6. Mean Steps per Day for the Week

Mean Steps/Day	**Mean**	**SD**	**Median**	**Min**	**Max**	**Q1**	**Q3**
RAW	11,195.0	2,982.1	10,880.1	5.552.8	19,378.9	9,362.1	12,685.3
CORRECTED	10,906.9	2,957.0	10,519.1	5,500.5	18,998.9	9,144.3	12,513.0
Participant Recorded	8,931.8	3,228.0	8,574.9	1,104.1	16,418.1	6,439.1	11,086.4

Validity of Participant Recorded Pedometer Step Logs

Three different conditions were examined when testing for validity of the participant-recorded pedometer step logs. The conditions were: 1) RAW and participant recorded steps per day, 2) CORRECTED and participant recorded steps per day, and 3) total accumulated steps across 8 days from the sealed pedometer and participant recorded pedometer. In each of these conditions a test of equivalence was utilized to examine equivalence between measures. Further, Pearson Product Moment correlations coefficients were calculated to explore relationships between the measures, and Bland-Altman plots were used to explore agreement and bias between the measures.

RAW and Participant Recorded Steps per Day

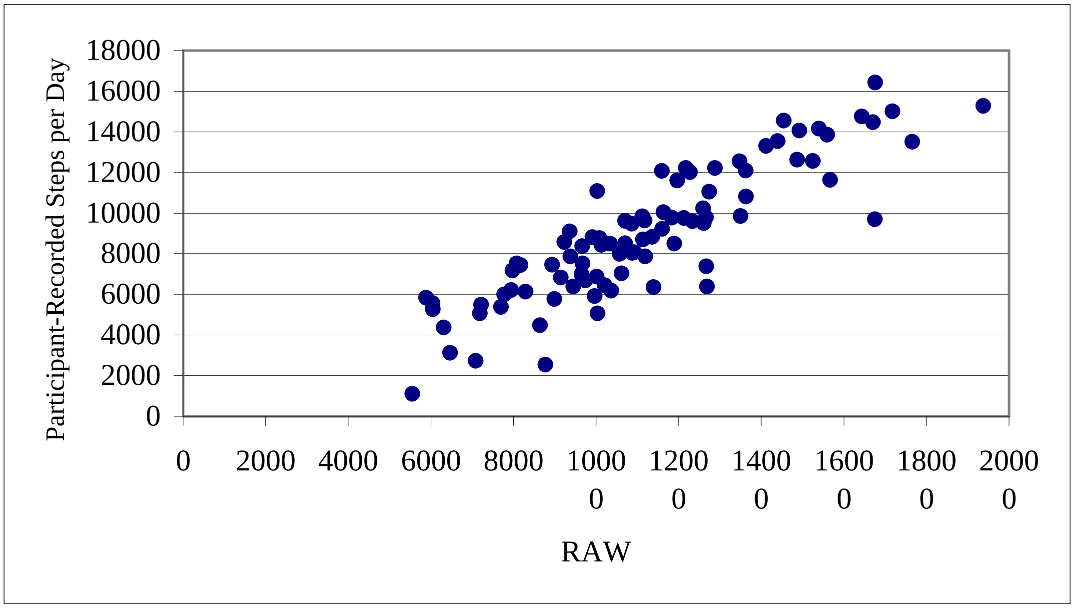
Equivalency of Measures

Testing for equivalence between RAW and participant-recorded steps per day revealed a mean value of 2,264 ± 1,551.7. In order for the two assessments to be considered significantly equivalent, both 1-sided *t*-tests must be significant and have a negative test statistic. Additionally, the 95% confidence intervals should have limits that were within the equivalent value, of between -1,845 steps per day to 1,845 steps per day. Results indicated that the measures were not equivalent with two 1-sided *t*-tests ($t[1] = 2.55$, $p < 0.12$) and ($t[1] = -24.98$, $p < 0.01$; 95% CI: 1,937.2, 2,590.9) demonstrating 95% confidence intervals clearly not within –1,845 steps per day to 1,845 steps per day.

Relationship Between Measures

A Pearson Product Moment correlation coefficient was calculated to examine the relationship between RAW and participant recorded steps per day. RAW shared a strong significant correlation with the participant-recorded steps per day ($r = 0.88$, $p < 0.0001$; Figure 1).

Figure 1. Relationship Between RAW and Participant Recorded Steps per Day



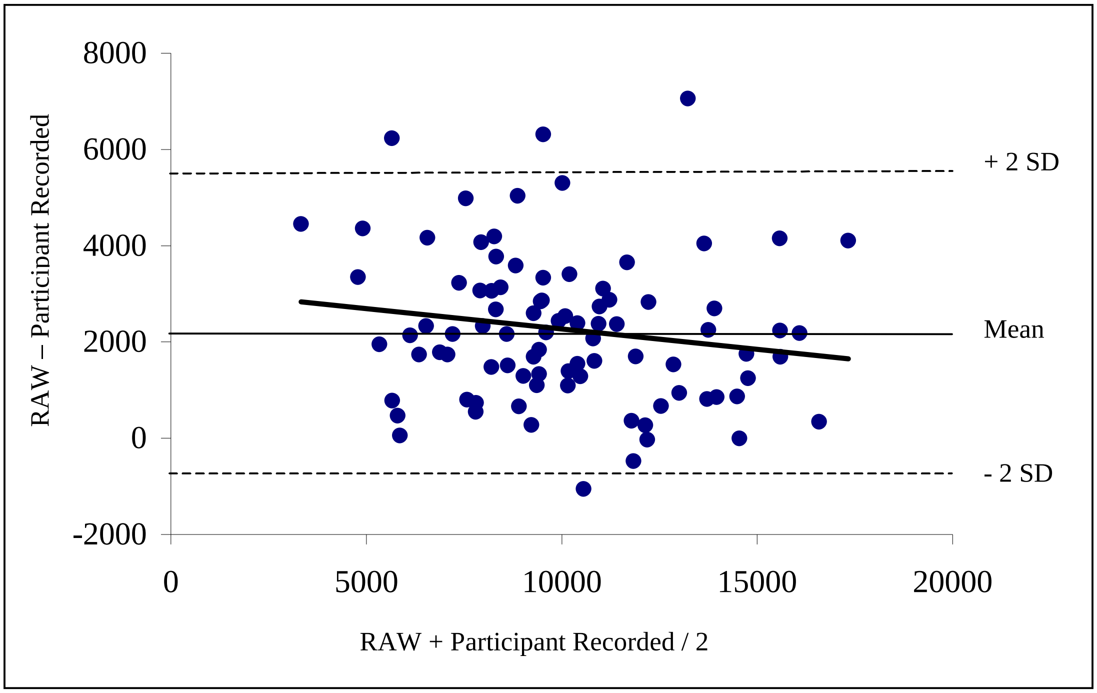
Note: N = 89, r = 0.88, p < 0.0001

Agreement Between Measures

A Bland-Altman plot was utilized to explore agreement and possible bias between RAW and participant recorded steps per day. The mean difference between the two measures was 2,264.04 ± 1,551.7 steps per day (RAW – participant recorded) and the limits of agreement ranged from –839.3 to 5,367.4 steps per day. There were three individuals who recorded significantly fewer steps per day than were detected by the Actigraph. However, there was no bias detected between the measures

(r = -0.16, p = 0.13; Figure 2). Therefore, there was agreement between the measures.

Figure 2. Agreement Between RAW and Participant Recorded Steps per Day



N = 89; r = -0.16, p < 0.0001

CORRECTED and Participant Recorded Steps per Day

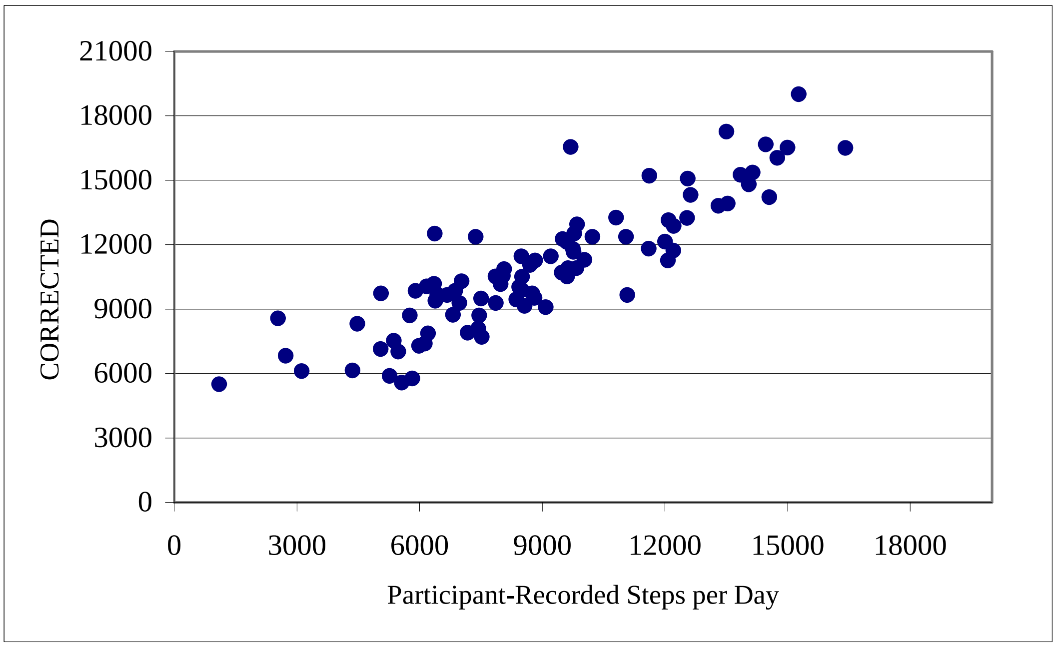
Equivalency Between Measures

A test of equivalence was also used to examine if CORRECTED and participant recorded steps per day were significantly equivalent. Again, the 95% confidence intervals of the two 1-sided *t*-tests must not have exceeded -1,845 to 1,845 steps per day. The mean difference between the measures was 1,975 ± 1,534.7 steps per day. There was a lack of equivalence between the two measures (t[1] = -23.48, p < 0.01) and (t[1] = 0.80, p = 0.28; 95% CI: 1,651.8, 2,298.4) with 95% confidence intervals clearly outside the range of –1,845 steps per day to 1,845 steps per day.

Relationship Between Measures

A Pearson Product Moment correlation coefficient between CORRECTED and participant recorded steps per day yielded similar results to that of RAW. Mean steps per day from RAW were significantly and strongly correlated with participant-recorded steps per day (r = 0.88, $p < 0.0001$; Figure 3).

Figure 3. Relationship Between CORRECTED and Participant Recorded Steps per Day

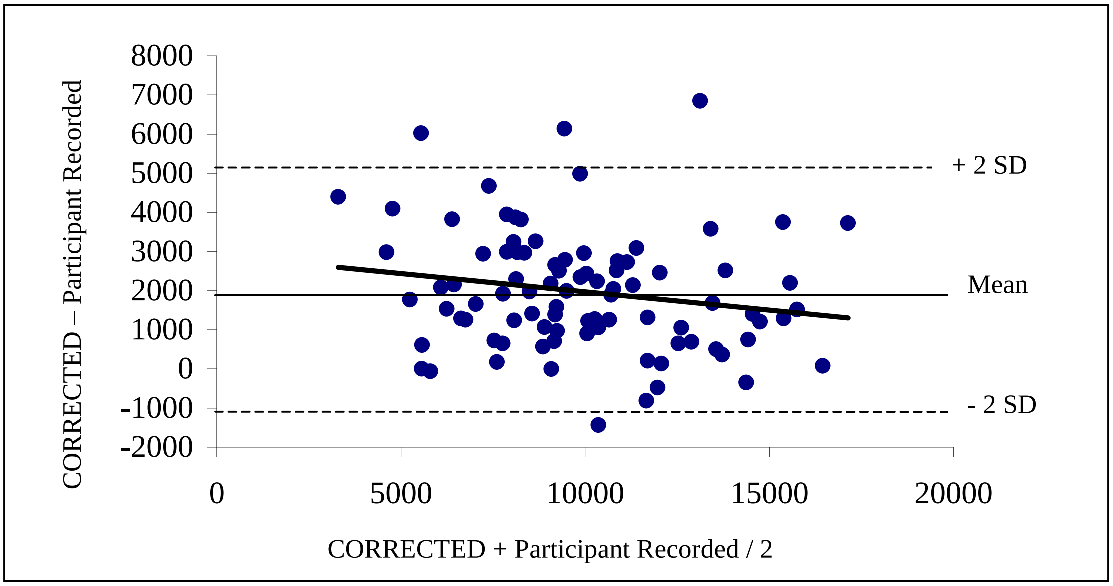


Note: N = 89, r = 0.88, p < 0.0001

Agreement Between Measures

There was a mean difference of 1,975.1 ± 1,534.7 steps per day between CORRECTED and participant recorded steps per day (CORRECTED – participant recorded). The upper limit of agreement was 5,044.5 steps per day while the lower limit was –1,094.3 steps per day. There were three individuals who recorded fewer steps than detected by the Actigraph; however, there was not a bias between the CORRECTED and participant recorded steps per day (r = -0.18, $p = 0.09$). Therefore, the three individuals did not affect the overall mean, and as a result, these two measures exhibited acceptable agreement. The Bland-Altman plot of CORRECTED and participant recorded steps per day is presented in Figure 4.

Figure 4. Agreement Between CORRECTED and Participant Recorded Steps per Day



N = 89; r = -0.18, p = 0.09

Total Accumulated Steps from Sealed and Participant Recorded Conditions

Equivalency Between Measures

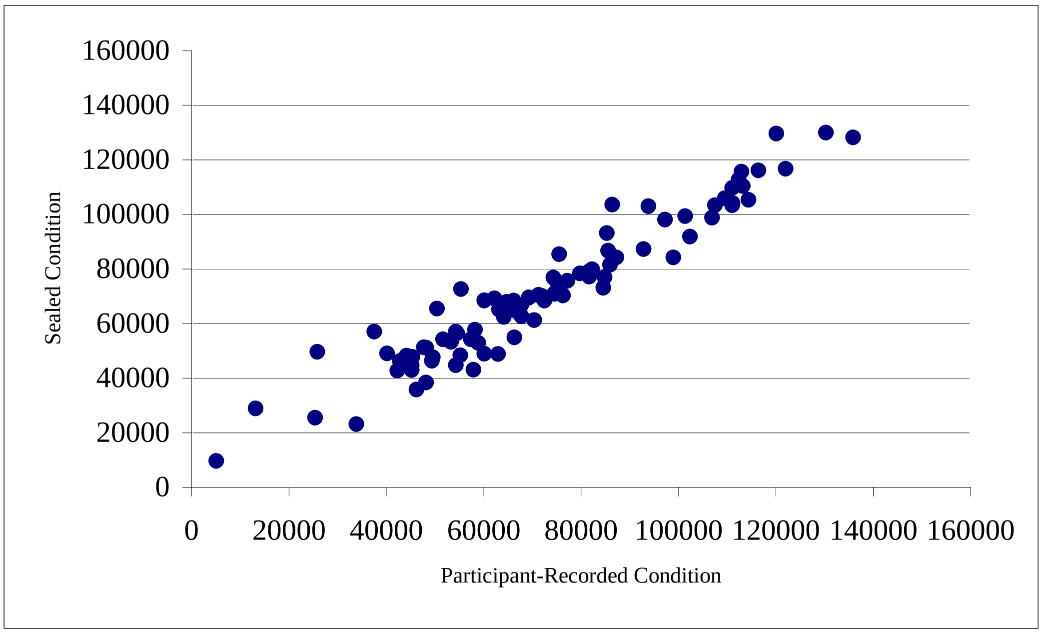
Results from the test of equivalence between total accumulated steps over 8 days from the sealed and participant recorded conditions yielded a mean difference of 822.95 ± 7,542.1 total steps. The equivalent value for this test of equivalence was 2,976 steps. In order to find these two measures significantly similar, the 95% confidence intervals of each 1-sided *t*-test must have been within –2,976 steps and 2,976 steps. The two 1-sided *t*-tests had values (t[1] = -4.75, p < 0.0001) and (t[1] =

-2.69, $p = 0.009$; 95% CI: -2,411.71, 765.81), indicating that the sealed pedometer and the participant-recorded pedometer are significantly equivalent.

Relationship Between Measures

The results of the Pearson Product Moment correlation indicate that the two measures (sealed and participant recorded conditions) share a strong, positive, significant relationship ($r = 0.96$, $p < 0.0001$) in accumulated total steps over the 8-day study period (Figure 5).

Figure 5. Relationship Between Sealed and Participant Recorded Accumulated Steps

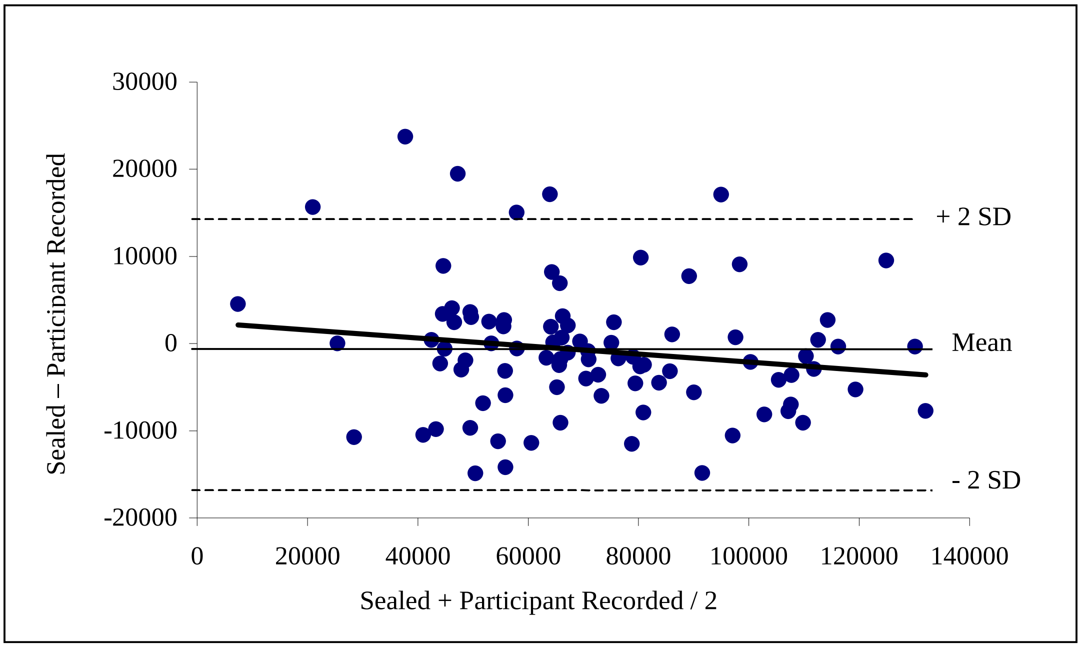


Note: $N = 89$, $r = 0.96$, $p < 0.0001$

Agreement Between Measures

The mean difference (participant recorded – sealed) was –822.96 steps per day. The limits of agreement ranged from a low of –15,907.2 total steps to a high of 14,261.28 total steps. There were 6 individuals who reported significantly more steps than were detected by the sealed pedometer, but this discrepancy was not enough to result in measurement bias (r = -0.16, p = 0.14). Therefore, participant recorded total accumulated steps per day and total accumulated steps per day from the sealed pedometer demonstrated acceptable agreement (Figure 6).

