CROSS-SECTIONAL AND LONGITUDINAL COMPARISON OF SELF-REPORT VERSUS OBJECTIVE MEASUREMENT IN PHYSICAL ACTIVITY AMONG WOMEN

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ABSTRACT

CROSS-SECTIONAL AND LONGITUDINAL COMPARISON OF SELF-REPORT VERSUS OBJECTIVE MEASUREMENT IN PHYSICAL ACTIVITY AMONG WOMEN

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Physical activity improves health while combating the obesity epidemic. However, quantifying physical activity through self-report questionnaires or objective measures can provide varying results. The purposes of these studies were to determine if time, body mass index, or treatment assignment could affect the validity of physical activity measurements. The data were part of a larger physical activity promotion study conducted at the Miriam Hospital/Brown Medical School in Providence, Rhode Island and in communities in Southeastern Massachusetts from 2002 to 2005. In this trial, 280 women, with a mean age of 47.1 years, were randomly assigned to one of three intervention groups: Choose to Move (n=93), Jumpstart (n=95) and Wellness (n=92). A randomly selected sub sample of participants simultaneously wore an ActiGraph accelerometer and completed a 3-Day Physical Activity Recall questionnaire at baseline, 3 months and 12 months. Body mass index and treatment assignment were also used in-group comparisons. The results indicated that all components of time, BMI and treatment assignment influenced the accuracy of self-reported measurements when compared to objective accelerometer data. Additional research is essential to uncover the independent aspects considered influential to these physical activity measurements to enhance study design and participant outcomes in future trials.

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Thanks be to God!

DEDICATION

To my parents who provided constant support and always encouraged me to take that extra step. Also to my husband who has tremendous patience, compassion, and love.

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CHAPTER 1

This chapter will address the health risks of physical inactivity and the relevance of measurement accuracy of physical activity as an outcome in prevention research. Cross-sectional and longitudinal data previously collected from an exercise promotion study conducted with women from the southeastern Massachusetts region were used for this dissertation. It compared whether the relationship between self-reported 3-Day Physical Activity Recall questionnaire (3D-PAR) and objective measurement of the Actigraph accelerometer differs by body mass index, treatment assignment and time.

Benefits of Physical Activity

Research has firmly established the association between physical activity and positive health benefits (Haskell et al., 2007; Paffenbarger, Hyde, Wing, & Hsieh, 1986; Lee, Hsieh, & Paffenbarger, 1995). Engaging in regular physical activity is fundamental to chronic disease prevention (United States Department of Health and Human Services [USDHHS], 2002) and is of critical importance for the health and well-being of people of all age ranges. Morbidity and mortality from chronic diseases such as high blood pressure, stroke, coronary artery disease, type 2 diabetes, colon cancer, osteoporosis and obesity (Dietary

Guidelines for Americans, 2005; Pate, et al., 1995; USDHHS, 2002) reduces with regular physical activity. Research has repeatedly shown that an inverse relationship exists linking a sedentary lifestyle to morbidity and mortality prevalence rates (American College of Sports Medicine (ACSM), 2001). A dose-response relationship between physical activity and positive health outcomes is dependent upon the frequency, duration and intensity of the activity itself (Kesaniemi, et al., 2001; Lee, & Skerrett, 2001).

Over the last 10 to 20 years, research has continued to provide evidence that regular physical activity can actually avert premature mortality in all adults, but especially in women (Farrell, Braun, Barlow, Cheng, & Blair, 2002; Mora, Lee, Buring, & Ridker, 2006; Oguma, Sesso, Paffenbarger, & Lee, 2002). Research shows women to have an inverse correlation linking their level physical activity to their potential death rates from chronic disease. Also documented, aging in women progressively heightens chronic disease risk while at the same time their corresponding physical activity levels are declining (Oguma, et al., 2002; Pate et al., 1995; USDHHS, 2002).

Postponement of mortality from chronic disease is contingent upon physical activity levels in adults, especially in women. Moreover, the awareness and importance of regular physical activity continues to be a health priority among researchers and governmental organizations (Haskell et al., 2007; USDHHS, 2002).

Current Physical Activity Guidelines

Health organizations are devoted to increasing public awareness and establishing recommendations for the appropriate quantity and quality of physical activity for adults (ACSM, 2001; Pate et al., 1995; USDHHS, 1996). Jointly, the Centers for Disease Control and Prevention [CDC] and the American College of Sports Medicine proposed physical activity guidelines for every United States adult. The guidelines represent the results from research studies over several decades, which have indicated that moderate-intensity physical activity is an appropriate dose considered safe and effective for disease prevention (Haskell et al., 2007; Lee & Paffenbarger, 2000; Pate, 1995; USDHHS, 1996). The current physical activity guidelines are as follows: at least 30 minutes of moderate-intensity physical activity should be accumulated on most, preferably all, days of the week (Haskell et al., 2007; Pate, 1995). Most recently, this was updated and simplified to 2.5 hours of moderate intensity physical activity should be accumulated over the course of one week (USDHHS, 2008). Adults could alternately try to engage in vigorous-intensity physical activity three or more days per week, 20 minutes per session (Haskell et al., 2007; USDHHS, 2000) for the same health benefits[1]. Also recently updated to indicate the cumulative amount of one hour and 15 minutes of vigorous intensity physical activity could be accumulated over one week (USDHHS, 2008). Both activity guidelines should be performed in episodes of at least 10 minutes (USDHHS, 2008). Utilizing standard methods such as MET levels, the Borg scale, and the Compendium of Physical Activities offer researchers a means to properly define and measure physical activity levels for use in epidemiological research.[2,3]