Figure 6. Agreement Between Sealed and Participant Recorded Accumulated Steps

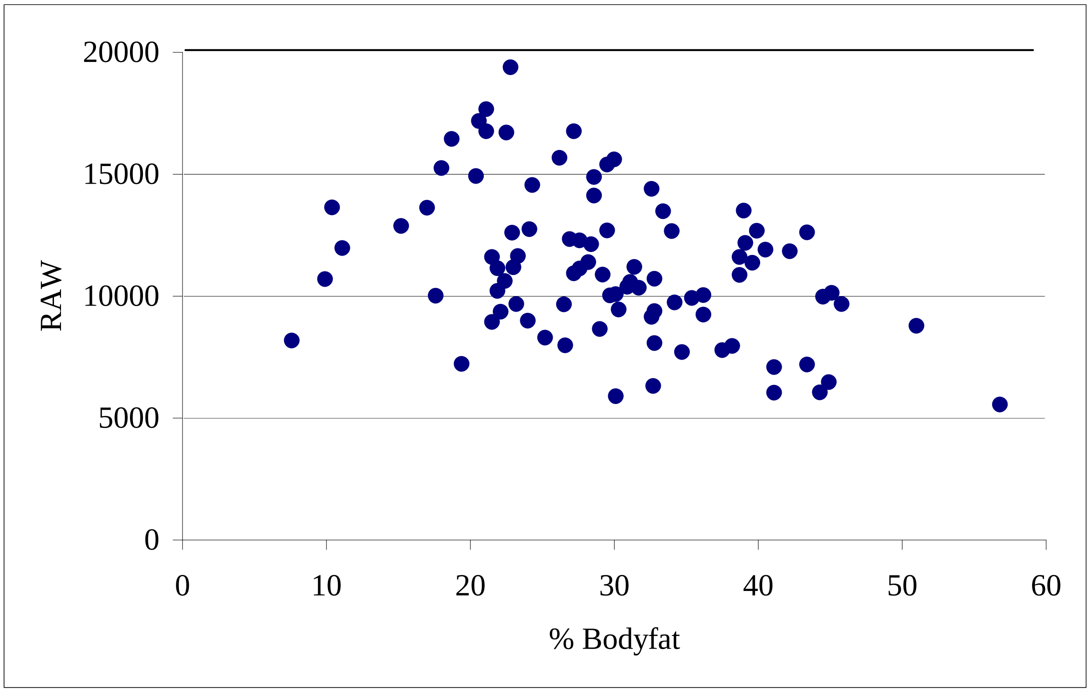


N = 89; r = -0.16, p = 0.14

Relationship Between Steps per Day and Percent Body Fat

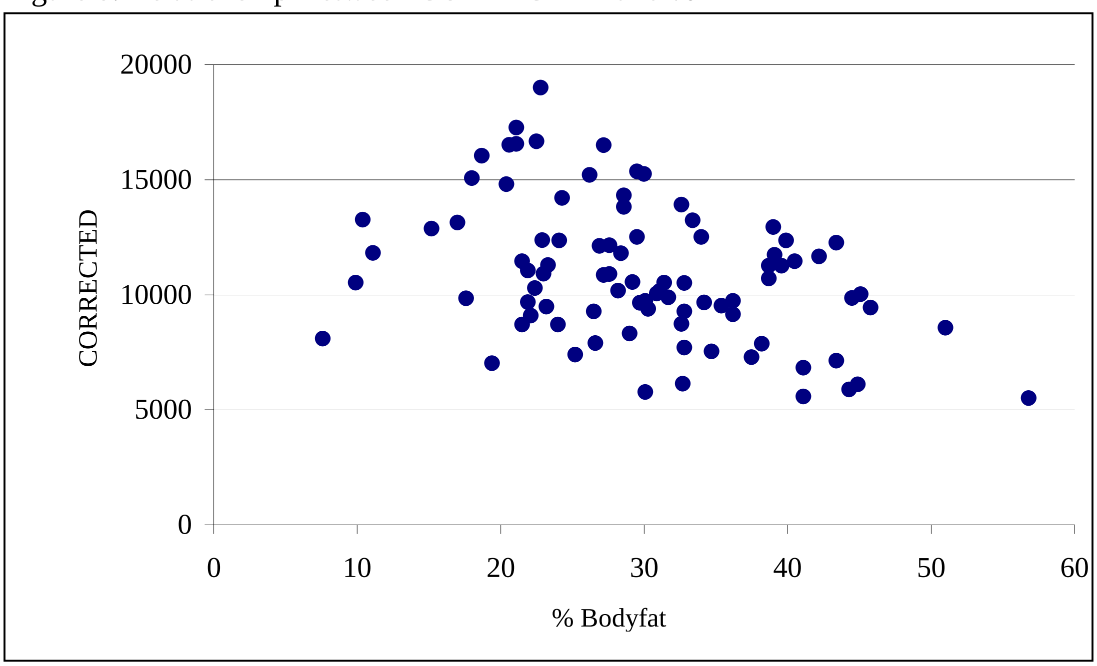
A Pearson Product Moment correlation was utilized to examine the relationships between steps per day from the RAW, CORRECTED, and participant recorded conditions with % BF. RAW and % BF shared a moderate, significant inverse correlation (r = -0.40, p = 0.0001; Figure 7). Similarly, CORRECTED and % BF demonstrated a moderate, significant, inverse relationship (r = -0.40, p = 0.0001; Figure 8). Although still a moderate correlation, participant recorded steps per day and % BF revealed a slightly stronger significantly inverse relationship (r = -0.45, $p < 0.0001$; Figure 9).

Figure 7. Relationship Between RAW and % BF



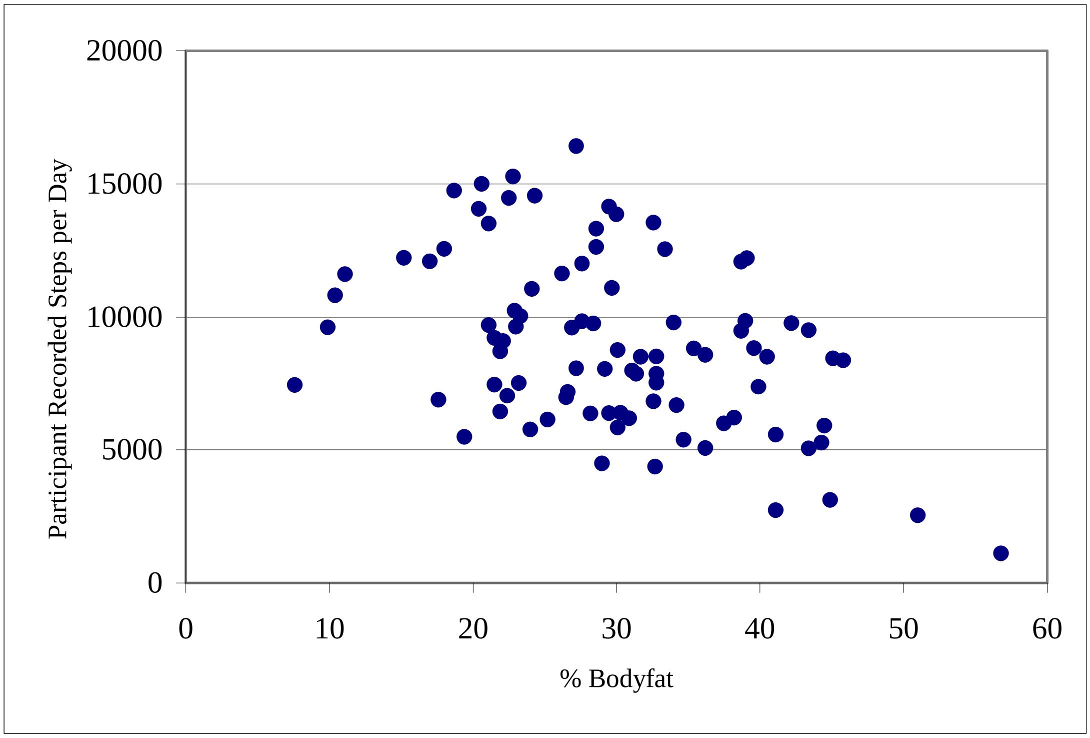
Note: N = 89; r = -0.40, $p = 0.0001$

Figure 8. Relationship Between CORRECTED and % BF



Note: N = 89; r = -0.40, $p = 0.0001$

Figure 9. Relationship Between Participant Recorded Steps per Day and % BF



Note: N = 89, r = -0.45, $p < 0.0001$

Difference in Steps per Day by BMI

Independent *t*-tests were used to examine differences in steps per day by BMI in each of the three conditions (RAW, CORRECTED, and participant recorded). When examining RAW and BMI, an independent t-test revealed no significant difference in steps per day based on those with healthy (< 25kg/m^2) and overweight/obese (≥ 25 kg/m^2) BMI's. An independent t-test between CORRECTED and BMI also revealed no significant difference in steps per day. However, when the participant recorded condition was examined, a significant difference was found between steps per day and BMI. The information regarding each of the conditions and BMI is located in Table 7.

Table 7. RAW, CORRECTED, and Participant Recorded Steps per Day and BMI

Variable	**n**	**Mean**	**SD**	**95% CI**	**t**	**df**	**p**
RAW							
< 25 kg/m^2	49	11,397.0	2,618.6	10,645.0, 12,149.0			
≥ 25 kg/m^2	40	10,949.0	3,393.2	9,864.0, 12,034.0	0.70	87	0.48
CORRECTED							
< 25 kg/m^2	49	11,124.0	2,619.7	10,372.0, 11,876.0			
≥ 25 kg/m^2	40	10,641.0	3,339.4	9,572.9, 11,709.0	0.76	87	0.45
Participant Recorded							
< 25 kg/m^2	49	9,591.9	2,825.4	8,780.4, 10,403.0			
≥ 25 kg/m^2	40	8,123.2	3,531.1	6,993.9, 9,252.5	2.18	87	0.03

Accuracy of Step Logs by BMI Category

On order to investigate the accuracy of healthy weight participants' (BMI < 25 kg/m^2) and overweight/obese participants' (BMI ≥ 25 kg/m^2) recording of steps per day, a difference score was calculated for each of the three comparisons (i.e., sealed pedometer – participant recorded, RAW - participant recorded, and CORRECTED - participant recorded). Because variances were unequal in each of the comparisons, *t*-tests were adjusted for unequal variances. Independent *t*-tests were utilized to examine significant differences in the participants' ability to accurately record steps per day, dependent upon BMI category (i.e., < 25kg/m^2 and ≥ 25 kg/m^2). When examining total accumulated steps over the entire study period (i.e., 8 days) there was a significant difference ($p = 0.005$) with overweight/obese individuals recording 1,641 ± 9,172 more total steps than were detected by the sealed pedometer, and healthy weight individuals recording less steps (2,834 ± 5,170) than were detected by the sealed pedometer.

When examining RAW, there was a significant difference between BMI categories ($p = 0.002$) with individuals in both BMI categories underreported steps per day. The magnitude of error was greater for overweight/obese individuals (2,826 ± 1,751 steps per day) than for healthy weight individuals (1,805 ± 1,202 steps per day). Similarly, when examining CORRECTED, individuals in both BMI categories underreported steps per day with the magnitude of error greater for overweight/obese individuals (2,518 ± 1,752 steps per day) versus healthy weight individuals (1,532 ± 1,174 steps per day). Again, these differences were significant ($p = 0.002$) between BMI categories. Data for these comparisons are located in Table 8.

Table 8. Differences in Steps per Day and Total Accumulated Steps by BMI Category.

Variable	n	Mean	SD	95% CI	t	df	p
RAW – Participant Recorder							
< 25 kg/m^2	49	1,805.3	1,202.6	1,349.3, 4,319.5			
≥ 25 kg/m^2	40	2,826.0	1,751.0	2.299.0, 3,386.0	-3.13	66.8	0.003
CORRECTED – Participant Recorded							
< 25 kg/m^2	49	1,532.1	1,173.5	1,195.0, 1,869.1			
≥ 25 kg/m^2	40	2,517.8	1,752.5	1,957.3, 3,078.2	-3.04	65.6	0.003
Sealed - Participant Recorded[a]							
< 25 kg/m^2	49	2,834.4	5,170.4	1,349.3, 4,318.5			
≥ 25 kg/m^2	40	-1,641.1	9,172.8	-4,774.7, 1,292.6	2.75	58.6	0.008

[a] = Total accumulated steps over the entire study period (8 days)

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

Many recent physical activity interventions have used pedometers as motivational (Croteau, 2004; DuVall et al., 2004; Moreau et al., 2001; Sidman et al., 2004) and measurement tools (Bassett et al., 2004; Bassett & Strath, 2002; Behrens & Dinger, 2003; Tudor-Locke, Williams et al., 2002; Tudor-Locke, 2002; Tudor-Locke, Myers et al., 2002). In many of these studies it is incumbent upon the individual to record the amount of steps taken. To date, there have been no studies that have attempted to examine the validity of these participant recorded step logs. Therefore, the primary purpose of this study was to examine the validity of participant recorded pedometer step logs. Secondary purposes of this study were to examine the relationship between steps per day and percent body fat (%BF), to examine whether steps per day differed between those individuals with healthy weight (BMI < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2), and to determine if healthy weight individuals (BMI < 25 kg/m^2) recorded their steps per day more accurately than overweight/obese individuals (BMI ≥ 25 kg/m^2).

Results of this study indicated that 1) participant recorded step logs are valid measures of actual steps taken, 2) there was a significant moderate, inverse relationship between % BF and steps per day, 3) there was not a significant difference in steps per day detected by the Actigraph between those with healthy (< 25 kg/m^2) and overweight/obese (≥ 25 kg/m^2) BMI's, 4) participant recorded steps per day did differ between those with a healthy weight (< 25 kg/m^2) and overweight/obese (≥ 25 kg/m^2) individuals, 5) healthy weight individuals (< 25 kg/m^2) did not report their steps with more accuracy than overweight/obese ($\geq$ 25 kg/m^2) individuals against the Actigraph criterion, and 6) healthy weight individuals (< 25 kg/m^2) did report their steps with more accuracy than overweight/obese ($\geq$ 25 kg/m^2) individuals against the sealed pedometer criterion.

Validity of Participant Recorded Pedometer Step Logs

Because this study is the first to examine the validity of participant recorded pedometer step logs, little, if any, evidence exists with which to compare these findings. In this study, the question of validity and agreement between assessment techniques was examined using three different methods; tests of equivalence, Pearson Product Moment correlation coefficients, and Bland-Altman plots. Previously, four studies (Le Masurier et al., 2004; Le Masurier & Tudor-Locke, 2003; Schneider et al., 2004; Tudor-Locke, Ainsworth et al., 2002) examined the relationship between step-counting devices when worn simultaneously. However, none of these studies was conducted with the goal of validating pedometer step logs.

When validity was examined between RAW and participant recorded steps per day in this study, a strong correlation was found indicating a high degree of validity by correlation. However, a simple significant, strong correlation does not always imply validity. Bland and Altman (1986) suggest that using correlation coefficients to determine validity is fundamentally flawed because in this case two methods of measuring the same thing should be related, thus, have a high correlation, and because strong correlations are not necessarily indicative of strong agreement. Therefore, Bland and Altman suggest plotting true values against the mean difference of the two measures with 95% confidence intervals. This allows for a visual representation of the agreement between two different measures of a similar outcome. When a Bland-Altman plot was produced, the RAW and participant recorded steps per day demonstrated acceptable agreement, without significant bias.

However, comparing RAW with participant recorded steps per day for a test of equivalence revealed a lack of equivalence between the measures. This could be due, in part, to the measure of equivalence used in this study. In the present study an equivalence of 1,845 steps was used. These values are from a study by Tudor-Locke, Ainsworth, and colleagues (2002) in which they reported a mean difference between Actigraph-derived and participant recorded steps per day as 1,845 ± 2,116 steps per day in their sample. To date, this is the only published report of mean differences between Actigraph and pedometer steps per day. It is plausible that because the aforementioned study is the only study that has reported mean differences between the measures, the actual difference may be greater than previously reported. In the present study the mean difference between RAW and participant recorded steps per day was 2,264 ± 1,1551.7 steps per day with a 95% confidence interval between 1,937.2 and 2,590.0 steps per day.

Similar to the RAW and participant recorded comparison, when CORRECTED and participant recorded steps per day were examined, a strong correlation between the two measures was revealed. When examined by a Bland-Altman plot, there was not bias between measures and both were in agreement. However, testing for equivalence between the measures indicated a lack of equivalence. This test utilized the same Actigraph data that were used for the RAW comparison. However, these data were adjusted using a correction factor of 12.5 steps per mile traveled by vehicle (Le Masurier & Tudor-Locke, 2003) that adjusts the Actigraph data to account for the increased sensitivity of the Actigraph (i.e., 0.30 *g* for the Actigraph versus ≥ 0.35 *g* for the Yamax Model 200; Schneider, Crouter, & Bassett, 2004). This correction factor is from one study conducted in stringent conditions (i.e., same vehicle over a standard route). After application of the correction factor, the same equivalence value as indicated by Tudor-Locke, Ainsworth, and colleagues (2002) was applied (i.e., 1,845 steps per day). Unfortunately, the data indicated that the measures were still not significantly equivalent.

In this study it appears as though identifying a mean difference between Actigraph steps per day and participant recorded steps per day from a pedometer is an important issue. If the actual mean value used to test equivalence would have been greater than 2,600 steps per day, then these values would have been significantly equivalent. Further, after the application of the correction factor recommended by Le Masurier (Le Masurier & Tudor-Locke, 2003), there still was not enough of a correction to find significant similarities between Actigraph-derived and participant recorded steps per day. These findings in this study suggest that it is still unclear as to the actual difference between steps per day and participant recorded steps per day. Moreover, these findings suggest that the correction factor for vehicular travel indicated by Le Masurier and Tudor-Locke (2003) may not be applicable in free-living situations in which individuals must recall their mileage, and in which day to day traveling situations cannot be controlled (e.g., bumpy roads, type of vehicle, etc.).

These are important findings and deserve further inquiry to examine the differences between Actigraph-derived and pedometer-derived steps per day.

Conversely, when examining the validity of the sealed and participant recorded total accumulation of steps over the entire study period, results indicated a significant, strong positive correlation. At first glance, this may mean a strong relationship suggesting a high degree of validity. Additionally, a Bland-Altman plot reinforced the idea of agreement without directional bias. When tested for equivalence, it was found that the two measures were significantly equivalent. The value for equivalence used in this test was from Schneider, Crouter, and Bassett (2004). In their study participants simultaneously wore identical pedometers over their right and left waistbands. The mean difference between the Yamax Model 200 pedometers was recorded at 372 ± 1,685 steps over a 24-hour period. Therefore, 372 steps per day multiplied by 8 days equal 2,976 steps. In the present study, the mean difference was 822.95 ± 7,542.1 steps with 95% confidence intervals between –2,411 to 765 total steps; well inside the bounds of 2,976 total steps.

These findings indicate that using two of the same types of devices is much more efficient than using different devices, even if both devices are designed to measure steps. Since the Actigraph generally resulted in more steps per day than the participant recorded steps per day from the pedometer it is likely that the sensitivity of the instruments causes a great deal of disagreement. As previously mentioned, the Actigraph is much more sensitive to recording vertical movements that the Yamax pedometer (≥ 0.30 versus ≥ 0.35 *g's*, respectively; Schneider, Crouter, & Bassett, 2004). This sensitivity could cause the Actigraph to incorrectly record non-step movement as steps. Such movements could include vehicular travel, but it is clear that correcting for vehicular travel using the guidelines provided by Le Masurier and Tudor-Locke (2003) was not sufficient to allow for comparison between Actigraphs and pedometers. Future research should continue to examine the recording differences between Actigraph steps and pedometer steps to provide a more thorough examination of the differences in steps. Further, future studies should examine the relationship between Actigraph sensitivity and vehicular travel in free-living populations during normal travel conditions.

Relationship Between Percent Bodyfat and Steps per Day

A secondary purpose of this study was to examine the relationship between % BF and steps per day. McClung and colleagues (1999) were among the first to hypothesize that there should be a significant inverse relationship between % BF and steps per day. Welk, Differding, Thompson, et al. (2000) were among the first to indicate that the hypothesis of McClung et al (1999) may be correct when Welk and colleagues (1999) found that there was a significant relationship between accumulated steps and % BF. In their study, 31 participants were required to walk and jog on a track and treadmill for standard times and distances. Bodyfat was assessed by skinfolds. Their results indicated strong correlations between % BF and steps taken while walking ($r = -0.66$) and jogging ($r = -0.55$). While these correlation coefficients are quite high, it should be noted that this study was timed, and that the correlations reported therein may be more representative of participant fitness. Because this may be a measure of fitness, which may be more prone to a lesser % BF than in an idyllic free-living situation, these results needed to be investigated in a free-living setting.

When the results of the present study are compared with comparable previous studies in free-living settings, more concurrence is found. Tudor-Locke, Ainsworth, and Whitt et al. (2001) collected data from 109 adults (males: n = 41, females: n = 68) in a cross-sectional study to examine the relationship between steps per day and body composition. The results of their study indicated that steps per day were negatively associated with % BF ($r = -0.30$, $p < 0.01$). These findings are very similar to the results of this study [RAW and participant recorded ($r = -0.40$, $p < 0.0001$); CORRECTED and participant recorded ($r = 0.40$, $p < 0.0001$); sealed and participant recorded ($r = -0.45$, $p < 0.0001$)] in which there was a negative inverse relationship between steps per day and % BF.

Further, in the most recent study investigating these effects, researchers examined 80 women who were instructed to wear a pedometer at their waist for seven consecutive days (Thompson et al., 2004). The participants recorded their daily steps on a log and then reported back to researchers at the end of the 7-day period. Similar to the present study, Pearson Product Moment correlation coefficients were significant, and negatively related to average steps per day. While the present study revealed a moderate correlation between steps per day and % BF, their study indicated a strong ($r = -0.71$, $p < 0.0001$) relationship. Because the findings of the present study [RAW and % BF ($r = -0.40$, $p < 0.0001$), CORRECTED and % BF ($r = -0.40$, $p < 0.0001$), and participant recorded steps per day and % BF ($r = -0.45$, $p < 0.0001$)] share a similarity to previous research, these results seem to be efficacious and add to the empirical literature base regarding the relationship between steps per day and % BF.

It may be assumed that since % BF is an indirect measure of physical activity and motion detectors are direct measures of physical activity (Ainsworth, 2000), there should be a stronger association between % BF and steps per day. However, because total accumulated steps per day (as captured with a pedometer) is of varying intensities of physical activity, the relationship between steps per day and % BF would be expected to be lower than if all of the activities were vigorous physical activity (VPA). Although not the purpose of this study, the finding that there was only a moderate association between % BF and steps per day in this study may indicate that 1) motion detectors are more efficient at detecting usual, habitual physical activity than % BF, and 2) the ongoing problem of overweight and obesity is not a problem that can simply be conquered through increased physical activity. These are both issues that should be addressed in future research.

In a study examining the sources of variance while wearing an Actigraph accelerometer (Matthews et al., 2002), researchers measured physical activity among 92 participants for 21 consecutive days while wearing an Actigraph. Results indicated that 3-4 days of monitoring were necessary for 80% reliability of measuring normal physical activity patterns, while 7 days of monitoring were necessary for assessing both physical activity and physical inactivity with 90% reliability. In the present study, the participants wore the devices for greater than 6 days, meaning that more than 80% reliability was achieved. This time frame provides an accurate and reliable measure of habitual physical activity, and is a much better estimate of habitual physical activity than % BF. With regards to the ongoing problem of overweight and obesity, even in the strongest correlation in this study (participant recorded steps per day and % BF; r = -0.45) steps per day was only able to explain approximately 20% of the variance in predicting % BF. The strongest relationship mentioned in a previous study (i.e., r = -0.71; Thompson et al., 2004) can only account for approximately 50% of the variance in explaining the % BF of the women in their sample. Because of findings such as these, interventions designed to treat overweight and obese individuals should take an integrative, health-promoting, approach. An integrative intervention model should encompass a holistic view that includes not only increasing physical activity, but also monitoring dietary intake, increasing self-esteem and self-confidence, building social supports, and fostering a strong spiritual component.

Differences in Steps per Day by BMI Category

In addition to the relationship between steps per day and % BF, another purpose of this study was to examine steps per day by BMI. Because BMI is an easily assessed outcome in health-related research, it is not surprising that many studies (Chan, Spangler, Valcour, & Tudor-Locke, 2003; Thompson et al., 2004; Tudor-Locke et al., 2004; Tudor-Locke et al., 2001; Whitt, DuBose, Ainsworth, & Tudor-Locke, 2004) have examined steps per day and BMI. In most of these studies the examination is reported as a relationship (Chan et al., 2003; Thompson et al., 2004; Tudor-Locke et al., 2001; Whitt et al., 2004). However, few studies have examined the differences in steps per day by BMI category. In a recent study examining this issue (Tudor-Locke et al., 2004) researchers examined 209 participants (males: n =

76, females: n = 133) to provide a descriptive epidemiology of pedometer-derived physical activity patterns. Participants were instructed to wear a waist-mounted pedometer for seven consecutive days, and to record their daily steps on a log that was provided for them. BMI was determined from a self-reported questionnaire that was given to each participant. Results of the study revealed a significant difference in average daily steps by BMI category ($F = 6.35$, $p = 0.002$), where the difference was only observed between those with obese (> 30 kg/m^2) and healthy (< 25 kg/m^2) BMI's.

In another recent study examining steps per day by BMI category, Chan and colleagues (2003) recruited more than 500 office workers from different governmental workplaces in Prince Edward Island, Canada. Participants wore a sealed pedometer for three days, and the researchers divided the total accumulated steps by three to obtain a mean step per day value. BMI was categorized as healthy (BMI < 25 kg/m^2), overweight (BMI ≥ 25 kg/m^2 and < 30 kg/m^2), and obese (BMI ≥ 30 kg/m^2). Results indicated that there was a significant difference in steps per day, in that as BMI increased, steps per day decreased ($F_{(2162)} = 10.52$, $p < 0.0001$).

Interestingly, the findings of this study are not in agreement with the aforementioned studies. Our results indicated no significant differences in steps per day between those with an overweight/obese BMI and those with a healthy BMI when assessed by Actigraph (RAW & CORRECTED). However, when assessed in the participant recorded condition, the findings of this study are in agreement with previous research. With regards to disagreement, this could be due in part to the socio-demographic make up of the sample in this study. These participants were all highly educated and of very high incomes. The majority of the subjects in the Tudor-Locke study (2004) were of lower income, and assumedly, lower socioeconomic status than the participants in the current study. Further, the great majority of the participants in the current study are Caucasian, as compared to a much more ethnically diverse population in that of Tudor-Locke and colleagues (2003). Although not reported in their study, it is likely that the participants in the study by Chan and colleagues (2003) were more similar to those in this study, based on occupation. Still, Chan (2003) found significant differences in steps per day by BMI while this study did not. However, it can be argued that because the overwhelming majority of the participants in this study were employed in academic settings, their physical activity patterns would likely be similar, regardless of their BMI. If the results of this study are to be believed, it further indicates that step per day-determined physical activity may not be the best indicator of body fatness, or health.

With regard to the differences between Actigraph and participant recorded steps per day and BMI category, the issue again revolves around the sensitivity differences between the two instruments. It is plausible that because the position of the two instruments on the body, the results may have been different. Swartz and colleagues (Swartz, Bassett et al., 2003) recruited 66 individuals with varying BMI's (BMI < 25 kg/m^2 = 25; BMI between 25 kg/m^2 and 29.99 kg/m^2 = 24; BMI > 29.99 kg/m^2 = 17) and had them simultaneously wear three identical pedometers on their front waist, hip, and over the buttocks. The researchers found that the placement of the pedometer did not affect the outcome of the results. However, other research has suggested that regional adiposity my play a role in pedometer accuracy (McClung et al., 2000). This is still an area for future research to address. Another potential area for differences between Actigraph and pedometers can be found in the speed of movement. Although the Yamax pedometers are the highest quality pedometers for research purposes (Crouter et al., 2003; Schneider et al., 2004; Schneider et al., 2003; Swartz, Bassett et al., 2003), they notoriously undercount steps taken at slower speeds (Bassett et al., 1996; Bassett et al., 2000; Swartz, Bassett et al., 2003). However, the increased sensitivity of the Actigraph may compensate for walking at slower speeds. Therefore, if the majority of the participants in this study were moving at slower rates, than the Actigraph's increased sensitivity may have recorded steps closer to actual steps taken.

However, as previously mentioned, steps per day plays a small role in explaining body fatness. In a study conducted by Tudor-Locke, Ainsworth, Whitt, et al. (2001) there was a significant difference in time spent in physical activity by BMI category. As BMI increased, time in physical activity decreased. However, *post hoc* comparisons indicated that there was not a difference in time spent in moderate physical activity (MPA) or VPA by BMI category. Rather, the difference was due to time spent in light-intensity activities. The findings of this study regarding BMI and steps per day, coupled with that of Tudor-Locke, Ainsworth, Whitt and colleagues (2001) might indicate that light intensity physical activity and physical inactivity may have a more influential role in weight maintenance than higher intensity physical activity that is suggested in physical activity recommendations. That is, an individual having less inactive time may be more important than an individual spending more time in physical activity of at least moderate intensity.

Accuracy of Recorded Steps by BMI Category

The final purpose of this study was to determine if healthy weight individuals (BMI ≥ 25 kg/m^2) recorded their steps more accurately than overweight/obese (< 30 kg/m^2) individuals. To answer this question, difference variables were created for each of the three validity comparisons; a) RAW – participant recorded steps per day, b) CORRECTED – participant recorded steps per day, and c) total accumulated steps from the sealed pedometer for the entire study period – total participant recorded steps for the entire study period. Results indicated significant differences by BMI in each of the comparisons, and although not the case when examining the sealed pedometer minus participant recorded comparison, healthy weight individuals were generally able to record steps more accurately than overweight/obese individuals.

In two comparisons using the Actigraph (RAW - participant recorded, and CORRECTED - participant recorded), healthy weight individuals recorded steps per day that were closer to the steps per day recorded by the Actigraph (-1,805 ± 1,202 and -1,532 ± 1,173 for RAW and CORRECTED, respectively) than overweight/obese individuals (-2.826 ± 1,751 and -2,517 ± 1,752 for RAW and CORRECTED, respectively). The reasons for this discrepancy are unclear. Although two previous studies (Thompson, 2004; Swartz, Bassett, et al., 2003) have concluded that adiposity does not play a role in pedometer accuracy, there still needs to be further investigation into this area. Because no studies to date have examined the effects of adiposity when comparing Actigraph and pedometer steps per day, it is plausible that the positional differences of the different devices could have played a role in this discrepancy.

Swartz and colleagues (2003) had 66 participants (males: n = 35; females: n = 31) wear a pedometer on three different sites on the right side of the body (anterior midline of the thigh, mid-axillary line, and posterior mid line of the thigh) while walking on a treadmill at different speeds. There were 25 normal weight (BMI > 25 kg/m^2), 24 overweight (BMI = 25 kg/m^2 – 29.99 kg/m^2), and 17 obese (BMI < 30 kg/m^2) individuals that participated in the study. Steps from the pedometer were validated against direct observation with a hand-tally counter. The researchers found that the accuracy of the pedometer was not affected by the placement of the pedometer, regardless of BMI. However, when wearing an Actigraph, the placement on the body is different than with a pedometer. In their study, Swartz and colleagues (2003) placed pedometers on the mid-axillary line at the waist, but Actigraphs are worn higher, above the iliac crest. Because of a lack of information in the literature regarding Actigraph and pedometer comparisons, it is unclear as to whether this slight difference in placement may have been affected by total, or regional, adiposity.

Furthermore, because Actigraphs are more sensitive to incremental movements than pedometers, this could also help in explaining the discrepancy. If the overweight/obese participants were moving slowly, these movements might not have been registered by the pedometers, which are notoriously poor at detecting slower movements (Bassett, 1996). The difference between Actigraph and participant recorded steps per day for healthy weight and overweight/obese individuals only ranged from 986 steps per day for CORRECTED to 1,021 steps per day for RAW. It is plausible that such differences could be explained by slow movement accrued throughout the day.

When comparing total accumulated steps from the sealed and participant recorded pedometers by BMI category, the findings are somewhat different than with Actigraph steps per day. The findings of this study indicate that overweight/obese individuals recorded an average of 1,641 ± 9,172 more steps than were detected by the sealed pedometer. Conversely, healthy weight individuals recorded an average of 2,834 ± 5,170 fewer steps than were recorded by the sealed pedometer. That is, in this comparison, overweight/obese individuals recorded steps per day that were closer to zero (i.e., the criterion measure) than healthy weight individuals. The reasons for this are unclear.

In this study, participants wore the sealed pedometer on their left waistband, while the participant recorded pedometer was worn over the right waistband. According to Swartz and colleagues (2003), the placement of the pedometer should not be influenced by BMI. However, the findings of Swartz and colleagues (2003) were all assessed from the right side of the body. It is possible; therefore, that regional adiposity could play a role in the accuracy of devices worn on different sides of the body. However, one must remember that these values are representative of total accumulated steps over an 8-day period. Divided by 8 days, healthy weight individuals underreported by only 354 steps per day, and overweight/obese individuals over reported by only 205 steps per day. This represents an absolute value difference of approximately 559 steps per day. While each researcher and practitioner must decide for himself or herself what constitutes acceptable error, one can easily conceive that a difference of 559 steps per day is inconsequential, and not truly meaningful.

Limitations

This study is not without its limitations. The first limitation is the choice of test for determining validity. In this study validity was determined with a test of equivalence and Pearson Product Moment correlations. Also, Bland-Altman plots were used to visually examine the agreement and potential bias between methods. Although researchers have been unable to determine a criterion test for examining validity among free-living populations, it could be argued that this study used a number of measures for validity in an attempt to reduce the error found in each potential method. Further, by utilizing three different techniques, the data in this study can be triangulated with the three tests. This allowed the researcher to examine the comparisons among the different techniques.

Another possible limitation is the rate of equivalency used for the test of equivalence (1,845 ± 2,116 steps). There has only been one published study that has reported mean differences between Actigraph and pedometer steps per day in a free-living population (Tudor-Locke, Ainsworth et al., 2002). In their study researchers had a relatively small sample size (n = 52), and it is unclear as to whether the values found in their sample are representative of all adults. Additionally, the correction factor that was used for correcting the Actigraph due to vehicular travel (12.5 steps per mile traveled) was determined from one study (Le Masurier & Tudor-Locke, 2003) in which the driving environment was completely controlled. In addition to the equivalency value for Actigraph and participant recorded conditions, when examining the equivalency between sealed and participant recorded conditions, only one study has reported mean differences between the Yamax pedometer simultaneously worn on right and left hips (Schneider et al., 2004). In their study it was found that the two pedometers differed by approximately 372 steps over a 24-hour period. Therefore in the present study, this daily value was multiplied over eight days. Although the studies that have been mentioned are the only studies of their kind, and therefore, necessary for answering the questions of the present study, it is plausible that these values may have introduced unavoidable, yet necessary, error.

Finally, the participants in this study were all volunteers. Thus, they may have been more eager to participate and comply with the protocol. Because they were highly educated and had high household incomes, they may not have been representative of the typical adult population. It is also probable that their physical activity patterns would be more likely to be similar because the overwhelming majority of the participants were from academic settings with similar work schedules. Also, because these participants were highly active (e.g., 34.9 ± 16.7 minutes MPA per day from the Actigraph), they may not have been as tempted to artificially increase the steps per day on their step logs. Perhaps if less active participants would have been present, there might have been an aspect of social desirability.

Strengths of the Study

Although there were limitations present in this study, there were also strengths. This study was powered with a sample size that supplied ample strength for the reliability of its findings. As previously mentioned, 70 participants were needed to represent a power = 0.80. There were 89 participants for the analyses, thus exceeding *a priori* power of 0.80. The time frame for monitoring physical activity was also an important strength to this study. Matthews and colleagues (2002) noted that in order to represent habitual daily physical activity with 80% confidence, 3-4 days of monitoring are necessary. In this study participants averaged almost 7 days of monitoring, yielding results for physical activity and physical inactivity that can interpreted with approximately 90% confidence.

Second, the instruments used in this study represent the latest technology to answer the questions of the study. While many studies assess physical activity with questionnaires, in this study physical activity was assessed using an Actigraph accelerometer and Yamax pedometer. These devices allow researchers to accurately obtain information regarding the ambulatory physical activity of study participants.

Moreover, while many studies in the public health literature use BMI as a measure of body composition, this study utilized the BOD POD to obtain actual body composition in addition to BMI. This is important because BMI is not intended to be a measure of body composition, and recent studies have found considerable variation in BMI dependent upon gender, age, and ethnic group (Fernandez, Heo, Heymsfield, Pierson, Pi-Sunyer, Wanf, et al., 2003; Gallagher, Heymsfield, Heo, Jebb, Murgatroyd, & Sakamoto, 2000). By using % BF in this study, any gender, ethnic, or age variation could be better controlled.

Finally, the analyses used in this study were a strength. As previously mentioned, validity was examined by using two statistical techniques and a third plotting technique to examine agreement between measures. While many studies simply use correlation coefficients to describe validity, the use of three different techniques in this study allowed triangulating the results for a more meaningful interpretation.

Recommendations for Future Research

It appears as though participant recorded pedometer steps logs are valid measures of actual objectively assessed physical activity. However, this study has also introduced many questions for future research. First, future research should address the consistency between Actigraph-derived and pedometer-derived steps per day. Because of the disagreement between methods and the lack of studies reporting mean differences between the two measures when used simultaneously, there is a need for more studies to report mean differences between the two measures in free-living populations. Second, future research should attempt to determine a standard error rate for the sensitivity of the Actigraph in free-living populations. Further, one of the most pressing findings in this study for future research was among the body composition variables and the role of physical inactivity. From previous research (Tudor-Locke et al., 2001) it was suggested that lower-level intensity physical activity may be able to explain much of the discrepancy between the relationships of body composition (% BF & BMI) and steps per day. Examining the relationships between body composition and lower-intensity physical activity and physical inactivity is a critical area in need of further investigation.

Summary and Implications

In summary, participant-recorded pedometer step logs were valid when evaluated against a sealed pedometer. Actigraph steps per day demonstrated considerable variability when compared to participant recorded step logs. Further, there was a significant, moderate inverse relationship between steps per day and % BF, and in contrast to other published reports (Chan et al., 2003; Tudor-Locke et al., 2004), steps per day did not differ significantly between healthy weight (BMI < 25 kg/m^2) and overweight/obese (BMI ≥ 25 kg/m^2) individuals when pedometers were used. Finally, there was a significant difference in the accuracy of participant recorded step logs by healthy weight (BMI < 25 kg/m^2) individuals and overweight/obese (BMI ≥ 25 kg/m^2) individuals. These findings are important to the field of physical activity research and practice. Researchers using participant recorded step logs can use them knowing that they are a valid representation of actual steps. The findings regarding steps per day and body composition variables act to add to the empirical literature base, and provide a foundation for future research regarding physical inactivity and weight control.