Physical activity can be defined as “any bodily movement by skeletal muscles that results in energy expenditure” (Casperson et al., 1985) and may include anything from occupational activities, discretionary activities, optional household tasks, socially desirable activities and activity for physical fitness and health promotion (Food and Agriculture Organization (FAO)/ World Health Organization (WHO)/United Nations University (UNU),

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[1] Moderate-intensity physical activity, activity that increases breathing and heart rate, warrants a rating of 11-14 on the Borg scale, is 3 to 6 METs or burns 3.5 to 7 kcal/min. Vigorous-intensity physical activity is activity with a large increase in breathing and heart rate, a 15 or greater on the Borg scale, greater than 6 METs or burns more than 7 kcal/min (CDC, 2007).
[2] The standard metabolic equivalent, or MET level, is a unit used to estimate the amount of oxygen used by the body during physical activity (Brooks, Fahey, White, Baldwin, 2000).
[3] The Borg scale is method researcher’s use for measuring physical activity. It is based on a high correlation between a person's perceived exertion rating ***times 10*** and the actual heart rate during physical activity (Borg, 1998).

2001). The proposed guidelines are intended to assist the American population to evaluate their current physical activity levels and modify their activity levels accordingly. In addition, by using the definitive criterion for measuring physical activity, adults as well as researchers will be able to clarify and quantify what may or may not count as moderate-intensity physical activity.

Through the development of these physical activity guidelines, health organizations continually strive to promote Americans to initiate or increase current levels of physical activity for the benefit their health. Although current guidelines are critical in sustaining positive health outcomes, researchers still considered them as minimum recommendations. Advanced health benefits are probable through incorporating additional types of moderate to vigorous intensity physical activities or by spending more time engaging in them (Haskell et al., 2007).

Where Current Americans Match Up

Despite the mounting evidence that urges regular participation in physical activity, most Americans still fall short of meeting recommendations. In fact, a mere 49.1% of all adults actually meet the current physical activity recommendations proposed by the CDC and ACSM (CDC, 2008a;

Haskell et al., 2007). Currently, 38% of all adults report no light, moderate, or vigorous intensity physical activity during their leisure time (CDC, 2008b). Unfortunately, the percentage of adults that partake in regular leisure time physical activity also declines with age, 39.3% among adults 18 to 24 to 16.8% among adults 75 years or older (CDC, 2008c).

While the majority of the population falls short of recommended guidelines, women are even more apt to have lower levels of physical activity. Women (60.4%), compared to men (64.0%), are more likely to engage in at least some form of leisure time physical activity. As of 2005, more than half of all women (52.3%) failed to meet the minimum recommendations (CDC, 2008e; Purath, 2006). An even more alarming statistic (trend data as of 2002) revealed that as many as 27.2% of women spent no time at all in leisurely physical activity (CDC, 2008c) while physical activity levels also declined with age. Approximately, 37% of females ages 18-44 are classified as inactive and while among women 75 years or older 65.6% reportedly are inactive (CDC, 2006). Additional factors including education, race, poverty status, marital status and geographic region may also contribute to the diminishing physical activity levels (CDC, 2008a).

Physical Inactivity and the Obesity Epidemic

Engaging in regular physical activity is an integral component in the prevention and treatment of obesity and thereby a fundamental factor in reducing chronic disease (CDC, 2007; Grundy et al., 1999; USDHHS, 2002). Currently, 58.7% of the United States population is overweight (Body Mass Index [BMI][4] ≥ 25.0 & ≤ 29.9) and 23.0% is obese (BMI ≥ 30.0) (CDC, 2008d). Obesity rates have grown in epidemic proportions over the past few decades and can expect to continue according to recent prediction studies (CDC, 2008d; Wang, Colditz, & Kuntz, 2007).