Conclusions

Research Hypothesis 1. Participant recorded steps logs are an accurate representation of the actual daily steps detected by an Actigraph accelerometer with cycle mode enabled.

When participant recorded step logs were compared to Actigraph steps per day, there was a strong significant correlation ($r = 0.88$, $p < 0.0001$). A Bland-Altman plot indicated agreement between the measures without directional bias. However, a test of equivalence revealed that the assessments were not significantly similar with 95% confidence intervals from 1,937 to 2,590 steps per day. This was beyond the 1,845 steps per day that determined the rate of equivalence.

Research Hypothesis 2. Participant-recorded steps logs are an accurate representation of the actual daily steps detected by an Actigraph accelerometer with cycle mode enabled, and corrected for vehicular travel.

When corrected for vehicular travel, the steps per day from the Actigraph had a strong significant correlation ($r = 0.88$, $p < 0.0001$) with participant recorded steps per day. A Bland-Altman plot demonstrated agreement between the assessment techniques, but a test of equivalence indicated that the techniques were not significantly similar. The 95% confidence interval (1,651 to 2,298 steps per day) exceeded the equivalent value of 1,845 steps per day.

Research Hypothesis 3. The total accumulated steps recorded by participants on step logs are an accurate representation of total accumulated steps recorded from a sealed pedometer.

Total participant recorded steps shared a strong significant correlation to that of the total steps recorded by the sealed pedometer ($r = 0.96$, $p < 0.0001$). Further, a Bland-Altman plot revealed agreement between the measures. Additionally, a test of equivalence revealed that the two measures were significantly equivalent with 95% confidence intervals between 765 and 2,411 steps. These values are clearly within the equivalent value of 2,976 steps.

Research Hypothesis 4. There is a strong linear, inverse relationship, between steps per day and percent body fat (% BF).

There is a moderate inverse relationship between Actigraph-derived steps per day and % BF (RAW: $r = -0.40$, $p < 0.0001$; CORRECTED: $r = -0.40$, $p < 0.0001$). Further, there is a moderate inverse relationship between participant recorded steps per day and % BF ($r = -0.45$, $p < 0.0001$).

Research Hypothesis 5. Healthy weight individuals (BMI < 25 kg/m^2) take significantly more steps per day than overweight/obese individuals (BMI ≥ 25 kg/m^2).

There was not a significant difference in Actigraph-derived steps per day by healthy weight individuals (BMI < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2) by RAW ($t[87] = 0.70$, $p = 0.48$) or CORRECTED ($t[87] = 0.76$, $p = 0.45$)

steps per day. However, there was a significant difference (t[87] = 2.18, p = 0.03) in participant recorded steps per day by healthy weight individuals (BMI < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2).

Research Hypothesis 6. Healthy weight individuals (BMI < 25 kg/m^2) record steps per day more accurately than overweight/obese (BMI ≥ 25 kg/m^2) individuals.

There were significant differences between healthy weight (BMI < 25 kg/m^2) and overweight/obese individuals (BMI ≥ 25 kg/m^2) in the recording of steps per day for the entire study period (i.e., 8 days; t[58.6] = 2.75,p = 0.008), RAW (t[66.8] =- 3.13, p = 0.003), and CORRECTED (t[65.6] = -3.04, p = 0.003). In the Actigraph comparisons (i.e., RAW & CORRECTED) healthy weight individuals recorded steps per day more accurately than overweight/obese individuals, while in the sealed-participant recorded comparison, overweight/obese individuals recorded their steps per day with more accuracy.

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Appendices

Appendix A. Study Advertisement Text

Appendix B. Sample Study Flyer

Appendix C. Demographic Questionnaire

Appendix D. PAR-Q

Appendix E. International Physical Activity Questionnaire – Short Form

Appendix F. Mileage Questionnaire

Appendix G. Participant Logs for Actigraph and Pedometer

Appendix H. Informed Consent Form

Appendix I. HIPPA Form

Appendix J. Institutional Review Board – Norman Campus Approval

Appendix L. Data

APPENDIX A

Study Advertisement Text

OU Norman Campus Mass e-mail

How Active Are You?
Participants ages 25 to 60 are being sought for a physical activity research study. Participants will complete questionnaires and wear three small, pager-like devices during the study. Participants who complete the study will receive a report that includes information about their physical activity, caloric expenditure and body composition. To participate or for more information, contact Tim Behrens in the Department of Health and Exercise Science at 325-5211 or physactlab@ou.edu.

OUHSC Campus Mass e-mail and newspapers

How Active Are You?
Participants ages 25 to 60 are being sought for a physical activity research study. Participants will complete questionnaires and wear three small, pager-like devices during the study. Participants who complete the study will receive a report that includes information about their physical activity, caloric expenditure and body composition. To participate or for more information, contact Tim Behrens in the University of Oklahoma, Norman Campus, Department of Health and Exercise Science at 325-5211 or physactlab@ou.edu.

Radio
Participants ages 25 to 60 are being sought for a physical activity research study. Participants will complete questionnaires and wear three small, pager-like devices during the study. Participants who complete the study will receive a report that includes information about their physical activity, caloric expenditure and body composition. To participate or for more information, contact Tim Behrens in the University of Oklahoma, Norman Campus, Department of Health and Exercise Science at 325-5211 or p-h-y-s-a-c-t-l-a-b at o-u dot e-d-u.

Advertisement for Channel 22

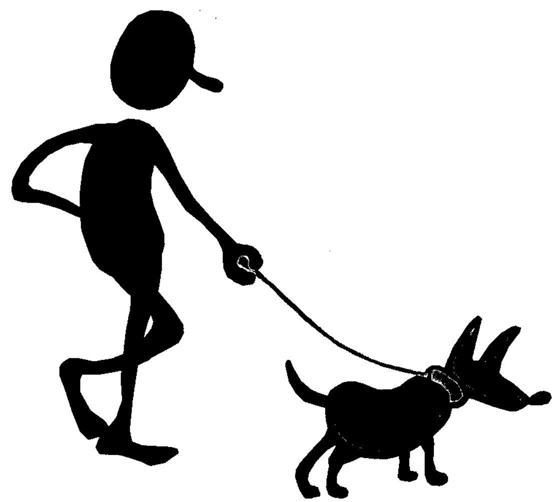
How Active Are You?
Participants ages 25 to 60 are being sought for a physical activity research study. For information contact Tim Behrens at the University of Oklahoma, Norman Campus, Department of Health and Exercise Science at 325-5211 or physactlab@ou.edu.

APPROVED
JUL 29 2004
OU-NC IRB

APPENDIX B

Sample Study Flyer

Learn More About Your Activity



- Adults, ages 25 to 60, are needed for a one-week physical activity research study.
- Participants will receive information regarding their physical activity, caloric expenditure and body composition at the end of the study.

Contact Tim Behrens at the
University of Oklahoma, Norman campus, Department of
Health and Exercise Science, 325-5211 or physactlab@ou.edu

The University of Oklahoma is an
equal opportunity institution

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JUL 2 9 2004
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APPENDIX C

Demographic Questionnaire

Physical Activity Assessment in Free-Living Adults
Demographic Items

Directions: Please fill in the blank or circle the number that represents your response. Please select only ONE response for each item.

1. How old are you?
   ____________ Years

2. What is your date of birth?
   ____

3. What is your sex?
   1. Male
   2. Female

4. How do you describe yourself?
   1. American Indian or Alaska Native
   2. Asian
   3. Black or African American
   4. Hispanic or Latino
   5. Native Hawaiian or Other Pacific Islander
   6. White or Caucasian
   7. Other ____________________________

5. What is the highest grade or year of school you have completed?
   1. Never attended school or only kindergarten
   2. Grades 1 through 8 (elementary)
   3. Grades 9 through 11 (some high school)
   4. Grade 12 or GED (high school graduate)
   5. College 1 year to 3 years (some college or technical school)
   6. College 4 or more years (college graduate)
   7. Graduate/professional school

6. Regarding your occupational status, are you currently?
   1. Employed for wages
   2. Self employed
   3. Out of work for more than one year
   4. Out of work for less than one year
   5. A homemaker
   6. A student
   7. Retired
   8. Unable to work

7. What is your occupation?

____

8. Is your annual household income from all sources:
    1. Less than $10,000
    2. $10,001 - $15,000
    3. $15,001 - $20,000
    4. $20,001 - $25,000
    5. $25,001 - $35,000
    6. $35,001 - $50,000
    7. $50,001 - $75,000
    8. More than $75,000
    9. Don't know/not sure

PLEASE DO NOT WRITE BELOW THIS LINE

Date________________ Height_______________ inches

Weight_______________ pounds

APPENDIX D

PAR-Q

Physical Activity Readiness
Questionnaire-PAR-Q
(revised 1994)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
___	___	1. Has your doctor ever said that you have a heart condition *and* that you should only do physical activity recommended by a doctor?
___	___	2. Do you feel pain in your chest when you do physical activity?
___	___	3. In the past month, have you had chest pain when you were not doing physical activity?
___	___	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
___	___	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
___	___	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
___	___	7. Do you know of *any other reason* why you should not do physical activity?

If you answered ⇒ **YES to one or more questions**

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

If you answered ⇒ **NO to all questions**

If you honestly answered NO to *all* PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active-begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in the fitness appraisal-this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

Delay becoming much more active:

- If you are not feeling well because of a temporary illness such as a cold or fever-wait until you feel better; or
- If you are or may be pregnant-talk with your doctor before you start becoming more active.

Please note:

If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

Note: If the PAR-Q is being given to a person before he or she participates in a physical activity program or fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

Name ______________________________ Date ________________

Signature ___________________________ Witness ______________

APPENDIX E

International Physical Activity Questionnaire – Short Form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

APPENDIX F

Mileage Questionnaire

Mileage Questionnaire

The following questions deal with vehicular travel over the study period. These questions apply to all travel in a motor vehicle, whether a driver or a passenger. For each of these questions please try and recall all travel (errands, routine trips, etc.) during the study period. Please record the mileage traveled on each day as accurately as possible.

1. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Friday?

   ____

2. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Saturday?

   ____

3. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Sunday?

   ____

4. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Monday?

   ____

5. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Tuesday?

   ____

6. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Wednesday?

   ____

7. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Thursday?

   ____

8. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Friday?

   ____

9. Approximately how many miles did you travel in a motor vehicle (car, bus, truck, motorcycle, etc.) on Saturday?

   ____

APPENDIX G

Participant Logs for Actigraph and Pedometer

ID_______________________

Pedometer Data Sheet

Date	Time On (a.m. / p.m.)	Time Off (a.m. / p.m)	Total Steps	Comments

**Don't forget to reset your pedometer at the end of each day
If you forget to wear the pedometer at any time during the day, please record this in the section labeled "comments**".

Actigraph Data Sheet

Date	Time On (a.m. / p.m.)	Time Off (a.m. / p.m.)	Work day? (Y / N) # of Hours Worked	Exercise day? (Y / N) Type & Duration	Sports day? (Y / N) Type & Duration	Comments

** If you forget to wear your Actigraph at anytime during the day, please record this in the Comments column.
** Please remember to remove your Actigraph while swimming or showering. It is important that the Actigraph does not get wet.
**If you remove your Actigraph to go swimming, or participate in some other type of water activity, please record the activity intensity and duration in the Comments column.

APPENDIX H

Informed Consent Form

INFORMED CONSENT FORM FOR RESEARCH BEING CONDUCTED UNDER THE AUSPICES OF THE UNIVERSITY OF OKLAHOMA-NORMAN CAMPUS

Project Title: Physical activity assessment in free-living adults
Principal Investigator: Timothy K. Behrens, M.Ed., Doctoral Candidate
Department of Health and Exercise Science

This is a research study. Research studies involve only individuals who choose to participate. Please take your time to make your decision. Discuss this with your family and friends. You are volunteering to take part in this study because you would like to learn more about your physical activity.

Why Is This Study Being Done?
The purpose of this study is to examine the validity of different methods of physical activity assessment among adults.

How Many People Will Take Part In The Study?
Approximately 125 adults will take part in this study.

Study Description
On your first visit to the Physical Activity Assessment Lab your height and weight will be assessed. In addition, you will complete several questionnaires, which should take approximately 30 minutes. During the study you will asked to wear an accelerometer and two pedometers. These devices are small, "pager-like" devices that you will wear during all waking hours for seven consecutive days. At the conclusion of the 7th day you will bring all equipment (accelerometer, pedometer, and log-sheets) to the lab and have your body composition measured by air-displacement plethysmography. This visit should take approximately 40 minutes.

When your body composition is assessed you will sit quietly in an "egg-shaped" machine called the BOD POD for 45 seconds while computerized pressure sensors determine the amount of air displaced (air-displacement plethysmography). The testing chamber has an "escape button" if you feel the need to terminate the test at any time. For part of the test, you will be asked to breathe normally through a hose (this measures lung volume). You will wear a swimsuit and soft nylon cap (supplied). The whole procedure takes approximately 35 minutes. This procedure is accepted as a standard research method.

All participants who complete the study will receive information regarding their physical activity, caloric expenditure during physical activity, and body composition.

How Long Will I Be In The Study?
You will be in the study for 9 days. You can stop participating in this study at any time. Please notify the researcher if you decide to stop your participation in the study.

What Are The Risks of The Study?
No foreseeable risks, beyond those present in routine daily life, are anticipated in this study.

Are There Benefits to Taking Part in The Study?
This project will provide information regarding physical activity measurement among adults. In addition, participants completing the study will receive information regarding their physical activity, caloric expenditure during physical activity, and body composition.

Page 1 of 2

What Other Options Are There?
Your alternative is to not participate in this study.

What About Confidentiality?
Efforts will be made to keep your personal information confidential. You will not be identifiable by name or description in any reports or publications about this study. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. You will be asked to sign a separate authorization form for use or sharing of your protected health information.

The OU Institutional Review Board may inspect and/or copy your research records for quality assurance and data analysis.

What Are the Costs?
The cost of the study will be the responsibility of researchers and no cost will be passed onto any of the participants.

Will I Be Paid For Participating in This Study?
Participants who complete the study will receive information about their physical activity patterns, caloric expenditure during physical activity, and body composition at the end of the study.

What are My Rights As a Participant?
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. If you agree to take part and then decide against it, you can withdraw for any reason. Leaving the study will not result in any penalty to you.

Whom Do I Call If I have Questions or Problems?
If you have questions about the study or have a research-related injury, contact Timothy K. Behrens at 325-5211, tkbehrens@ou.edu, with questions about the study. For inquires about rights as a research participant, contact the University of Oklahoma-Norman Campus Institutional Review Board (OU-NC IRB) at 405/325-8110 or irb@ou.edu.

Signature:
By signing this form, you are agreeing to participate in this research study under the conditions described. You have not given up any of your legal rights or released any individual or institution from liability for negligence. You have been given an opportunity to ask questions. You will be given a copy of this consent document.

I agree to participate in this study:

Research Subject: ______________________________ Date: ____________________

Subject's Printed Name: __________________________

Witness: ______________________________________ Date: ____________________

Person Obtaining
Informed Consent: ______________________________ Date: ____________________

Principal Investigator: ___________________________ Date: ____________________

Page 2 of 2

APPENDIX I

HIPPA Form

IRB No.:FY2004-409

AUTHORIZATION TO USE or DISCLOSE PROTECTED HEALTH INFORMATION FOR RESEARCH

Title of Research Project: Physical activity assessment in free-living adults

Leader of Research Team: Timothy K. Behrens, M.Ed.

Address: Department of Health and Sport Sciences, 111 Huston Huffman Center, Norman, OK 73019

Phone Number: 405-325-5211

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Privacy Official
University of Oklahoma
660 Parrington Oval, Room 318 Evans Hall, Norman, OK 73019
If you have questions call: (405) 271-2511 or e-mail: ou-privacy@ouhsc.edu

Giving Permission. By signing this form, you give OU and OU's researchers led by Timothy K. Behrens, permission to share your private information for the research project called Reactivity in Objectively Measured Physical Activity.

Subject Name:________________________________

________________________________ Date ______________
Signature of Subject

Or

________________________________ Date ______________
Signature of Legal Representative**

**If signed by a Legal Representative of the Subject, provide a description of the relationship to the Subject and the Authority to Act as Legal Representative:

____
OU may ask you to produce evidence of your relationship.

A signed copy of this form must be given to the Subject or the Legal Representative at the time this signed form is provided to the researcher or his representative.

IRB No.: FY2004-409

APPROVED
JUL 29 2004
OU-NC IRB

APPENDIX L

Institutional Review Board – Norman Campus Approval

The University of Oklahoma

OFFICE OF HUMAN RESEARCH PARTICIPANT PROTECTION

July 29, 2004

Mr. Timothy K. Behrens
902 Hardin Dr.
111 Huston Huffman Center
Norman, OK. 73072

Dear Mr. Behrens:

Your research application, "Physical activity assessment in free-living adults," has been reviewed according to the policies of the Institutional Review Board and found to be exempt from the requirements for full board review. Your project is approved under the regulations of the University of Oklahoma - Norman campus Policies and Procedures for the Protection of Human Subjects in Research Activities.

Should you wish to deviate from the described protocol, you must notify this office, in writing, noting any changes or revisions in the protocol and/or informed consent document, and obtain prior approval. Changes may include but are not limited to adding data collection sites, adding or removing investigators, revising the research protocol, and changing the subject selection criteria. A copy of the approved informed consent document(s) is attached for your use.

Should you have any questions, please contact me at 325-8110 or irb@ou.edu.