A substantial public health burden of physical inactivity and obesity exists and results in significant economic consequences within the U.S. health care system. In 1995, the direct cost of obesity was over 70 billion dollars (Colditz, 1999) and increased as high as 78.5 billion dollars in 1998 (CDC, 2008g). Obesity combined with physical inactivity costs 9.4% of the total national health care expenditures (Colditz, 1999) while this deadly duo also results in 12% of total annual mortality (McGinnis & Foege, 1993). As obesity rates soar and

[4] BMI, a commonly used ratio of weight-to-height for an individual (kg/m2), assesses weight status and obesity. It is also highly correlated with body fat than other height and weight indicators (Spiegel and Foulk, 2006; National Research Council, 1998).

physical activity levels diminish, annual health care expenses and resultant mortality rates consequently rise.

Participation in regular physical activity may be a major contributing factor in combating this obesity epidemic. Presently, regular physical activity has been connected with enhanced physical functioning (Brach et al., 2004), lower body weight (DiPetro, 1995), and weight gain prevention (Ball, Owen, Salmon, Bauman, & Gore, 2001). Physical activity may actually offer a protective mechanism, not only against obesity but also more importantly against chronic disease. Barlow et al. (1995) published the first report evaluating the relationship between physical activity, specifically cardiorespiratory fitness, and reduced mortality rates in overweight and obese individuals. It was hypothesized that moderate to high levels of cardiorespiratory fitness protects against much, if not most, of the increased mortality that accompanies weight status (Barlow, Kohl, Gibbons, & Blair, 1995). Following this line of research, Blair & Brodney (1999) concluded that physical activity actually attenuates many of the health risks associated with increased body weight. Active obese individuals have lower morbidity and mortality than their normal weight peers who are sedentary, inactive or have low cardiorespiratory fitness. Thus, physical activity and cardiorespiratory fitness rates are as important as weight status alone in being mortality predictors (Blair & Brodney, 1999). Despite the benefits of physical activity, overweight or obese individuals are more physically inactive, as compared to their leaner peers (Adams, Der Anaian, DuBose, Kirtland & Ainsworth, 2003; Cooper, Page, Fox & Misson, 2000; Davis, Hodges & Gillham, 2006).

Research has shown that women are more prone to the consequences of all cause and cardiovascular mortality based on their weight status and physical activity levels compared to men (Farrell et al., 2002; Oguma et al., 2002; Kesaniemi et al., 2001). Farrell et al. (2002) also noted that low cardiorespiratory fitness levels in women are an important predictor of all-cause mortality even more so than BMI alone. Presently, researchers are devoting more time to designing the necessary courses of intervention to prevent this cycle of obesity, physical inactivity and mortality from continuing.

Physical Activity Promotion

Over recent decades, physical activity promotion studies have narrowed their focus to target women as research participants. Concurrently, funding for these types of studies has rapidly increased based on a search of a national database for scientific projects (National Institute of Health-Computer Retrieval of Information on Scientific Projects (CRISP), 2008).

Approximately, 1011 grants awarded since 2003 concentrate on "women" and "physical activity". The 2008 Fiscal Year budget proposed for Nutrition, Physical Activity and Obesity is for $41,309 as compared to the $958,732 total budget for Health Promotion (CDC, 2008f). Unfortunately, despite the increasing need for economic support to combat this health epidemic, this annual budget has remained stagnant over the past few years ($41,280 in 2006 and $41,309 in 2007). The USDHHS continues to set recommendations to decrease the proportion of women who do not participate in leisure time physical activity down to 20%; however, resources continue to be limitations to achieving these outcomes (CDC, 2008e; USDHHS, 2002; USDHHS, 2000).

Various studies continue to focus on finding the most advantageous avenue of a physical activity promotion or intervention study. Thus far, researchers have found that both lifestyle and structured exercise programs may improve physical activity levels in previously sedentary adults (Dunn et al., 1999). One limitation to this area of research may be the implementation of the exercise itself, whereas another limitation may lie in the researchers' inabilities to capture or record physical activity levels due to underdeveloped research mechanisms for measurement.

Measurement of Physical Activity

The CDC, ACSM and the U.S. Surgeon General, have stated that developing valid and reliable measures of physical activity is a public health priority (Pate et al., 1995; USDHHS, 1996). Quantifying physical activity has proven to be a complex task, continually limited by measurement accuracy. Current collection methods include physical activity diaries, concurrent physical activity histories, maximal and submaximal exercise performances, accelerometer measurements, heart rate telemetry, and caloric expenditure assessment (Welk, 2002). Cost, participant compliance, ease for research administration and data accuracy are all factors for consideration.

Even though numerous measurement methods exist, they can be multifaceted in nature, thereby posing challenges to capturing and quantifying activity (Ainsworth, 2000). Sallis and colleagues (1985) identified some obstacles in physical activity data capture including diverse forms, time of day, location, and reason. Patterns for each individual will possibly differ day-to-day, week-to-week and season to season. Additionally, activities may vary by duration, intensity, intermittency, and frequency. With such a multitude of variables, researchers must make decisions to determine how to assess physical activity (Sallis et al., 1985). There is a need for the standardization of physical activity measurement methods that are reliable, valid and practical since interpretations are apt to fluctuate study to study. Finally, measurement accuracy is crucially important given that any inaccurate findings can obscure the associations of physical activity with positive health outcomes.