Cordially,

Grayson Noley, Ph.D.
Vice Chair
Institutional Review Board – Norman Campus (FWA #00003191)

FY2004-409

cc: Dr. Mary K. Dinger, Health & Exercise Science

660 Parrington Oval, Suite 316, Norman, Oklahoma 73019-3085 PHONE: (405) 325-8110 FAX: (405) 325-2373

APPENDIX L

Data

id	pedmean	PEDid	group	monday	sunday	tuesday	wednesday	thursday	friday	saturday	minctwk	totctwk	mlttot
A12593	8041.4	AP12593	11.0	7491.0	12069.0	13539.0	10409.0	14227.0	10668.0	7758.0	424.1	410813.7	127.4
A12595	6357.3	AP12595	11.0	14010.0	9868.0	6873.0	12414.0	7053.0	16682.0	12851.0	336.3	328584.1	109.3
A12608	4481.6	AP12608	11.0	12018.0	4510.0	6083.0		9520.0	14089.0	5656.0	330.0	283833.0	142.8
A13728	6377.3	AP13728	11.0	18498.0	9328.0	10966.0	10589.0	15177.0	13575.0	10664.0	339.1	406938.1	255.1
B12612	6181.1	BP12612	12.0	10427.0	9000.0	15580.0	11498.0	8675.0	10871.0	6569.0	243.0	260368.7	129.7
B13782	7030.6	BP13782	12.0	8103.0	11181.0	9732.0	9321.0	5201.0	12810.0	17972.0	326.3	299278.1	159.4
B13790	8068.3	BP13790	12.0	16102.0	8357.0	11629.0	13829.0	9943.0	8397.0	8247.0	282.7	278703.3	125.6
C13733	10033.7	CP13733	13.0	14427.0	11528.0	13481.0	13081.0	14106.0	5252.0	9582.0	330.5	308777.1	106.7
C13784	9087.7	CP13784	13.0	7427.0	12877.0	9770.0	11647.0	6471.0	6523.0	10820.0	407.8	370544.3	117.7
C13788	5764.1	CP13788	13.0	4259.0	11043.0	8701.0	10016.0	7268.0	8601.0	13066.0	237.4	221783.6	106.4
C13792	7461.7	CP13792	13.0	5831.0	7530.0	10450.0	7153.0	9448.0	11028.0	11147.0	271.0	269488.9	117.3
C13793	14999.3	CP13793	13.0	14089.0	7164.0	16594.0	32590.0	14367.0	24585.0	10881.0	536.0	574293.6	132.1
C13797	6875.9	CP13797	13.0	9795.0	16256.0	12556.0	6780.0	10615.0	8956.0	5125.0	361.9	366053.4	134.4
D12570	9699.0	DP12570	21.0	14985.0	22146.0	20409.0	7684.0	14808.0	16485.0	20777.0	374.1	391252.3	247.9
D12606	10805.9	DP12606	21.0	12227.0	16450.0	12661.0	13673.0	11104.0	12747.0	16560.0	564.8	571282.6	134.1
D12615	6388.0	DP12615	21.0	9577.0	11851.0	8517.0	7980.0	11363.0	6697.0	10174.0	259.3	280059.3	167.6
D13781	6439.1	DP13781	21.0	9832.0	9742.0	10136.0	7516.0	10792.0	14422.0	9014.0	311.9	299390.7	116.9
D13787	14748.6	DP13787	21.0	18529.0	15959.0	18232.0	12776.0	21289.0	16747.0	11531.0	550.7	538125.9	177.3
D13791	7442.3	DP13791	21.0	6393.0	12100.0	7671.0	7797.0	6980.0	10628.0	5642.0	317.4	321019.6	72.1
D13793	10229.7	DP13793	21.0	10421.0	17597.0	10609.0	13145.0	11842.0	10152.0	14401.0	458.9	452356.0	225.0
E12611	15277.9	EP12611	22.0	18601.0	17557.0	18444.0	18156.0	16049.0	27030.0	19815.0	782.3	663843.0	321.0
E13797	9610.4	EP13797	22.0	7962.0	10937.0	9777.0	14056.0	8628.0	11454.0	12095.0	309.3	307550.0	139.0
F12596	7512.0	FP12596	31.0	11686.0	8284.0	8326.0	6966.0	9380.0	10641.0	12447.0	343.1	308748.0	146.3
F12603	8705.6	FP12603	31.0	14747.0	7095.0	10795.0	14582.0	9014.0	13441.0	8314.0	424.7	425949.9	126.4
F12615	5482.9	FP12615	31.0	3113.0	5144.0	6212.0	6343.0	4911.0	11176.0	13649.0	215.3	193800.4	56.9
F13783	13506.3	FP13783	31.0	18431.0	15077.0	19006.0		19249.0	20215.0	13978.0	587.4	587427.8	233.0
F13788	11604.3	FP13788	31.0	10693.0	11486.0	10382.0	15393.0	7663.0	11490.0	16662.0	279.2	284828.7	150.4
G12610	6134.9	GP12610	32.0	8538.0	7772.0	9039.0	8596.0	7606.0	8171.0	8365.0	262.7	263478.0	95.6
G13784	12214.0	GP13784	32.0	12512.0	8013.0	17274.0	9331.0	12678.0	13754.0	16583.0	599.6	570513.7	105.7
A12568	5272.0	AP12568	11.0	5559.0		2664.0	9862.0	4417.0	4569.0	9231.0	211.8	186950.1	76.1
A12569	7862.9	AP12569	11.0	9480.0	15678.0	15008.0	11097.0	8653.0	6948.0	11496.0	323.6	332850.6	112.1
A12596	12091.3	AP12596	11.0	18812.0	11423.0	8435.0	21494.0	7909.0	18996.0	8304.0	595.6	571730.7	108.3
A12597	9851.7	AP12597	11.0	17859.0	8467.0	9462.0	9532.0	8900.0	16056.0	24229.0	366.5	376956.9	127.0
A12603	12008.0	AP12603	11.0	12848.0	11690.0	13283.0	13921.0	12507.0	13467.0	8227.0	391.6	355753.7	136.4
A12605	11625.0	AP12605	11.0	10380.0	17905.0	15882.0	8352.0	17794.0	18808.0	20558.0	494.2	487177.6	123.1
A12607	8829.4	AP12607	11.0	8988.0	9132.0	10402.0	10041.0	12492.0	15824.0	12650.0	321.3	280948.6	111.4
A12609	12629.3	AP12609	11.0	14467.0	16089.0	17084.0	15266.0	16344.0	9428.0	15451.0	311.1	309316.1	136.9
A12615	8438.0	AP12615	11.0	10179.0	10339.0	9809.0	9400.0	10284.0	10760.0		258.0	255400.8	113.8
A13739	12543.3	AP13739	11.0	11244.0	18133.0	13195.0	18720.0	17789.0	11091.0	4188.0	386.1	373950.7	93.6
A13740	8509.7	AP13740	11.0	14704.0		15364.0	9246.0	5865.0	8340.0		278.3	280569.6	76.0
A13783	8757.0	AP13783	11.0	9754.0	6846.0	11413.0	9651.0	11268.0	8475.0	13189.0	256.9	248800.9	123.1
A13785	5052.0	AP13785	11.0	5669.0	7033.0	7687.0	7075.0	5966.0	8940.0	7950.0	204.0	204569.0	103.6
A13791	9836.7	AP13791	11.0	11584.0	12364.0	7388.0	10634.0	8650.0	9837.0	17402.0	273.1	262150.4	114.4
B12599	14148.9	BP12599	12.0	17556.0	10489.0	12003.0	19006.0	12660.0	14330.0	21731.0	482.1	487620.1	138.6
B12604	8496.9	BP12604	12.0	4803.0	11053.0	12221.0	14137.0	12130.0	17034.0	11927.0	286.1	272191.6	150.4
B12606	12558.6	BP12606	12.0	13078.0	19346.0	12762.0	14159.0	15838.0	15207.0	16392.0	729.3	693858.1	101.7
B12611	12208.4	BP12611	12.0	7074.0	18172.0	12498.0	14242.0	11178.0	8451.0	13638.0	323.7	324607.6	172.4
B12614	9506.7	BP12614	12.0	14103.0	14287.0	12399.0	10522.0	9912.0	10564.0	16482.0	593.3	564522.4	112.4
B12616	7177.0	BP12616	12.0	7597.0	9072.0	6455.0	11500.0	4235.0	8281.0	8706.0	235.8	216271.9	92.1
B13787	8815.1	BP13787	12.0	9119.0	9343.0	9338.0	8131.0	12259.0	6234.0	14990.0	293.5	279269.0	84.9
C12567	7373.6	CP12567	13.0	11960.0	16408.0	12181.0	12534.0	12258.0	11117.0	12239.0	385.7	363701.3	258.6
C12591	6820.3	CP12591	13.0	7472.0	7939.0	11709.0	6740.0	11267.0	9498.0	9423.0	244.7	232854.4	105.0
C12592	9602.7	CP12592	13.0	13802.0	11672.0	15060.0	15167.0	8053.0	10155.0	12460.0	299.4	300215.6	87.3
C13781	11048.7	CP13781	13.0	12760.0	13091.0	13309.0	14975.0	10128.0	14997.0	9953.0	454.7	491043.3	148.4
C13786	12079.0	CP13786	13.0	10889.0	10236.0	14767.0	13714.0	10666.0	10327.0	10594.0	393.3	357298.1	138.3
D12567	13310.9	DP12567	21.0	14073.0	12281.0	13682.0	15100.0	10253.0	14817.0	18660.0	363.0	357771.3	165.6
D12591	1104.1	DP12591	21.0	4806.0	4321.0			4814.0	7065.0	6758.0	170.0	163219.8	97.6
D12594	11086.4	DP12594	21.0	16184.0	10959.0	4992.0	12129.0	6649.0	7485.0	11805.0	293.4	316907.4	128.9
D12596	5569.6	DP12596	21.0	3683.0	2832.0	4699.0	8625.0	7264.0	9202.0	5963.0	209.5	168810.4	90.4
D12599	9767.7	DP12599	21.0	8101.0		12828.0	10875.0	12133.0	16315.0	10770.0	396.8	384930.3	169.7
D12603	7866.9	DP12603	21.0	8879.0	8511.0	9537.0	13570.0	7052.0	8987.0	9115.0	299.4	292598.1	138.9
D12608	4366.4	DP12608	21.0	8711.0	5358.0	3062.0	6492.0	6304.0	5192.0	9080.0	214.2	205642.3	98.4
D12609	13852.7	DP12609	21.0	8024.0	21595.0	12131.0	8999.0	14689.0	13712.0	30064.0	409.5	410664.3	126.3
D12610	6679.7	DP12610	21.0	8565.0	14780.0	9092.0	11491.0	7139.0	7378.0		312.1	324631.7	207.8
D12616	3120.3	DP12616	21.0	6640.0	8650.0	9829.0	4592.0	7384.0	3977.0	4192.0	315.9	316848.0	186.3
D13738	9637.9	DP13738	21.0	11295.0	11363.0	9995.0	14002.0	14335.0	9679.0	7583.0	402.6	365761.3	101.1
D13740	14469.6	DP13740	21.0	15389.0	8524.0	17922.0	22578.0	20886.0	13056.0	18592.0	494.8	564052.7	211.7
D13784	13542.3	DP13784	21.0	11001.0		10780.0	25591.0	10144.0	16898.0	11964.0	591.2	532036.7	146.5
D13786	9478.1	DP13786	21.0	9519.0	16310.0	10207.0	9404.0	7413.0	12706.0	10524.0	298.8	279133.9	113.4
D13788	8500.7	DP13788	21.0	7130.0	11409.0	14003.0	5348.0	12640.0	9563.0	12288.0	314.8	291416.6	103.3
D13790	2732.1	DP13790	21.0		9390.0	6475.0	4541.0	5133.0	9161.0	7823.0	192.8	198558.3	99.7
D13792	9757.3	DP13792	21.0	13161.0		15737.0	8036.0	13961.0	9764.0		334.8	309370.6	97.4
E12593	14555.0	EP12593	22.0	10909.0	12684.0	18568.0	11546.0	17676.0	13466.0	16988.0	408.8	364402.3	114.9
E12595	2543.6	EP12595	22.0	10529.0	7264.0	8560.0	7776.0	9919.0	10533.0	6853.0	229.1	229771.6	146.7
F12595	5904.0	FP12595	31.0		5909.0	9482.0	8652.0	10702.0	13432.0	11650.0	286.0	248805.2	150.2
F12602	14059.3	FP12602	31.0	15322.0	8952.0	17993.0	16362.0	15494.0	16356.0	13995.0	532.0	497000.6	75.7
F12605	5058.9	FP12605	31.0	9398.0		9168.0	9528.0	12672.0	12978.0	6502.0	245.1	225482.0	123.2
F12609	5370.9	FP12609	31.0	8993.0	8143.0	6353.0	6535.0	6192.0	9363.0	8319.0	198.1	186816.0	119.4
F12616	7983.7	FP12616	31.0	12927.0	13213.0	5928.0	10193.0	8755.0	12446.0		354.1	332900.5	97.8
F13738	9787.6	FP13738	31.0	18358.0		4592.0	21119.0	5023.0	14228.0		415.6	374053.0	73.8
F13740	6980.3	FP13740	31.0	12605.0	5591.0	10329.0	10112.0	9120.0	10195.0	9627.0	316.1	311554.0	125.6
F13789	7525.9	FP13789	31.0	10690.0	5750.0	8469.0	10040.0	6451.0	7483.0	7644.0	261.8	249059.4	96.3
F13791	5830.9	FP13791	31.0	7897.0	5994.0	4671.0	5779.0	5228.0	4821.0	6825.0	144.4	122531.9	63.3
F13797	5993.7	FP13797	31.0	6029.0	9463.0	5696.0	9955.0	6988.0	7893.0	8436.0	186.7	180870.1	91.1
G12599	16418.1	GP12599	32.0	24330.0	9948.0	14721.0	17336.0	18916.0	16164.0	15910.0	453.3	458503.9	209.0
G12601	8574.9	GP12601	32.0	6414.0	14113.0	9750.0	5747.0	7538.0	8252.0	12833.0	217.6	212618.4	104.6
G12608	8373.0	GP12608	32.0	10824.0	10182.0	10203.0	9074.0	8028.0	9765.0	9586.0	271.5	251328.6	140.7
G13785	6211.6	GP13785	32.0	5725.0	9186.0	6691.0	6052.0	5128.0	6459.0	16393.0	218.8	206274.4	100.3
G13792	9214.0	GP13792	32.0	10950.0	14443.0	10219.0	12158.0	8196.0	11279.0	13985.0	299.6	285076.0	120.4

mmodtot	mhardtot	minactot	COHORT	AGE	SEX	RACE	EDU	EMPLOY	OCCUP	INCOME	Q1A	Q2A	Q3A
47.4	11.6	782.1	11.0	51.0	1.0	6.0	7.0	1.0	5.0	8.0	2.0	60.0	3.0
36.7	6.1	825.0	11.0	47.0	1.0	6.0	7.0	1.0	10.0	8.0	3.0	75.0	0.0
35.0	0.0	682.2	11.0	43.0	1.0	6.0	6.0	1.0	3.0	7.0	3.0	120.0	3.0
28.0	0.3	916.6	11.0	45.0	1.0	3.0	6.0	1.0	8.0	6.0	4.0	120.0	4.0
22.6	0.0	919.1	12.0	48.0	1.0	6.0	6.0	1.0		7.0	0.0	0.0	5.0
32.6	0.6	724.6	12.0	36.0	1.0	6.0	6.0	1.0	5.0	4.0	4.0	75.0	3.0
34.3	0.0	825.9	12.0	44.0	1.0	6.0	7.0	1.0	5.0	8.0	1.0	60.0	0.0
47.0	0.1	780.4	13.0	33.0	1.0	6.0	7.0	1.0	12.0	7.0	0.0	0.0	2.0
33.9	11.0	746.0	13.0	26.0	1.0	6.0	6.0	1.0	19.0	7.0	4.0	30.0	0.0
27.7	0.0	800.1	13.0	52.0	1.0	6.0	6.0	1.0	10.0	8.0	2.0	30.0	2.0
26.9	2.1	848.0	13.0	25.0	1.0	6.0	7.0	6.0	9.0	7.0	0.0	0.0	2.0
67.6	14.0	857.7	13.0	31.0	1.0	6.0	5.0	1.0	10.0	7.0	4.0	45.0	0.0
43.1	5.6	828.3	13.0	31.0	1.0	6.0	6.0	1.0	19.0	7.0	2.0	45.0	0.0
27.9	0.0	770.0	21.0	48.0	1.0	6.0	6.0	1.0	10.0	7.0	0.0	0.0	3.0
55.1	26.1	796.0	21.0	49.0	1.0	6.0	7.0	1.0	5.0	8.0	4.0	60.0	5.0
18.0	0.1	894.3	21.0	38.0	1.0	6.0	7.0	1.0	5.0	8.0	0.0	0.0	0.0
39.0	0.0	804.1	21.0	60.0	1.0	2.0	7.0	1.0	5.0	8.0	0.0	0.0	5.0
68.9	10.6	720.4	21.0	27.0	1.0	6.0	7.0	1.0	3.0	5.0	3.0	60.0	3.0
32.6	11.9	894.9	21.0	37.0	1.0	6.0	7.0	1.0	3.0	6.0	5.0	15.0	5.0
59.0	0.1	701.6	21.0	41.0	1.0	6.0	7.0	1.0	5.0	6.0	0.0	0.0	0.0
88.4	3.7	435.4	22.0	38.0	1.0	6.0	5.0	1.0	12.0	8.0	4.0	30.0	4.0
30.4	2.1	822.7	22.0	33.0	1.0	6.0	7.0	1.0	3.0	7.0	0.0	0.0	0.0
34.9	0.0	718.9	31.0	42.0	1.0	6.0	7.0	1.0	5.0	8.0	2.0	30.0	2.0
47.7	10.9	817.9	31.0	30.0	1.0	1.0	5.0	6.0	9.0	5.0	2.0	45.0	1.0
30.9	0.0	812.3	31.0	25.0	1.0	6.0	7.0	6.0	9.0	3.0	2.0	60.0	5.0
62.2	10.2	694.7	31.0	27.0	1.0	6.0	6.0	1.0	27.0	5.0	5.0	30.0	1.0
15.9	2.9	850.9	31.0	28.0	1.0	6.0	6.0	1.0	26.0	5.0	0.0	0.0	1.0
31.3	1.1	874.9	32.0	33.0	1.0	6.0	7.0	1.0	5.0	7.0	0.0	0.0	2.0
41.4	38.1	766.1	32.0	33.0	1.0	6.0	7.0	6.0	9.0	3.0	4.0	90.0	3.0
22.4	0.0	784.3	11.0	38.0	2.0	6.0	5.0	1.0	11.0	7.0	1.0	10.0	1.0
40.9	2.3	873.3	11.0	41.0	2.0	6.0	7.0	1.0	2.0	8.0	1.0	60.0	1.0
44.7	27.0	780.0	11.0	33.0	2.0	6.0	7.0	1.0	5.0	8.0	3.0	90.0	0.0
52.7	0.1	848.7	11.0	43.0	2.0	7.0	5.0	1.0	13.0	5.0	0.0	0.0	0.0
41.1	5.1	725.9	11.0	31.0	2.0	7.0	7.0	1.0	5.0	6.0	2.0	30.0	2.0
36.0	22.4	804.1	11.0	49.0	2.0	6.0	7.0	1.0	5.0	7.0	5.0	60.0	0.0
26.4	3.0	733.4	11.0	35.0	2.0	6.0	7.0	1.0	7.0	7.0	3.0	60.0	0.0
28.9	2.0	826.6	11.0	49.0	2.0	6.0	6.0	1.0	14.0	5.0	3.0	30.0	4.0
29.2	0.0	847.0	11.0	37.0	2.0	6.0	7.0	1.0	1.0	8.0	3.0	30.0	2.0
66.7	2.0	806.3	11.0	51.0	2.0	6.0	7.0	1.0	3.0	8.0	1.0	45.0	0.0
49.2	0.0	882.8	11.0	50.0	2.0	1.0	6.0	1.0	5.0	4.0	0.0	0.0	2.0
29.1	0.0	816.3	11.0	43.0	2.0	6.0	5.0	2.0	6.0	7.0	0.0	0.0	6.0
21.7	0.0	877.6	11.0	25.0	2.0	6.0	6.0	6.0	9.0	7.0	1.0	35.0	2.0
26.9	0.1	818.6	11.0	37.0	2.0	2.0	7.0	1.0	2.0	8.0	1.0	15.0	1.0
25.6	25.6	821.7	12.0	35.0	2.0	6.0	7.0	1.0	5.0	8.0	4.0	45.0	7.0
21.7	0.0	779.3	12.0	54.0	2.0	6.0	7.0	1.0	1.0	6.0	5.0	40.0	1.0
35.1	32.6	782.0	12.0	41.0	2.0	6.0	7.0	1.0	5.0	8.0	7.0	30.0	4.0
26.0	3.4	801.0	12.0	42.0	2.0	6.0	6.0	1.0	13.0	8.0	0.0	0.0	4.0
51.7	33.3	754.0	12.0	51.0	2.0	7.0	7.0	1.0	1.0	8.0	0.0	0.0	3.0
32.7	0.0	792.3	12.0	28.0	2.0	6.0	7.0	6.0	9.0		0.0	0.0	3.0
42.0	1.4	823.1	12.0	60.0	2.0	6.0	7.0	1.0	17.0	8.0	3.0	60.0	1.0
16.6	0.0	667.7	13.0	42.0	2.0	6.0	7.0	1.0	1.0	8.0	2.0	60.0	7.0
23.1	0.0	823.3	13.0	25.0	2.0	6.0	6.0	1.0	18.0	7.0	0.0	0.0	2.0
41.1	0.7	873.7	13.0	51.0	2.0	6.0	6.0	1.0	14.0	8.0	1.0	25.0	1.0
30.7	14.1	886.7	13.0	30.0	2.0	4.0	5.0	1.0		7.0	3.0	45.0	0.0
17.7	14.6	738.0	13.0	25.0	2.0	6.0	6.0	1.0	20.0	7.0	5.0	30.0	0.0
35.3	0.9	784.0	21.0	39.0	2.0	6.0	6.0	1.0	18.0	8.0	4.0	30.0	7.0
5.2	0.0	857.2	21.0	59.0	2.0	6.0	4.0	1.0	14.0	5.0	0.0	0.0	0.0
11.3	10.9	929.0	21.0	49.0	2.0	6.0	6.0	1.0	17.0	8.0	5.0	30.0	5.0
13.4	0.0	701.9	21.0	30.0	2.0	6.0	5.0	6.0	9.0	6.0	3.0	90.0	3.0
51.2	0.2	749.0	12.0	49.0	2.0	6.0	7.0	1.0	20.0	8.0	1.0	30.0	0.0
37.4	0.0	800.9	21.0	30.0	2.0	6.0	7.0	1.0	5.0	7.0	0.0	0.0	4.0
18.4	0.9	842.3	21.0	33.0	2.0	6.0	7.0	1.0	22.0	7.0	2.0	50.0	0.0
75.6	0.0	801.0	21.0	46.0	2.0	6.0	7.0	1.0	5.0	8.0	0.0	0.0	0.0
18.7	0.2	813.3	21.0	39.0	2.0	2.0	7.0	1.0	5.0	9.0	0.0	0.0	3.0
27.9	0.0	788.7	21.0	25.0	2.0	6.0	6.0	6.0	9.0	7.0	1.0	60.0	3.0
39.3	10.0	758.1	21.0	27.0	2.0	6.0	6.0	6.0	9.0	6.0	0.0	0.0	0.0
71.6	4.7	852.0	21.0	27.0	2.0	6.0	7.0	6.0	5.0	2.0	3.0	90.0	7.0
45.7	17.7	690.2	21.0	39.0	2.0	6.0	6.0	1.0	12.0	8.0	4.0	45.0	0.0
34.1	0.0	786.7	21.0	31.0	2.0	6.0	7.0	1.0	3.0	6.0	2.0	20.0	3.0
35.9	1.1	785.4	21.0	50.0	2.0	6.0	7.0	1.0	17.0	7.0	6.0	30.0	3.0
21.0	0.5	908.8	21.0	39.0	2.0	6.0	6.0	1.0	12.0	6.0	1.0	120.0	1.0
34.6	4.6	787.4	21.0	25.0	2.0	6.0	7.0	1.0	3.0	4.0	3.0	60.0	0.0
62.3	0.0	714.3	22.0	50.0	2.0	6.0	7.0	1.0	5.0	6.0	1.0	120.0	3.0
10.6	0.0	845.6	22.0	55.0	2.0	6.0	5.0	1.0	14.0	6.0	3.0	45.0	1.0
18.7	0.0	701.2	31.0	58.0	2.0	6.0	7.0	1.0	25.0	6.0	0.0	0.0	0.0
61.4	19.1	778.0	31.0	33.0	2.0	6.0	7.0	1.0	5.0	6.0	2.0	60.0	4.0
14.7	0.0	782.2	31.0	55.0	2.0	6.0	6.0	1.0	13.0	6.0	0.0	0.0	0.0
8.0	0.1	815.3	31.0	36.0	2.0	2.0	7.0	1.0	12.0	8.0	0.0	0.0	7.0
43.5	8.2	790.5	31.0	29.0	2.0	1.0	7.0	1.0	5.0	4.0	2.0	120.0	5.0
49.8	8.2	768.2	31.0	52.0	2.0	7.0	7.0	1.0	17.0	8.0	3.0	50.0	0.0
40.3	0.4	819.4	31.0	25.0	2.0	1.0	6.0	6.0	9.0	6.0	0.0	0.0	0.0
22.1	2.9	830.1	31.0	25.0	2.0	1.0	6.0	1.0	21.0	5.0	4.0	30.0	0.0
12.4	0.0	772.9	31.0	38.0	2.0	2.0	7.0	1.0	12.0	8.0	0.0	0.0	1.0
14.6	0.4	862.4	31.0	28.0	2.0	6.0	6.0	1.0	12.0	6.0	0.0	0.0	0.0
51.1	1.3	750.0	32.0	34.0	2.0	6.0	7.0	5.0	28.0	8.0	2.0	60.0	2.0
23.6	0.0	849.0	32.0	59.0	2.0	6.0	7.0	1.0	2.0	8.0	0.0	0.0	0.0
21.0	0.0	764.0	32.0	57.0	2.0	6.0	7.0	1.0	5.0	5.0	0.0	0.0	0.0
12.3	2.1	828.1	32.0	36.0	2.0	6.0	7.0	1.0	5.0	7.0	0.0	0.0	0.0
20.0	4.3	806.7	32.0	51.0	2.0	6.0	6.0	1.0	17.0	8.0	0.0	0.0	2.0

Q4A	Q5A	Q6A	Q7A	Q1B	Q2B	Q3B	Q4B	Q5B	Q6B	Q7B	STEPD1	STEPD2	STEPD3
60.0	1.0	60.0	420.0	2.0	65.0	4.0	60.0	1.0	30.0	420.0	5496.0	10024.0	9930.0
0.0	2.0	40.0	600.0	2.0	80.0	0.0	0.0	2.0	70.0	480.0	1340.0	3706.0	5802.0
30.0	7.0	20.0	300.0	0.0	0.0	4.0	120.0	5.0	90.0	300.0	6741.0	6696.0	10786.0
120.0	6.0	120.0	360.0	5.0	120.0	3.0	120.0	7.0	45.0	480.0	2730.0	7010.0	7034.0
30.0	6.0	20.0	600.0	0.0	0.0	5.0	30.0	5.0	60.0	780.0	2207.0	5688.0	3981.0
10.0	5.0	20.0	480.0	3.0	70.0	4.0	60.0	3.0	10.0	360.0	5103.0	7085.0	12519.0
0.0	6.0	40.0	660.0	1.0	60.0	0.0	0.0	5.0	30.0	540.0	9851.0	7165.0	2524.0
25.0	7.0	45.0	360.0	0.0	0.0	3.0	20.0	5.0	20.0	390.0	2336.0	9482.0	10232.0
0.0	0.0	0.0	720.0	4.0	35.0	1.0	60.0	0.0	0.0	720.0	851.0	10431.0	12760.0
60.0	3.0	30.0	360.0	0.0	0.0	0.0	0.0	5.0	10.0	300.0	1255.0	7421.0	3191.0
45.0	2.0	45.0	600.0	1.0	45.0	0.0	0.0	2.0	45.0	720.0	651.0	9713.0	5816.0
0.0	5.0	30.0	840.0	4.0	43.0	0.0	0.0	3.0	30.0	660.0	598.0	10552.0	7393.0
0.0	0.0	0.0	180.0	5.0	60.0	2.0	10.0	0.0	0.0	420.0	275.0	2627.0	9049.0
20.0	3.0	120.0	780.0	3.0	25.0	5.0	10.0	6.0	120.0	780.0	7768.0	9032.0	11082.0
60.0	7.0	60.0	300.0	2.0	60.0	2.0	60.0	6.0	45.0	360.0	9212.0	7421.0	10481.0
0.0	3.0	60.0	840.0	0.0	0.0	0.0	0.0	2.0	30.0	840.0	3135.0	7152.0	5084.0
50.0	7.0	120.0	480.0	0.0	0.0	3.0	45.0	7.0	45.0	360.0	3435.0	7119.0	8627.0
60.0	0.0	0.0	180.0	3.0	30.0	1.0	60.0	4.0	60.0	180.0	1418.0	20275.0	15050.0
20.0	7.0	60.0	360.0	5.0	20.0	5.0	15.0	5.0	60.0	420.0	3721.0	6253.0	13467.0
0.0	4.0	30.0	420.0	4.0	120.0	0.0	0.0	5.0	45.0	300.0	4636.0	7915.0	7228.0
120.0	7.0	120.0	180.0	4.0	60.0	7.0	120.0	7.0	120.0	300.0	22541.0	20171.0	13322.0
0.0	5.0	45.0	600.0	0.0	0.0	0.0	0.0	4.0	30.0	600.0	10986.0	11042.0	9851.0
60.0	3.0	15.0	240.0	7.0	120.0	7.0	120.0	7.0	30.0	240.0	7599.0	7929.0	8540.0
45.0	5.0	40.0	420.0	1.0	45.0	1.0	45.0	5.0	10.0	420.0	777.0	6813.0	11348.0
45.0	4.0	20.0	360.0	1.0	90.0	3.0	40.0	7.0	20.0	720.0	4903.0	7603.0	10977.0
30.0	7.0	120.0	480.0	2.0	30.0	4.0	60.0	7.0	120.0	300.0	1174.0	15969.0	14848.0
10.0	1.0	10.0	420.0	2.0	20.0	2.0	10.0	5.0	30.0	480.0	3600.0	7604.0	10682.0
60.0	1.0	60.0	360.0	0.0	0.0	7.0	15.0	3.0	45.0	360.0	4365.0	4438.0	6491.0
20.0	7.0	25.0	300.0	4.0	90.0	5.0	20.0	7.0	25.0	420.0	21485.0	11487.0	16262.0
30.0	3.0	30.0	660.0	1.0	15.0	3.0	25.0	3.0	40.0	760.0	6185.0	3715.0	3552.0
120.0	7.0	120.0	540.0	0.0	0.0	2.0	60.0	7.0	120.0	600.0	9649.0	7406.0	5393.0
0.0	1.0	120.0	360.0	3.0	60.0	1.0	90.0	0.0	0.0	540.0	15855.0	6893.0	18218.0
0.0	4.0	40.0	960.0	0.0	0.0	0.0	0.0	7.0	60.0	900.0	2517.0	2733.0	13030.0
60.0	3.0	30.0	360.0	3.0	20.0	3.0	35.0	4.0	30.0	480.0	10187.0	11876.0	12880.0
0.0	0.0	0.0	840.0	5.0	60.0	0.0	0.0	0.0	0.0	840.0	2444.0	14544.0	15521.0
0.0	1.0	120.0	300.0	2.0	60.0	0.0	0.0	1.0	120.0	360.0	7630.0	11049.0	13235.0
60.0	7.0	120.0	420.0	5.0	60.0	3.0	60.0	0.0	0.0	360.0	8304.0	14919.0	6956.0
10.0	2.0	15.0	780.0	4.0	25.0	4.0	20.0	3.0	15.0	780.0	9766.0	8947.0	8732.0
0.0	6.0	45.0	720.0	2.0	60.0	2.0	90.0	5.0	60.0	720.0	6977.0	15600.0	9508.0
30.0	4.0	30.0		0.0	0.0	7.0	60.0	7.0	120.0	420.0	3158.0	5004.0	7160.0
40.0	5.0	15.0	450.0	0.0	0.0	6.0	45.0	6.0	15.0	480.0	4551.0	10606.0	6391.0
30.0	3.0	30.0	720.0	0.0	0.0	0.0	0.0	2.0	15.0	900.0	4778.0	4106.0	7173.0
15.0	5.0	30.0	600.0	0.0	0.0	0.0	0.0	7.0	60.0	540.0	14361.0	7754.0	7217.0
120.0	7.0	20.0	480.0	4.0	40.0	0.0	0.0	5.0	20.0	360.0	4820.0	13632.0	21664.0
75.0	3.0	60.0	300.0	5.0	45.0	2.0	30.0	4.0	30.0	360.0	9038.0	12952.0	6486.0
120.0	4.0	10.0	240.0	7.0	30.0	1.0	120.0	4.0	20.0	240.0	1093.0	13274.0	13477.0
40.0	7.0					3.0	35.0	7.0	10.0	420.0	8537.0	8676.0	13215.0
30.0	6.0	30.0	600.0	1.0	20.0	2.0	60.0	5.0	30.0	660.0	12458.0	7244.0	13968.0
30.0	6.0	60.0	600.0	0.0	0.0	3.0	20.0	5.0	50.0	600.0	7673.0	7656.0	8207.0
30.0	4.0	60.0	240.0	3.0	60.0	2.0	20.0	2.0	30.0	300.0	760.0	4737.0	14926.0
120.0	1.0	30.0	240.0	1.0	90.0	7.0	120.0	5.0	60.0	240.0	2431.0	5704.0	9707.0
45.0	2.0	30.0	720.0	0.0	0.0	1.0	20.0	2.0	45.0	720.0	281.0	6369.0	6057.0
60.0	5.0	30.0	600.0	0.0	0.0	1.0	30.0	5.0	30.0	420.0	2352.0	10849.0	10155.0
0.0	0.0	0.0	180.0	5.0	60.0	2.0	20.0	1.0	10.0	270.0	329.0	5879.0	12266.0
0.0	7.0	120.0	900.0	4.0	30.0	0.0	0.0	6.0	120.0	720.0	396.0	9958.0	9999.0
120.0	7.0	30.0	480.0	3.0	30.0	7.0	60.0	7.0	30.0	540.0	3015.0	9022.0	13393.0
0.0	0.0	0.0	780.0	0.0	0.0	0.0	0.0	1.0	10.0	720.0	1637.0	1594.0	3167.0
15.0	5.0	10.0	720.0	4.0	30.0	5.0	10.0	3.0	30.0	600.0	7465.0	6252.0	6576.0
30.0	4.0	45.0	480.0	2.0	30.0	4.0	30.0	2.0	10.0	300.0	5185.0	7582.0	8490.0
0.0	4.0	40.0	360.0	2.0	120.0	2.0	120.0	3.0	20.0	480.0	4289.0	9928.0	12465.0
40.0	3.0	20.0	840.0	0.0	0.0	3.0	30.0	5.0	20.0	840.0	2528.0	5499.0	8255.0
0.0	3.0	45.0	510.0	0.0	0.0	1.0	120.0	5.0	20.0	600.0	1857.0	4941.0	3688.0
0.0	5.0	90.0	600.0	1.0	10.0	0.0	0.0	5.0	120.0	720.0	21000.0	16802.0	10393.0
30.0	3.0	10.0	540.0	2.0	30.0	1.0	90.0	2.0	10.0	660.0	6795.0	5975.0	5688.0
30.0	2.0	15.0	360.0	0.0	0.0	3.0	30.0	3.0	15.0	390.0	3774.0	681.0	2913.0
0.0	5.0	30.0	480.0	0.0	0.0	3.0	30.0	7.0	20.0	480.0	9110.0	12093.0	8065.0
15.0	7.0	90.0	420.0	4.0	75.0	0.0	0.0	7.0	60.0	540.0	3771.0	20564.0	11705.0
0.0	5.0		240.0	4.0	60.0	3.0	30.0	6.0	30.0	480.0	7707.0	10088.0	20778.0
15.0	7.0	45.0	180.0	0.0	0.0	4.0	30.0	7.0	30.0	300.0	2507.0	6089.0	13424.0
10.0	6.0	30.0	480.0	4.0	30.0	1.0	40.0	2.0	15.0	600.0	5323.0	10791.0	8285.0
30.0	0.0	0.0	780.0	1.0	60.0	0.0	0.0	0.0	0.0	900.0	1325.0	1283.0	1523.0
0.0	0.0	0.0	120.0	3.0	60.0	0.0	0.0	1.0	15.0	240.0	868.0	13524.0	9150.0
30.0	4.0	60.0	480.0	1.0	120.0	1.0	60.0	5.0	60.0	720.0	12682.0	14593.0	15856.0
15.0	3.0	30.0	600.0	3.0	50.0	1.0	60.0	3.0	120.0	360.0	1459.0	1490.0	214.0
0.0	7.0	90.0	180.0	0.0	0.0	0.0	0.0	7.0	50.0	180.0	3346.0	8288.0	9745.0
35.0	7.0	60.0	600.0	1.0	60.0	7.0	35.0	7.0	120.0	600.0	6093.0	15081.0	16008.0
0.0	7.0	20.0	390.0	0.0	0.0	0.0	0.0	7.0	30.0	360.0	6781.0	9875.0	9316.0
15.0	4.0	25.0	540.0	0.0	0.0	7.0	10.0	4.0	20.0	540.0	5463.0	4466.0	5895.0
60.0	6.0	20.0	360.0	2.0	60.0	3.0	120.0	6.0	15.0	480.0	6755.0	8321.0	8696.0
0.0	3.0	65.0	780.0	7.0	63.0	0.0	0.0	4.0	63.0	780.0	1995.0	2950.0	14763.0
0.0	5.0	20.0	180.0	0.0	0.0	2.0	30.0	6.0	45.0	300.0	2570.0	7048.0	6931.0
0.0	2.0	20.0	720.0	1.0	30.0	0.0	0.0	1.0	30.0	720.0	987.0	5192.0	6895.0
10.0	4.0	20.0	600.0	0.0	0.0	0.0	0.0	6.0	30.0	540.0	3038.0	4478.0	4706.0
0.0	1.0	10.0	600.0	0.0	0.0	0.0	0.0	1.0	18.0	540.0	986.0	5863.0	6015.0
60.0	2.0	45.0	240.0	3.0	60.0	6.0		7.0	45.0	90.0	3756.0	14985.0	14930.0
0.0	4.0	40.0	720.0	0.0	0.0	0.0	0.0	1.0	40.0	480.0	7266.0	8039.0	12094.0
0.0	1.0	10.0	1260.0	0.0	0.0	0.0	0.0	1.0	10.0	660.0	5277.0	8486.0	8103.0
0.0	2.0	30.0	480.0	1.0	45.0	0.0	0.0	1.0	45.0	360.0	3142.0	5154.0	15495.0
45.0	1.0	30.0	210.0	0.0	0.0	2.0	30.0	4.0	30.0	300.0	2252.0	5660.0	11501.0