Physical Activity Questionnaires

Physical activity questionnaires offer the ability to capture and to recognize information regarding the types of activity engaged and regular patterns (Paffenbarger, Blair, Lee, & Hyde, 1993). Self-report questionnaires offer the benefit of being comparatively inexpensive, easy to distribute and relatively simple to administer especially for large scale studies (Durante & Ainsworth, 1996; Sallis & Saelens, 2000). Questionnaires may have been designed or selected to suit the needs of the population in which they are studied (e.g. age, gender, and race) and are often validated either against a more objective criterion.

Despite the profound reliance on self-report physical activity questionnaires, many limitations exist when considering their usability amongst study participants. These limitations may largely rely on variables such as participant compliance, response bias, ability or accuracy to report time spent in activities, or even ability to differentiate between varying intensities of physical activity (Conway, Seale, Jacobs, Irwin, & Ainsworth, 2002). Regardless of their ease of use, self-report questionnaires still pose the challenge of balancing methodological feasibility with measurement accuracy when used to collect data from study participants.

Baranowski (1988) was one of the first to hypothesize that participants' memory is bound to influence their self-report ability of physical activity. Other limitations that may affect accuracy of self-report questionnaires include level of instruction, description of variables and recall period. Questionnaires that rely solely on participant recall have an increased capability of capturing data that are more detailed if shorter times (e.g. ≤ 3 days) are used. Shorter periods are more sensitive to patterns of change (Kriska, & Caspersen, 1997). Additionally, researchers' ability to provide proper instruction to participants also determines whether participants understand how to answer self-report items (Mader, Martin, Schultz, & Marti, 2006). Standard practices continually develop allowing self-report questionnaires improved accuracy.

In addition to instructional variations in self-report questionnaires, some variables may be beyond the control of researchers. The ability to measure physical activity by self-report has been questioned based on the participants weight status (Timperio, Salmon & Crawford, 2003). This study found among women, the ability to accurately self-report physical activity was found only in those who were not overweight (Timperio et. al, 2003). Mahabir and colleagues also concluded on 3-4 questionnaire methods obese women overestimated energy expenditure the most (Mahabir et al., 2006). Durante & Ainsworth also found that not only obese individuals, but also older, sicker and poorly educated individuals over-report physical activity more frequently then other participants (Durante & Ainsworth, 1996).

Furthermore, factors such as reactivity, social recall bias and social desirability area also known to skew self-report accuracy (Adams et al., 2005). Participants may unintentionally have the desire to please researchers by over-reporting amounts of physical activity due to their inabilities to achieve their exercise goals (Jakicic, Polley, & Wing, 1997). This may thereby cloud data, and produce inaccuracies. Exposure effects of participants enrolled in a research study notably affect responses on self-report questionnaires according to Baranowski and colleagues (2006). Participants may respond differently because their interpretation of questions distorts once enrolled in an intervention, thereby biasing results (Baranowski, Allen, Mâsse & Wilson, 2006).

Finally, a major challenge for researchers continues to be the lack of standard practices judging physical activity questionnaires and other activity assessment techniques. An elusive “gold stand”, when it comes to physical activity questionnaires is yet to be found (Blair et al., 1985). Therefore, measurement accuracy via self-report questionnaire is still subject to these limitations.

Physical Activity Recall Questionnaire (PAR)

The Seven-Day Physical Activity Recall [7D-PAR] is a widely used questionnaire originally developed in the early 1980’s. This questionnaire assesses physical activity patterns in adults and provides estimates of energy expenditure (Blair et al., 1985; Sallis et al., 1985). Evaluating changes in habitual physical activity patterns in epidemiological studies was one of the primary reasons for developing this instrument (Blair, 1985). Designed to be a semi-structured interview, the 7D-PAR estimates an individual’s time spent in physical activity, strength, and flexibility activities for the 7 days prior to the interview. The 7D-PAR assesses a variety of physical activities from gardening to leisure-time activities. It is currently considered the most inclusive measure of physical activity because it asks what types of activities participants have done. In addition, the 7D-PAR questionnaire has also shown to be sensitive to activity changes in moderate intensity physical activity studies (Dubbert, Vander Weg, Kirchner & Shaw, 2004; Sarkin, Nichols, Sallis & Calfas, 2000).

Designed to constitute measures of physical activity, the interviewer administered protocol augments participants' recall ability and improves the accuracy of data collected by the questionnaire (Blair et al., 1985). The interview process follows a procedure manual intended to standardize the interview process and increase agreement among interviewers as well as limit any bias. The general interview format for the 7D-PAR is as follows: An interviewer asks the participant to recall the amount of time spent sleeping or doing physical activities for the past 7 days. The interviewer then guides the participant through the recall process, day by day to determine the duration and intensities of the activities they participated in (Sallis, 1985). Interviewer led conversation probes participants to recall portions of the day in specific time increments and help participants to estimate intensity accurately. The 7D-PAR captures an activity only if it totals 10 minutes or more in a single intensity category for one portion of the day. Response categories split the times of day into number of hours of sleep, morning, afternoon and evening. Then the activity intensity is ranked (e.g. moderate, hard or very hard activity) at these various time points.

Once collected, the data from the 7D-PAR questionnaire, including the number of hours spent in sleep or in different physical activity levels is verified and coded, Table 1.0 for examples of activities. Time spent in sleep (1 MET), light (1.5 METs), moderate (4 METs), hard (6 METs), and very hard (10 METs) activities are multiplied by their respective MET values and activity totals are summed. Work and leisure activities have separate coding. Finally, estimates of total kilocalories of energy expenditure are calculated (Sallis, 1985). Thus, total kilocalories of physical activity expenditure are the resultant unit of data used in analysis.

Table 1. Description of Physical Activity Categories for the Seven Day Physical activity recall (Stanford Five-City Project Community health survey, 1979-1980)

Intensity of Effort	METs (WMR/RMR*)	Example
Moderate	3.0-5.0	Brisk walking, 5.6 Km (3.5 miles)/hour
Hard	5.1-6.9	Cycling, level ground, 12.8 km (8 miles)/hour
Very hard	≥ 7.0	Jogging

*Work metabolic rate/rest metabolic rate

Two versions of this questionnaire exist and have been modified for usability over the years. There is a 7D-PAR and a more condensed 3 day Physical Activity Recall Questionnaire (3D-PAR). Both measures utilize an interviewer-conducted discussion. The three-day version of the 3D-PAR only uses 3 of the 7 collected days for data analysis, including two weekdays and one weekend day. This method allows data collection to distinguish the differences in energy expenditure on workdays versus days with more leisure time activity. The 7D-PAR was used to capture physical activity in this study. However, for data analysis in this dissertation only 3 of the 7 days collected were used for comparative measures. This study coordinated the use of 3 days worth of self-report data on the 7D-PAR questionnaire to correspond with 3 days of objective data collection, discussed shortly. Therefore, the 3D-PAR will be the assessment method referred to and focused upon for this dissertation. In addition, an interview process was conducted in person (Sallis, 1985) despite the large sample size of this study. The 7D-PAR questionnaire has established validity and reliability though its evaluation from various studies over the years thereby granting researchers the ability to have confidence its measurements (Blair, 1985; Sallis, 1985; Sarkin et al., 2000).

Reliability of 7-Day Physical Activity Recall (7D-PAR)

Studies that have evaluated the reliability of the 7D-PAR questionnaire did so by administering the instrument to the same individual on two separate occasions (Shepard, 2003). Test-retest reliability has been established for physical activity measurements of varying intensities in diverse populations. Dishman & Steinhart (1988) established reliability of the 7D-PAR in college aged students while Dubbert and colleagues (2004) went on to establish reliability in urban and rural men (Dishman & Steinhardt, 1988; Dubbert et al., 2004). Additionally, researchers established the reliability of the 7D-PAR within various ethnic groups (Rauh, Hovell, Hofstetter, Sallis & Gleghorn, 1992).

Specifically related to the 7D-PAR questionnaire, not only must the questionnaire itself have established reliability, but the reliability of the interview process must be tested as well. The interview process must produce similar results when performed by two independent interviewers to the same person on the same day (Gross, Sallis, Buono, Roby & Nelson, 1990). Gross and colleagues (1990) also evaluated the reliability of the 7D-PAR administration process after the interviewers participated in a structured training program. A test-retest reliability among these same interviewers of R= 0.99 was found across interview videotaped sessions and their scoring skills assessment. Additionally, reliability of the calculated energy expenditure of R=0.86 was found when the 7D-PAR was administered by two independent interviewers to the same person on the same day. These results indicate that after naïve interviewers attend a brief 7D-PAR training program, reliability can be established (Gross et al., 1990). Therefore, reliability and effectiveness of the interview administered 7D-PAR may depend on research personnel attending standard trainings prior to the questionnaire administration.

Despite, proper administration techniques, researchers have found a prominent shortcoming to the accuracy of self-report questionnaires is human memory. Some studies indicate when a questionnaire is completed on several occasions; subjects may become less precise in their responses, and thus producing variations in their reported physical activity levels (Shepard, 2003). It is unclear what may influence these discrepancies or what researchers can do to limit possibility of errors from occurring. Considering this notion, repeated measures of the 7D-PAR questionnaire has reduced reliability after longer durations or length of time between recall periods (Argiropoulou, Michalopoulou, Aggelousiss & Avgerinos, 2004; Jacobs, Ainsworth, Hartman & Leon, 1993; Shepard, 2003).