STEPD4	STEPD5	STEPD6	STEPD7	STEPD8	STEPD9	BF	HT	WT	BMI	WAIST	HIP	WHRATIO	ADDSTEP
3486.0	5682.0	6595.0	11445.0	9128.0	3682.0	29.2	72.8	200.6	26.6	37.8	37.5	1.0	65468.0
10216.0	5572.0	7029.0	4130.0	8046.0	5361.0	28.2	77.0	266.3	31.6	44.0	44.5	1.0	51202.0
2363.0	2390.0	5850.0	3286.0	0.0	270.0	29.0	72.0	228.5	31.0	41.0	41.3	1.0	38382.0
4542.0	4150.0	10356.0	5544.0	6005.0	1732.0	29.5	70.0	272.8	39.1	43.5	45.0	1.0	49103.0
5597.0	6463.0	11107.0	4841.0	5591.0	5859.0	30.9	74.8	235.1	29.6	40.5	41.0	1.0	51334.0
3954.0	6637.0	7378.0	7349.0	4292.0	2203.0	22.4	72.5	183.6	24.6	32.5	37.3	0.9	56520.0
3688.0	10507.0	10957.0	12543.0	9094.0	2055.0	27.2	69.3	189.5	27.8	36.3	40.3	0.9	68384.0
11897.0	12381.0	9577.0	12316.0	4351.0	484.0	23.3	69.5	160.2	23.3	35.5	38.0	0.9	73056.0
7212.0	9503.0	11661.0	6165.0	5882.0	530.0	22.1	70.3	166.1	23.7	33.0	35.8	0.9	64995.0
3134.0	6952.0	6966.0	5678.0	7007.0	1322.0	24.0	74.5	220.2	27.9	38.5	41.5	0.9	42926.0
3917.0	8328.0	5990.0	8686.0	9782.0	462.0	21.5	70.8	165.0	23.2	28.5	36.5	0.8	53345.0
12143.0	13345.0	28717.0	11781.0	21064.0	11122.0	20.6	71.5	191.2	26.3	33.0	38.8	0.9	116715.0
6724.0	9560.0	5104.0	9020.0	6047.0	529.0	17.6	71.3	190.3	26.3	32.5	37.8	0.9	48935.0
10032.0	11341.0	9831.0	11859.0	4716.0	8461.0	21.1	69.0	180.9	26.7	33.0	37.0	0.9	84122.0
13414.0	14065.0	9458.0	10379.0	10423.0	2422.0	10.4	68.8	120.0	17.8	26.5	32.5	0.8	87275.0
7221.0	7268.0	6821.0	5658.0	5512.0	5094.0	30.3	71.8	172.1	23.5	34.0	38.8	0.9	52945.0
4653.0	5154.0	7266.0	6817.0	5438.0	6404.0	21.9	66.3	155.3	24.9	36.5	35.8	1.0	54913.0
10071.0	14144.0	16861.0	15413.0	11426.0	617.0	18.7	68.0	172.2	26.2	31.5	38.5	0.8	105275.0
1451.0	10979.0	7658.0	6895.0	5393.0	1901.0	7.6	75.0	154.4	19.3	26.5	35.0	0.8	57718.0
11941.0	15101.0	8013.0	10058.0	11352.0	520.0	22.9	72.5	171.7	23.0	32.0	37.0	0.9	76764.0
18374.0	14212.0	15009.0	11902.0	13955.0	445.0	22.8	69.0	200.8	29.7	35.5	39.5	0.9	129931.0
9343.0	6771.0	8785.0	13773.0	7708.0	764.0	9.9	73.0	151.1	19.9	28.0	35.0	0.8	79023.0
9600.0	4670.0	9830.0	6780.0	5235.0	4241.0	23.2	74.0	177.0	22.7	33.0	37.5	0.9	64424.0
4961.0	3806.0	12694.0	7830.0	13487.0	782.0	21.9	67.0	163.1	25.5	32.0	36.0	0.9	62498.0
3489.0	2571.0	3831.0	5129.0	4780.0	3125.0	19.4	72.3	191.0	25.7	34.0	40.3	0.8	46408.0
11548.0	12726.0	15618.0	15277.0	8558.0	8418.0	21.1	70.3	182.1	25.9	33.3	39.0	0.9	104136.0
16040.0	11564.0	11401.0	8682.0	15257.0	7001.0	11.1	71.0	146.5	20.4	28.0	33.0	0.8	91831.0
3959.0	7466.0	8678.0	6248.0	5664.0	518.0	25.2	72.5	249.6	33.4	38.5	43.0	0.9	47827.0
7400.0	11831.0	17424.0	8940.0	12154.0	3343.0	15.2	68.3	164.0	24.8	29.0	35.0	0.8	110326.0
7217.0	5697.0	4821.0	2086.0	9816.0	5163.0	44.3	61.8	186.2	34.3	35.0	42.5	0.8	48252.0
8506.0	10271.0	5581.0	11835.0	6048.0	1741.0	31.4	68.0	128.6	19.6	24.5	37.0	0.7	66430.0
5850.0	7194.0	18314.0	8188.0	19982.0	5430.0	17.0	67.0	125.6	19.7	25.0	34.0	0.7	105924.0
17949.0	9117.0	13578.0	6361.0	6194.0	5450.0	39.0	61.5	163.1	30.3	32.0	41.5	0.8	76929.0
9240.0	10662.0	12795.0	12051.0	14552.0	9101.0	27.6	68.5	164.4	24.6	29.0	39.8	0.7	103344.0
16286.0	13747.0	3997.0	12042.0	5238.0	2840.0	26.2	63.0	112.1	19.9	25.5	33.3	0.8	86659.0
8442.0	6270.0	7065.0	8717.0	7028.0	1481.0	39.6	65.5	160.5	26.3	31.0	40.5	0.8	70917.0
12480.0	13729.0	13278.0	13638.0	13405.0	6581.0	28.6	65.5	125.5	20.6	25.5	35.3	0.7	103290.0
4188.0	8943.0	9885.0	8782.0	9589.0	354.0	45.1	67.5	221.7	34.2	37.0	48.5	0.8	69186.0
11960.0	12637.0	7410.0	12829.0	17859.0	3181.0	33.4	67.5	152.2	23.5	32.0	36.5	0.9	97961.0
2980.0	9267.0	12821.0	15102.0	7234.0	3950.0	32.8	65.5	132.3	21.7	31.0	36.5	0.8	66676.0
13065.0	5033.0	7487.0	10794.0	7923.0	3666.0	30.1	64.3	138.0	23.5	29.0	36.0	0.8	69516.0
4925.0	5114.0	4458.0	4005.0	5583.0	2599.0	43.4	64.3	166.0	28.3	33.3	40.5	0.8	42741.0
18127.0	11242.0	9721.0	6727.0	8069.0	901.0	27.6	63.6	115.0	20.0	25.0	33.8	0.7	84119.0
8354.0	16472.0	9642.0	18069.0	11209.0	8889.0	29.5	65.0	131.7	21.9	27.0	36.3	0.7	112751.0
8134.0	2786.0	9567.0	9022.0	10531.0	3990.0	40.5	67.5	172.5	26.6	31.5	40.0	0.8	72506.0
14549.0	11179.0	10407.0	12019.0	13005.0	10294.0	18.0	64.5	126.2	21.3	26.0	34.5	0.8	99297.0
20161.0	6478.0	12712.0	14134.0	10083.0	4771.0	39.1	67.5	168.2	26.0	30.3	42.0	0.7	98767.0
4655.0	12886.0	11336.0	8243.0	8215.0	2486.0	43.4	68.5	158.0	23.7	30.0	39.0	0.8	81491.0
8275.0	6625.0	5594.0	10637.0	3245.0	3415.0	26.6	63.5	114.8	20.0	24.0	34.5	0.7	61327.0
7831.0	7034.0	7637.0	7380.0	12161.0	5802.0	35.4	65.0	134.8	22.4	26.0	36.3	0.7	68268.0
7591.0	5973.0	8378.0	7064.0	7198.0	2969.0	39.9	66.8	173.3	27.3	35.0	40.5	0.9	57015.0
5385.0	9743.0	4790.0	8837.0	6561.0	393.0	32.6	62.8	116.0	20.7	25.3	35.3	0.7	48416.0
10650.0	10812.0	11599.0	5733.0	7421.0	714.0	26.9	63.8	134.2	23.2	27.0	37.0	0.7	70285.0
11699.0	12295.0	12795.0	8727.0	13680.0	641.0	24.1	61.8	124.4	22.9	27.0	33.3	0.8	78311.0
11253.0	16716.0	14636.0	11039.0	10952.0	432.0	38.7	68.5	168.9	25.3	31.5	42.0	0.8	85381.0
17540.0	11943.0	13087.0	13204.0	14987.0	6711.0	28.6	62.5	132.6	23.9	25.5	37.5	0.7	102902.0
1078.0	623.0	1267.0	0.0	0.0	307.0	56.8	63.8	256.0	44.3	46.5	57.0	0.8	9673.0
10177.0	10963.0	26567.0	4132.0	12938.0	7967.0	29.7	63.8	135.3	23.4	27.5	36.0	0.8	93037.0
4208.0	2247.0	3493.0	4657.0	8310.0	431.0	41.1	67.3	169.8	26.4	30.5	42.5	0.7	44603.0
5703.0	12094.0	6807.0	11523.0	9854.0	2880.0	42.2	65.8	165.5	26.9	34.0	39.5	0.9	75543.0
5925.0	7652.0	8312.0	8595.0	10830.0	5118.0	32.8	63.0	148.4	26.3	32.5	37.5	0.9	62714.0
5626.0	3544.0	5043.0	3129.0	4594.0	3343.0	32.7	66.3	151.4	24.2	29.0	37.0	0.8	35765.0
23247.0	21067.0	7059.0	10160.0	8241.0	11686.0	30.0	63.5	143.6	25.0	34.0	38.5	0.9	129655.0
2933.0	12070.0	5878.0	5668.0	8546.0	632.0	34.2	64.5	138.1	23.3	29.0	35.5	0.8	54185.0
3527.0	7673.0	4810.0	1825.0	413.0	3212.0	44.9	66.3	213.9	34.3	33.5	47.5	0.7	28828.0
7175.0	8826.0	8949.0	9220.0	13137.0	3250.0	23.0	68.8	135.0	20.1	26.0	36.8	0.7	79825.0
15907.0	5002.0	15779.0	15798.0	16532.0	4545.0	22.5	69.5	137.3	20.0	26.5	36.5	0.7	109603.0
2156.0	4578.0	15017.0	9296.0	32883.0	1013.0	32.6	67.3	194.6	30.2	30.3	44.5	0.7	103516.0
6805.0	14268.0	7880.0	7996.0	9885.0	8300.0	38.7	63.5	146.5	25.5	32.0	38.0	0.8	77154.0
9937.0	9084.0	5713.0	12303.0	3392.0	5617.0	31.7	66.0	152.4	24.6	28.0	39.5	0.7	70445.0
2166.0	7955.0	1140.0	2483.0	2575.0	2670.0	41.1	63.5	157.6	27.5	31.8	39.5	0.8	23120.0
6005.0	4739.0	12258.0	15375.0	7250.0	912.0	28.4	64.0	120.2	20.6	23.0	35.5	0.6	70081.0
12434.0	11115.0	18535.0	11627.0	17725.0	1080.0	24.3	66.5	120.3	19.1	24.0	34.5	0.7	115647.0
1946.0	4645.0	1990.0	2886.0	4634.0	6185.0	51.0	65.5	216.3	35.4	42.0	48.5	0.9	25449.0
6776.0	2666.0	8199.0	1605.0	4049.0	4943.0	44.5	65.3	184.9	30.5	36.5	42.5	0.9	49617.0
12979.0	8209.0	14016.0	16175.0	15947.0	11556.0	20.4	68.5	145.1	21.7	26.5	37.0	0.7	116064.0
4907.0	1463.0	3183.0	3893.0	2775.0	834.0	36.2	61.0	126.6	23.9	27.5	35.0	0.8	43027.0
5185.0	6611.0	6039.0	4364.0	5036.0	1611.0	34.7	65.0	122.7	20.4	28.0	36.5	0.8	44670.0
2790.0	11775.0	9813.0	4701.0	9790.0	1988.0	31.1	60.0	128.8	25.2	29.8	35.3	0.8	64629.0
14311.0	3291.0	14635.0	2501.0	16062.0	4603.0	34.0	63.5	134.7	23.5	28.5	36.0	0.8	75111.0
5732.0	4128.0	9717.0	8007.0	7299.0	5563.0	26.5	66.8	133.7	21.1	26.0	37.0	0.7	56995.0
8098.0	4959.0	10039.0	8119.0	9379.0	600.0	32.8	64.5	131.5	22.2	24.0	37.0	0.6	54268.0
7687.0	6185.0	7525.0	4437.0	5798.0	2391.0	30.1	62.0	120.8	22.1	29.5	36.0	0.8	46245.0
5778.0	7213.0	4876.0	4711.0	7500.0	5878.0	37.5	63.3	128.9	22.7	24.8	37.5	0.7	48820.0
9932.0	25155.0	14874.0	15776.0	19275.0	9512.0	27.2	63.0	120.1	21.3	24.0	34.8	0.7	128195.0
13571.0	5965.0	8443.0	4895.0	7017.0	570.0	36.2	61.5	164.2	30.5	31.8	40.0	0.8	67860.0
8849.0	8729.0	9797.0	7561.0	7086.0	1214.0	45.8	66.5	169.5	26.9	33.5	40.0	0.8	65102.0
5805.0	4313.0	3310.0	5018.0	4386.0	1042.0	38.2	61.0	135.0	25.5	27.0	39.5	0.7	47665.0
12203.0	9322.0	9025.0	10089.0	6698.0	1738.0	21.5	64.3	138.6	23.6	25.8	37.8	0.7	68488.0

ACCSTEP	mi1	mi2	mi3	mi4	mi5	mi6	mi7	mi8	mi9	totmile	mnstepwk	vigwkmn_b	modwkmn_t
50437.0	20.0	63.0	31.0	32.0	97.0	24.0	35.0	54.0	14.0	336.0	10880.1	120.0	180.0
48187.0	33.3	177.5	420.0	65.0	324.0	74.0	97.0	68.0	36.0	1225.5	11393.0	225.0	0.0
48225.0	50.8	56.9	58.5	58.0	0.0	117.0	51.1	0.0	1.5	341.5	8646.0	360.0	90.0
40225.0	4.0	4.5	5.0	45.0	20.0	46.0	10.0	40.0	3.0	170.5	12685.3	480.0	480.0
47721.0	47.0	51.8	30.3	15.0	45.0	64.0	52.0	68.0	21.0	326.1	10374.3	0.0	150.0
54557.0	6.0	102.0	58.0	96.0	18.0	14.0	21.0	17.0	5.0	326.0	10617.1	300.0	30.0
60192.0	6.0	5.0	0.0	5.0	5.0	9.0	0.0	50.0	0.0	74.0	10929.1	60.0	0.0
84573.0	24.0	18.0	22.0	71.0	78.0	128.0	18.0	12.0	6.0	347.0	11636.7	0.0	50.0
66789.0	26.6	81.2	105.6	37.6	23.0	14.0	7.5	8.3	23.7	277.2	9362.1	120.0	0.0
45225.0	7.2	30.2	23.6	34.5	29.7	86.0	33.6	51.5	7.1	289.1	8993.4	60.0	120.0
53328.0	0.0	100.0	10.0	8.0	100.0	10.0	0.0	12.0	3.0	240.0	8941.0	0.0	90.0
122007.0	5.0	80.0	25.0	100.0	120.0	140.0	100.0	100.0	20.0	665.0	17181.4	180.0	0.0
60167.0	26.0	62.0	55.0	10.0	15.0	4.0	20.0	7.0	25.0	173.0	10011.9	90.0	0.0
98975.0	13.7	76.5	40.0	7.0	1.0	27.0	30.0	25.8	12.9	207.3	16756.3	0.0	60.0
92883.0	90.0	35.0	38.0	70.0	75.0	64.0	36.0	51.0	40.0	369.0	13631.7	240.0	300.0
58901.0	5.6	13.8	14.0	0.0	0.0	13.9	13.9	16.8	14.9	72.4	9451.3	0.0	0.0
66326.0	10.0	10.0	10.0	70.0	410.0	10.0	10.0	10.0	10.0	530.0	10207.7	0.0	250.0
114386.0	6.0	40.0	100.0	90.0	80.0	35.0	35.0	22.0	40.0	402.0	16437.6	180.0	180.0
58283.0	5.0	0.0	5.0	50.0	15.0	0.0	0.0	10.0	1.0	80.0	8173.0	75.0	100.0
74329.0	3.0	15.0	65.0	10.0	5.0	47.0	40.0	45.0	2.0	227.0	12595.3	0.0	0.0
130301.0	65.0	52.0	50.0	50.0	51.0	52.0	58.0	67.0	6.0	380.0	19378.9	120.0	480.0
81657.0	49.5	17.1	50.3	48.2	29.2	15.1	10.4	16.7	14.0	187.0	10701.3	0.0	0.0
66906.0	3.0	50.0	20.0	20.0	20.0	0.0	20.0	60.0	0.0	190.0	9675.7	60.0	120.0
64145.0	1.6	10.5	23.4	7.0	20.0	10.4	9.6	10.4	18.0	91.3	11141.1	90.0	45.0
49413.0	8.0	52.0	52.0	16.0	0.0	16.0	52.0	16.0	44.0	204.0	7221.1	120.0	225.0
111148.0	25.0	38.0	48.0	68.0	48.0	92.0	66.0	42.0	64.0	402.0	17659.3	150.0	30.0
102386.0	1.0	17.0	23.0	2.0	4.0	7.0	83.0	23.0	30.0	159.0	11967.0	0.0	10.0
45392.0	25.0	400.0	30.0	400.0	40.0	0.0	40.0	0.0	25.0	910.0	8298.1	0.0	120.0
113257.0	4.0	2.0	6.0	0.0	0.0	2.0	3.0	0.0	5.0	13.0	12877.9	360.0	60.0
44198.0	28.0	26.0	26.0	10.0	20.0	28.0	28.0	32.0	26.0	170.0	6050.3	10.0	30.0
65753.0	103.9	53.9	62.8	86.8	227.7	94.9	86.3	62.8	43.1	675.2	11194.3	60.0	120.0
109554.0	27.0	46.0	34.0	277.0	5.0	19.0	21.0	82.0	4.0	484.0	13624.7	270.0	0.0
84860.0	23.0	125.0	94.0	49.0	30.0	78.0	106.0	80.0	145.0	562.0	13500.7	0.0	0.0
107538.0	3.3	17.9	19.8	8.2	7.4	25.8	24.5	28.7	22.2	132.3	12277.6	60.0	120.0
85614.0	36.0	40.0	41.0	40.0	18.0	251.0	41.0	36.0	44.0	467.0	15668.4	300.0	0.0
74519.0	8.5	15.5	15.0	15.0	8.0	15.5	15.5	15.0	8.5	99.5	11361.3	180.0	0.0
111054.0	19.5	36.0	206.8	36.8	178.6	40.2	23.6	41.3	29.0	563.3	14875.6	90.0	240.0
62294.0	1.0	15.0	10.0	8.0	50.0	16.0	10.0	0.0	0.0	109.0	10128.5	90.0	20.0
97256.0	44.0	34.0	39.0	10.0	31.0	32.0	29.0	69.0	35.0	244.0	13480.0	45.0	0.0
67734.0	16.4	14.7	15.0	57.2	17.5	29.2	23.2	44.5	10.3	201.3	10703.8	0.0	60.0
69271.0	43.0	51.0	57.0	35.0	57.0	48.0	42.0	68.0	33.0	358.0	10085.1	0.0	240.0
42324.0	4.5	10.0	10.0	4.0	2.0	10.0	10.0	10.0	5.0	56.0	7188.6	35.0	60.0
87297.0	25.0	17.0	68.0	35.0	55.5	11.0	27.0	11.0	5.5	224.5	11122.7	15.0	15.0
112358.0	3.0	3.0	2.0	10.0	5.0	5.0	9.0	8.0	1.0	42.0	15396.4	180.0	840.0
55399.0	27.0	18.0	0.0	290.0	0.0	41.0	89.0	12.0	6.0	450.0	11900.7	200.0	75.0
101414.0	6.5	10.0	20.0	60.0	20.0	20.0	30.0	25.0	10.0	185.0	15254.6	210.0	480.0
106908.0	40.0	63.0	108.0	10.0	88.0	54.0	85.0	43.0	22.0	451.0	12179.0	0.0	160.0
86002.0	10.0	160.0	8.0	150.0	10.0	10.0	0.0	12.0	5.0	350.0	12609.9	0.0	90.0
70434.0	4.5	35.6	3.0	12.8	0.0	8.5	9.9	7.3	10.0	77.1	7978.0	0.0	90.0
66221.0	7.0	50.0	69.0	115.0	45.0	43.0	35.0	40.0	52.0	397.0	9916.3	180.0	30.0
37539.0	7.0	190.0	2.0	23.0	36.0	36.0	24.0	2.0	7.0	313.0	12671.0	120.0	840.0
55258.0	0.0	70.0	6.0	70.0	70.0	70.0	60.0	70.0	5.0	416.0	9149.7	0.0	90.0
76301.0	15.1	30.2	46.0	14.5	28.6	31.1	26.6	42.3	7.1	219.3	12338.4	25.0	60.0
79831.0	26.0	78.0	55.0	30.0	34.0	70.0	57.0	63.0	25.0	387.0	12744.7	135.0	0.0
75536.0	26.6	81.2	99.0	55.9	17.4	15.5	11.5	54.5	23.7	335.0	11599.0	150.0	0.0
93845.0	13.0	70.0	55.0	25.0	40.0	50.0	30.0	44.0	18.0	314.0	14123.7	120.0	840.0
5139.0	2.4	3.5	5.7	22.7	18.2	2.2	0.0	0.0	1.8	52.3	5552.8	0.0	0.0
85305.0	35.9	9.6	119.7	106.6	0.0	120.1	14.5	9.6	28.2	380.1	10029.0	150.0	75.0
45222.0	100.0	61.0	90.0	82.0	36.0	74.0	58.0	62.0	3.0	463.0	6038.3	270.0	90.0
77246.0	3.0	49.0	6.0	56.0	10.0	30.0	15.0	10.0	3.0	176.0	11837.0	30.0	0.0
67753.0	2.5	0.0	0.0	10.5	84.5	1.6	0.2	8.1	0.5	104.9	9378.7	0.0	160.0
46261.0	7.4	41.0	6.0	10.0	10.0	12.0	5.0	95.0	2.0	179.0	6314.1	100.0	0.0
120146.0	55.0	55.0	45.0	45.0	48.0	55.0	45.0	56.0	0.0	349.0	15602.0	0.0	0.0
51675.0	12.0	13.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	85.0	9740.8	0.0	90.0
13172.0	10.3	5.2	274.0	11.6	56.3	7.8	4.8	7.0	10.0	366.7	6466.3	60.0	90.0
82270.0	26.0	40.5	41.0	13.9	78.2	34.9	26.7	38.2	5.6	273.4	11178.9	0.0	0.0
111071.0	2.0	5.0	4.0	4.0	4.0	3.0	0.0	20.0	0.0	40.0	16706.7	270.0	105.0
86423.0	50.0	80.0	150.0	20.0	30.0	40.0	40.0	130.0	10.0	490.0	14396.3	180.0	0.0
81725.0	0.0	12.5	49.5	31.0	49.5	14.0	7.0	7.0	4.0	170.5	10869.0	40.0	45.0
71316.0	37.2	10.8	12.8	128.1	31.4	23.8	29.8	219.0	21.7	455.7	10340.1	180.0	30.0
33863.0	64.0	44.0	47.0	0.0	17.0	44.0	67.0	44.0	50.0	263.0	7087.2	120.0	30.0
71924.0	6.0	40.0	106.0	15.0	20.0	70.0	35.0	50.0	6.0	336.0	12131.8	180.0	0.0
112970.0	5.0	5.0	200.0	120.0	5.0	2.0	2.0	5.0	1.0	339.0	14548.1	120.0	90.0
25445.0	60.0	74.0	89.0	10.0	20.0	6.0	6.0	10.0	6.0	215.0	8776.3	135.0	15.0
25895.0	9.0	11.0	10.0	34.0	6.0	16.0	36.0	10.0	8.0	123.0	9971.2	0.0	0.0
116432.0	0.0	0.0	10.0	40.0	10.0	50.0	0.0	10.0	0.0	120.0	14924.9	120.0	140.0
57916.0	50.0	55.0	50.0	10.0	60.0	45.0	45.0	45.0	3.0	310.0	10041.0	0.0	0.0
54341.0	13.3	15.8	49.7	50.0	19.1	15.4	11.1	11.1	11.1	172.2	7699.7	0.0	105.0
64508.0	28.1	32.0	30.0	196.4	30.0	34.0	29.0	65.0	15.0	416.4	10577.0	240.0	300.0
75044.0	50.0	15.0	21.0	24.0	14.0	32.0	15.0	30.0	25.0	151.0	12664.0	150.0	0.0
54318.0	22.4	41.6	41.2	106.4	41.0	53.6	41.3	53.6	22.9	378.7	9654.1	0.0	0.0
57421.0	1.6	90.0	60.0	20.0	20.0	63.0	56.0	62.0	1.8	371.0	8075.3	120.0	0.0
42851.0	13.5	17.5	51.8	3.5	11.7	14.6	10.2	10.1	9.1	119.4	5887.9	0.0	10.0
63009.0	2.1	68.0	115.0	55.3	21.7	65.5	68.8	108.5	65.5	502.8	7780.0	0.0	0.0
135916.0	20.0	46.0	18.5	21.0	18.2	62.0	60.3	39.6	20.5	265.6	16760.7	120.0	120.0
64747.0	20.0	8.0	40.0	9.0	8.0	9.0	9.0	8.0	20.0	91.0	9235.3	0.0	0.0
63203.0	18.7	37.5	35.5	18.5	56.0	31.0	15.0	30.0	7.0	223.5	9666.0	0.0	0.0
49616.0	17.0	10.0	12.0	16.0	11.0	6.0	16.0	12.0	25.0	83.0	7947.7	0.0	0.0
72508.0	0.0	33.0	30.0	15.0	17.0	9.6	45.0	5.0	6.8	154.6	11604.3	0.0	90.0