Several other factors significantly alter reliability coefficients of the 7D-PAR. Sex and overweight status cause variations in reliability in the 7D-PAR by greatly overestimating kilocalorie expenditure in overweight populations (Irwin, Ainsworth & Conway, 2001; Sallis, et al., 1985). This may mean either overweight women are extremely variable in their energy expenditure, or they are unreliable reporters of physical activity (Sallis et al., 1990). A final factor that has been known to reduce questionnaire reliability may also be due in part to seasonal variations in physical activity patterns or habitual changes in activity at different times of the year (Shepard, 2003) however; these variations have not been specifically studied for the 7D-PAR questionnaire.

Overall, once researchers apply proper methodology of 7D-PAR administration, one can anticipate reliability of the questionnaire. Additionally, even if using the condensed version of the 7D-PAR by using the 3 days worth of PAR data, reliability is predictable when following standard procedures. The methodology for this study enhanced questionnaire reliability by using a short recall period and a standard interview procedure. Furthermore, researchers and staff designed this study to account for and control factors that tend to limit reliability thereby capturing the most accurate self-reported physical activity data possible.

Validity of 7-Day Physical Activity Recall (7D-PAR)

The validity of a self-report questionnaire describes the degree to which an instrument can measure what it was intended to measure. Validation studies of the 7D-PAR questionnaire compare physical activity data against other objective measures to determine accuracy. Validating physical activity questionnaires against other standard measurements for use in research trials continues to benefit researchers with more tools to understand physical activity patterns.

Researchers have tested the validity of the 7D-PAR against standard criterion methods such as doubly labeled water (r = 0.66 in women), heart rate (r = 0.50), and VO_{2max} (r = 0.61) and found the results significantly correlate (Allor & Pivarnik, 2001; Dishman & Steinhardt, 1988; Washburn, Jacobsen, Sonko, Hill & Donnelly, 2003). Other studies assessed the validity of the 7D-PAR questionnaire against objective measures such as accelerometers (r = 0.76) or pedometers and found promising accuracy (Allor & Pivarnik, 2001; Richardson, Ainsworth, Jacobs & Leon, 2001; Taylor, et al., 1984; Wilkinson, Huang, Walker, Sterling & Kim, 2004). While specific studies found vigorous physical activity measures had higher validity (r = 0.40) than moderate physical activity measures (Rauh, Hovell, Hofstetter, Sallis & Gleghorn, 1992). Other studies tested validity of the 7D-PAR against criterion measures in various age groups, ethnic populations and genders and found significant correlations (Allor & Pivarnik, 2001; Rauh et al., 1992).

When comparing the 7D-PAR questionnaire to other physical activity questionnaires, researchers found the 7D-PAR to provide comparable estimates of physical activity. These highly correlated results were found to range from ($r = 0.83$ to 0.94) with other concurrent physical activity questionnaires (Dishman & Steinhardt, 1988). Other studies found the 7D-PAR to be superior to other physical activity questionnaires in terms of validity ($r = 0.73$), sensitivity ($p =0.14$) and specificity ($p < 0.01$) (Johnson-Kozlow, Sallis, Gilpin, Rock & Pierce, 2006).

Despite the established validity of the 7D-PAR in traditional studies, few studies examined the validity of the questionnaire by varied weight status. One study compared the 7D-PAR to 7 days worth of accelerometer data in normal, overweight and obese women. This study found significant correlations and validity only in women who were not overweight however, no differences were found among men of varied weight status. Thus, the 7D-PAR questionnaire may provide varying results based on weight status when used to measure self-reported physical activity levels among women (Timperio, et al., 2003). Other studies that compared 7D-PAR questionnaire to accelerometer data did not find correlations or the correlations were relatively low (Jacobs, Ainsworth, Hartman & Leon, 1993). Another study compared several physical activity questionnaires including the 7D-PAR against doubly labeled water and found that both obese and overweight women overestimated energy expenditure by as much as 16% compared to this criterion measure (Mahabir et al., 2006). These studies may indicate possible reductions in 7D-PAR validity when used in populations with varying weight status.

Additionally, the 7D-PAR must test the validity of the interview process to ensure optimal test strength. As part of the original design of the 7D-PAR, the interview process must be conducted in-person. However, over the years in order to use the 7D-PAR in large population trials, multiple questionnaire administration techniques and accuracy were evaluated in order to maintain validity and user ability. Hayden-Wade and colleagues validated both the telephone and in-person interview versions of the 7D-PAR against the criterion measure of an accelerometer and found both methods to have similar estimates of self-reported physical activity ($r = 0.94$ to 0.97) (Hayden-Wade, Coleman, Sallis, & Armstrong, 2003). Though the in-person interview was utilized for this study, these results provided a promising foundation for enabling the 7D-PAR to be validated for use in large-scale studies.

Although the validity of the 7D-PAR has been reported in this discussion, researchers may be able to believe that since the same administration standards are followed, validity of using only 3 days worth of the total 7 days worth of PAR data can also be granted. Only one study, to my knowledge by Pate and colleagues (2003) validates the use of specifically the 3-day version of the 3D-PAR in young women and against the criterion method of the ActiGraph accelerometer. This study found self-reported METs, 30-minute blocks of moderate-vigorous physical activity, 30-minute blocks of vigorous physical activity were all modest yet significantly correlated with the analogous ActiGraph variables for 7 days ($r = 0.35$-0.51; $P <0.01$) and 3 days ($r = 0.27$-0.46; $P < 0.05$) of monitoring. Thereby indicating the 3-day version of the 3D-PAR is a valid instrument for assessing overall physical activity levels (Pate, Ross, Dowda & Trost, 2003).

Finally, for optimal validity, self-report physical activity questionnaires require superior subject compliance and the prerequisite of careful instruction for their use (Conway, Seale, Jacobs, Irwin & Ainsworth, 2002). Despite the challenges that self-report physical activity questionnaires pose, they are still widely used in research, even if in conjunction with objective measures of physical activity.

Objective Physical Activity Measurement

Objectively quantifying physical activity patterns help to define the physical activity dose-response relationship between activity and positive health outcomes. Despite the mounting evidence increasing the use of objective measurement tools in research, this process is still in developmental stages and not without limitations. Numerous studies to date compare subjective measurement tools (i.e. self-report questionnaires) against objective measurement standards (i.e. doubly labeled water, motion sensors or heart rate telemetry). These comparative measurements have established relatively high correlations but produce limitations in larger scale studies (Bonnefoy, et al., 2001; Brach et al., 2004; Conway, Irwin & Ainsworth, 2002; Conway et al., 2002; Hayden-Wade et al., 2003; Irwin et al., 2001; Mader et al., 2006; Mahabir et al., 2006; Meriwether et al., 2006; Reis et al., 2005; Speck & Looney, 2006). Westerterp has suggested the use of accelerometers as an objective physical activity measurement tool appropriate for large populations over periods long enough to represent normal daily life (Westerterp, 1999).

Many objective measurements exist while being widely used in research for physical activity assessments. Unlike subjective measurement (i.e. self-reported questionnaires), objective measurement do have established "gold standards" for physical activity. Considered this gold standard is doubly labeled water. Doubly labeled water assesses total energy expenditure (TEE) by replacing hydrogen and oxygen in water with uncommon isotopes for tracking purposes. It is a useful test for measuring metabolic rate; however, it is extremely expensive and thus nearly impossible to use in large population studies. It also provides only the total energy expenditure but does not offer any information about types of patterns of physical activity in ones day.

Despite this established "gold standard", advances in technology have provided the ability for objectively monitored physical activity through other methods. This includes the use of body worn sensors such as accelerometers. Accelerometers are an objective measurement tool easily worn by individuals to quantify the amount of time spent in light [<3 METs], moderate (3 to 5.99 METs), and vigorous (>6 METs) physical activity. Accelerometers can also detect and record magnitude of acceleration, thereby allowing the quality or intensity of the activity to be determined. Accelerometer devices are also able to store data continuously over long periods allowing the analysis of information over the course of several days or even weeks. Due to the ease and feasibility of accelerometers, they offer researchers a practical and reliable objective physical activity measurement tool. Though research is trending towards technology advancements of objective physical activity measurement, continued study is necessary to increase understanding as well as interpretation of objectively monitored physical activity.

Actigraph Accelerometer

The Actigraph is the most commonly used accelerometer in physical activity research trials and was the objective measurement instrument used to assess participants' physical activity in this study. Currently, there are 196 research trials listed the Actigraph website as of February 2008 documenting the use of the ActiGraph accelerometer in research trials over the last 11 years (www.theactigraph.com). The Actigraph accelerometer, (formerly Computer Science and Applications CSA) model 7164 from Manufacturing Technology Inc. (Fort Walton Beach, Florida), is a small, noninvasive, lightweight, uniaxial instrument that can record and store acceleration as well as deceleration of movements (Actigraph LLC, 2004). The Actigraph accelerometer measures 2 x 1.6 x 0.6 in., weighs 1.5 ounces, and records accelerations from 0.05 g to 2.13 g while powered by a lithium battery (ActiGraph LLC, 2004; Welk, 2002).

When worn, the accelerometer captures movement that results in acceleration. The movement then acts on a cantilevered piezoelectric beam and produces a charge proportional to the strain. The acceleration signal filters by an analog bandpass filter and digitized by and 8-bit A/D converter at a rate of 10 samples per second (ActiGraph users manual). Each signal sums over a user-specific interval of time. The Actigraph initializes and downloads using a reader interface that is connected to the serial port of a computer. Actigraph data measures counts of activity per unit time and represents the level and intensity of the activity. The Actigraph accelerometer is distinctive since it can detect continuous and intermittent bouts of physical activity which is unique in capturing lifestyle as well as structured physical activity, which can be unpredictable and sporadic (Mâsse et al., 1999).