wlkwkmn_b	vigwkmn_p	modwkmn_	wlkwkmn_p	figstep	actistep	pthurs	pfri	psat	psun	pmon	ptues	pwed	MiAcst
60.0	130.0	240.0	30.0	4625.0	6255.1	10024.0	9930.0	3486.0	5682.0	6595.0	11445.0	9128.0	10544.1
80.0	160.0	0.0	140.0	16185.0	-4792.0	3706.0	5802.0	10216.0	5572.0	7029.0	4130.0	8046.0	10167.5
140.0	0.0	480.0	450.0	4922.5	3723.5	6696.0	10786.0	2363.0	2390.0	5850.0	3286.0	0.0	8304.5
720.0	600.0	360.0	315.0	2218.8	10466.5	7010.0	7034.0	4542.0	4150.0	10356.0	5544.0	6005.0	12514.8
120.0	0.0	150.0	300.0	4926.3	5448.0	5591.0	5688.0	3981.0	5597.0	6463.0	11107.0	4841.0	10048.2
100.0	210.0	240.0	30.0	4212.5	6404.6	4292.0	7085.0	12519.0	3954.0	6637.0	7378.0	7349.0	10291.1
240.0	60.0	0.0	150.0	1000.0	9929.1	9094.0	7165.0	2524.0	3688.0	10507.0	10957.0	12543.0	10855.1
315.0	0.0	60.0	100.0	4712.5	6924.2	12316.0	4351.0	9482.0	10232.0	11897.0	12381.0	9577.0	11289.7
0.0	140.0	60.0	0.0	4093.8	5268.4	6165.0	5882.0	10431.0	12760.0	7212.0	9503.0	11661.0	9084.9
90.0	0.0	0.0	50.0	3792.5	5200.9	5678.0	7007.0	7421.0	3191.0	3134.0	6952.0	6966.0	8704.3
90.0	45.0	0.0	90.0	3037.5	5903.5	8686.0	9782.0	9713.0	5816.0	3917.0	8328.0	5990.0	8701.0
150.0	172.0	0.0	90.0	8625.0	8556.4	11781.0	21064.0	10552.0	7393.0	12143.0	13345.0	28717.0	16516.4
0.0	300.0	20.0	0.0	2800.0	7211.9	9020.0	6047.0	2627.0	9049.0	6724.0	9560.0	5104.0	9838.9
360.0	75.0	50.0	720.0	2923.8	13832.5	9032.0	11082.0	10032.0	11341.0	9831.0	11859.0	4716.0	16549.0
420.0	120.0	120.0	270.0	6237.5	7394.2	7421.0	10481.0	13414.0	14065.0	9458.0	10379.0	10423.0	13262.7
180.0	0.0	0.0	60.0	1161.3	8290.0	7152.0	5084.0	7221.0	7268.0	6821.0	5658.0	5512.0	9378.9
840.0	0.0	135.0	315.0	6875.0	3332.7	7119.0	8627.0	4653.0	5154.0	7266.0	6817.0	5438.0	9677.7
0.0	90.0	60.0	240.0	5600.0	10837.6	20275.0	15050.0	10071.0	14144.0	16861.0	15413.0	11426.0	16035.6
420.0	100.0	75.0	300.0	1075.0	7098.0	6253.0	13467.0	1451.0	10979.0	7658.0	6895.0	5393.0	8093.0
120.0	480.0	0.0	225.0	2900.0	9695.3	7915.0	7228.0	11941.0	15101.0	8013.0	10058.0	11352.0	12368.3
840.0	240.0	840.0	840.0	5637.5	13741.4	13955.0	20171.0	13322.0	18374.0	14212.0	15009.0	11902.0	18998.9
225.0	0.0	0.0	120.0	3131.3	7570.0	7708.0	11042.0	9851.0	9343.0	6771.0	8785.0	13773.0	10514.3
45.0	840.0	840.0	210.0	2412.5	7263.2	7929.0	8540.0	9600.0	4670.0	9830.0	6780.0	5235.0	9485.7
200.0	45.0	45.0	50.0	1386.3	9754.9	6813.0	11348.0	4961.0	3806.0	12694.0	7830.0	13487.0	11049.8
80.0	90.0	120.0	140.0	3200.0	4021.1	7603.0	10977.0	3489.0	2571.0	3831.0	5129.0	4780.0	7017.1
840.0	60.0	240.0	840.0	6137.5	11521.8	15969.0	14848.0	11548.0	12726.0	15618.0	15277.0	8558.0	17257.3
10.0	40.0	20.0	150.0	2375.0	9592.0	7604.0	10682.0	16040.0	11564.0	11401.0	8682.0	15257.0	11808.0
60.0	0.0	105.0	135.0	12000.0	-3701.9	5664.0	4438.0	6491.0	3959.0	7466.0	8678.0	6248.0	7388.1
175.0	360.0	100.0	175.0	275.0	12602.9	12154.0	11487.0	16262.0	7400.0	11831.0	17424.0	8940.0	12864.9
90.0	15.0	75.0	120.0	2800.0	3250.3	3715.0	3552.0	7217.0	5697.0	4821.0	2086.0	9816.0	5880.3
840.0	0.0	120.0	840.0	10277.5	916.8	7406.0	5393.0	8506.0	10271.0	5581.0	11835.0	6048.0	10519.1
120.0	180.0	90.0	0.0	6437.5	7187.2	6893.0	18218.0	5850.0	7194.0	18314.0	8188.0	19982.0	13140.7
160.0	0.0	0.0	420.0	9125.0	4375.7	2733.0	13030.0	17949.0	9117.0	13578.0	6361.0	6194.0	12938.7
90.0	60.0	105.0	120.0	1972.5	10305.1	11876.0	12880.0	9240.0	10662.0	12795.0	12051.0	14552.0	12145.3
0.0	300.0	0.0	0.0	6837.5	8830.9	14544.0	15521.0	16286.0	13747.0	3997.0	12042.0	5238.0	15201.4
120.0	120.0	0.0	120.0	1456.3	9905.0	11049.0	13235.0	8442.0	6270.0	7065.0	8717.0	7028.0	11261.8
840.0	300.0	180.0	0.0	7647.5	7228.1	14919.0	6956.0	12480.0	13729.0	13278.0	13638.0	13405.0	14312.3
30.0	100.0	80.0	45.0	1375.0	8753.5	8947.0	8732.0	4188.0	8943.0	9885.0	8782.0	9589.0	10019.5
270.0	120.0	180.0	300.0	4037.5	9442.5	15600.0	9508.0	11960.0	12637.0	7410.0	12829.0	17859.0	13236.0
120.0	0.0	420.0	840.0	2850.0	7853.8	5004.0	7160.0	2980.0	9267.0	12821.0	15102.0	7234.0	10502.5
75.0	0.0	270.0	90.0	5425.0	4660.1	10606.0	6391.0	13065.0	5033.0	7487.0	10794.0	7923.0	9727.1
90.0	0.0	0.0	30.0	818.8	6369.8	4106.0	7173.0	4925.0	5114.0	4458.0	4005.0	5583.0	7132.6
150.0	0.0	0.0	420.0	3187.5	7935.2	7754.0	7217.0	18127.0	11242.0	9721.0	6727.0	8069.0	10898.2
140.0	160.0	0.0	100.0	575.0	14821.4	11209.0	13632.0	21664.0	8354.0	16472.0	9642.0	18069.0	15354.4
180.0	225.0	60.0	120.0	6037.5	5863.2	10531.0	12952.0	6486.0	8134.0	2786.0	9567.0	9022.0	11450.7
40.0	210.0	120.0	80.0	2518.8	12735.8	13005.0	13274.0	13477.0	14549.0	11179.0	10407.0	12019.0	15069.6
		105.0	70.0	6412.5	5766.5	10083.0	8676.0	13215.0	20161.0	6478.0	12712.0	14134.0	11728.0
180.0	20.0	120.0	150.0	4562.5	8047.4	8215.0	7244.0	13968.0	4655.0	12886.0	11336.0	8243.0	12259.9
360.0	0.0	60.0	250.0	1145.0	6833.0	3245.0	7656.0	8207.0	8275.0	6625.0	5594.0	10637.0	7900.9
240.0	180.0	40.0	60.0	5700.0	4216.3	12161.0	4737.0	14926.0	7831.0	7034.0	7637.0	7380.0	9519.3
30.0	90.0	840.0	300.0	4087.5	8583.5	7064.0	7198.0	5704.0	9707.0	7591.0	5973.0	8378.0	12358.0
60.0	0.0	20.0	90.0	5262.5	3887.2	8837.0	6561.0	6369.0	6057.0	5385.0	9743.0	4790.0	8733.7
150.0	0.0	30.0	150.0	3018.8	9319.7	5733.0	7421.0	10849.0	10155.0	10650.0	10812.0	11599.0	12119.1
0.0	300.0	40.0	10.0	5475.0	7269.7	8727.0	13680.0	5879.0	12266.0	11699.0	12295.0	12795.0	12357.7
840.0	120.0	0.0	720.0	4816.3	6782.8	11039.0	10952.0	9958.0	9999.0	11253.0	16716.0	14636.0	11264.0
210.0	90.0	420.0	210.0	4312.5	9811.2	9022.0	13393.0	17540.0	11943.0	13087.0	13204.0	14987.0	13809.7
0.0	0.0	0.0	10.0	706.3	4846.6	1594.0	3167.0	1078.0	623.0	1267.0	0.0	0.0	5500.5
50.0	120.0	50.0	90.0	5552.5	4476.5	6252.0	6576.0	10177.0	10963.0	26567.0	4132.0	12938.0	9648.9
180.0	60.0	120.0	20.0	7075.0	-1036.7	7582.0	8490.0	4208.0	2247.0	3493.0	4657.0	8310.0	5575.3
160.0	240.0	240.0	60.0	2275.0	9562.0	9928.0	12465.0	5703.0	12094.0	6807.0	11523.0	9854.0	11661.0
60.0	0.0	90.0	100.0	1348.8	8030.0	5499.0	8255.0	5925.0	7652.0	8312.0	8595.0	10830.0	9273.8
135.0	0.0	120.0	100.0	2355.0	3959.1	4941.0	3688.0	5626.0	3544.0	5043.0	3129.0	4594.0	6135.1
450.0	10.0	0.0	600.0	5050.0	10552.0	16802.0	10393.0	23247.0	21067.0	7059.0	10160.0	8241.0	15253.0
30.0	60.0	90.0	20.0	1362.5	8378.3	5975.0	5688.0	2933.0	12070.0	5878.0	5668.0	8546.0	9655.8
30.0	0.0	90.0	45.0	4837.5	1628.8	681.0	2913.0	3527.0	7673.0	4810.0	1825.0	413.0	6099.6
150.0	0.0	90.0	140.0	3812.5	7366.4	12093.0	8065.0	7175.0	8826.0	8949.0	9220.0	13137.0	10905.5
630.0	300.0	0.0	420.0	525.0	16181.7	20564.0	11705.0	15907.0	5002.0	15779.0	15798.0	16532.0	16666.7
	240.0	90.0	180.0	6875.0	7521.3	10088.0	20778.0	2156.0	4578.0	15017.0	9296.0	32883.0	13906.3
315.0	0.0	120.0	210.0	2181.3	8687.8	6089.0	13424.0	6805.0	14268.0	7880.0	7996.0	9885.0	10698.5
180.0	120.0	40.0	30.0	6432.5	3907.6	10791.0	8285.0	9937.0	9084.0	5713.0	12303.0	3392.0	9884.4
0.0	60.0	0.0	0.0	4712.5	2374.7	1283.0	1523.0	2166.0	7955.0	1140.0	2483.0	2575.0	6824.2
0.0	180.0	0.0	15.0	4350.0	7781.8	13524.0	9150.0	6005.0	4739.0	12258.0	15375.0	7250.0	11795.8
240.0	120.0	60.0	300.0	4312.5	10235.6	17725.0	14593.0	15856.0	12434.0	11115.0	18535.0	11627.0	14209.1
90.0	150.0	60.0	360.0	3512.5	5263.8	4634.0	1490.0	214.0	1946.0	4645.0	1990.0	2886.0	8561.3
630.0	0.0	0.0	350.0	1750.0	8221.2	8288.0	9745.0	6776.0	2666.0	8199.0	1605.0	4049.0	9848.2
420.0	60.0	245.0	840.0	1500.0	13424.9	15081.0	16008.0	12979.0	8209.0	14016.0	16175.0	15947.0	14804.9
140.0	0.0	0.0	210.0	4537.5	5503.5	9875.0	9316.0	4907.0	1463.0	3183.0	3893.0	2775.0	9731.0
100.0	0.0	70.0	80.0	2457.5	5242.2	4466.0	5895.0	5185.0	6611.0	6039.0	4364.0	5036.0	7527.5
120.0	120.0	360.0	90.0	5743.8	4833.3	8321.0	8696.0	2790.0	11775.0	9813.0	4701.0	9790.0	10160.6
195.0	441.0	0.0	252.0	2825.0	9839.0	2950.0	14763.0	14311.0	3291.0	14635.0	2501.0	16062.0	12513.0
100.0	0.0	60.0	270.0	5300.0	4354.1	7048.0	6931.0	5732.0	4128.0	9717.0	8007.0	7299.0	9275.4
40.0	30.0	0.0	30.0	4680.0	3395.3	5192.0	6895.0	8098.0	4959.0	10039.0	8119.0	9379.0	7704.3
80.0	0.0	0.0	180.0	1775.0	4112.9	4478.0	4706.0	7687.0	6185.0	7525.0	4437.0	5798.0	5768.5
10.0	0.0	0.0	18.0	7130.0	650.0	5863.0	6015.0	5778.0	7213.0	4876.0	4711.0	7500.0	7277.2
90.0	180.0		315.0	3826.3	12934.5	19275.0	14985.0	14930.0	9932.0	25155.0	14874.0	15776.0	16495.1
160.0	0.0	0.0	40.0	1637.5	7597.8	7017.0	8039.0	12094.0	13571.0	5965.0	8443.0	4895.0	9144.3
10.0	0.0	0.0	10.0	3115.0	6551.0	7086.0	8486.0	8103.0	8849.0	8729.0	9797.0	7561.0	9442.5
60.0	45.0	0.0	45.0	1562.5	6385.2	4386.0	5154.0	15495.0	5805.0	4313.0	3310.0	5018.0	7864.7
30.0	0.0	60.0	120.0	2017.5	9586.8	6698.0	5660.0	11501.0	12203.0	9322.0	9025.0	10089.0	11449.7