The ActiGraph accelerometer collects, records and stores information for up to 22 consecutive days. Actigraph accelerometers require calibration initially, before each distribution period, as well as after use to ensure measurement accuracy. Following device use, data are uploaded from the monitor to the computer where results can compare the participant's log of physical activity to the days the monitor was worn. The Actigraph is not manufactured to convert physical activity counts into energy expenditure, but can be converted to physical activity-related energy expenditure (PAEE) using a regression equation established by Freedson and colleagues (Freedson et al., 1998).

Several well-known limitations of the accelerometer exist. One is the general concept that the accelerometer measures segment or limb acceleration, rather than overall body acceleration. Thus, placement of the instrument (hip versus wrist) can influence output results from actual human movement (Welk, 2002). Accelerometers may have limitations related to the type of activity performed, specifically they are known to not be able to account for the increased energy expenditure of uphill walking or when carrying or moving a load. This is mainly due to unchanged acceleration despite the additional effort required regardless of monitor placement (Welk, 2002). Finally, effects of orientation may affect accelerometer output. Since the uniaxial accelerometer picks up movement along a particular axis, it will only record movements proportional to the direction of orientation. Thus, this may be a limitation of using a uniaxial versus triaxial accelerometer for physical activity measurement. Regardless of these limitations, accelerometry-based activity monitors provide valuable objective physical activity information regarding patterns under controlled and free-living conditions (Welk, 2002).

In this present study, the Freedson equation (Freedson, Melanson & Sirard, 1998) computed cut-points for light, moderate and vigorous activities to help calculate the total energy expenditure of physical activity. Previous trials used this conversion equation and have found good agreement with time spent in various intensity categories (Ainsworth et al., 2000). Also in this present study, a randomly assigned subgroup wore the Actigraph monitor for three consecutive days to validate the PAR at baseline, 3 and 12 months. The monitor's purpose was to verify the energy expenditure, intensity and type of exercise bouts performed. As with any objective measurement tool, the ActiGraph has undergone extensive reliability and validity tests to verify its use in research studies thereby allowing researchers' confidence in the instrument for accurate physical activity results.

Reliability of ActiGraph

Testing the ActiGraph accelerometer's reliability has been imperative in determining whether a given device accurately measures and records the physical activity collected during research trials. Reliability of monitors depends on accuracy and precision, both intra- and inter-instrument. Studies that tested the ActiGraph accelerometer for technical reliability did so by replicating both laboratory conditions as well as field settings thereby enabling generalized results for larger populations (Metcalf, Curnow, Evans, Voss & Wilkin, 2002).

Intra-instrument reliability assesses the differences between a single ActiGraph accelerometer over different research trials and typically requires testing within mechanical or laboratory settings. Brage and colleagues (2003) tested the intra-instrument reliability of the six ActiGraph accelerometers at 51 different acceleration settings and found reasonable reliability (mean coefficient of variation [CV] of 4.4%) when comparing all units (Brage, Brage, Wedderkopp & Froberg, 2003). However, it was noted that large unit specific differences were identified which may warrant unit-specific calibrations or statistical adjustments within research trials in order to achieve optimal reliability. Metcalf (2002) also tested intra-instrumentation using eight identical ActiGraph monitors mounted on motorized turntable devices. These turntables tilt relative to the plane of movement producing a range of controllable and reproducible cycle frequencies that may mimic the body’s degree of movement during physical activity. Data were collected at three separate time points and two different speeds (Metcalf et al., 2002). High speeds found promising results with Intra-class Correlation Coefficients [ICC] (ICC = 0.93, $p < 0.001$) and medium speeds (ICC= 0.84, $p < 0.001$). These results identify the ActiGraph accelerometer as a precise tool for measuring acceleration changes within laboratory settings.

Generalized results are the intent of most physical activity research trials thereby making laboratory settings extremely limiting. Thus, further reliability testing of the ActiGraph accelerometer within field-settings or free-living conditions is imperative. Inter-instrument reliability assesses the variations between ActiGraph accelerometers during a single trial using optimal testing sites of free-living conditions or field settings. Brage and colleagues (2003) also tested inter-instrument reliability of the ActiGraph monitors in field settings and again found both overall systematic bias and acceleration specific differences between monitor units with error magnitudes of 20% from the mean (Brage, Brage et al., 2003). This noted large unit difference requires researchers to evaluate for extreme values or outliers within the data set prior to data analysis. Thus, linearity between the ActiGraph accelerometer and actual acceleration may only have ideal inter-instrument reliability if corrections are made for filtering frequencies (Brage, Brage, et al., 2003).

On the contrary, Metcalf et al., (2002) tested inter-instrument reliability using 23 monitors worn by children at both high and low frequency speeds and found activity scores with Inter-batch Correlation Coefficients ranged from (high speeds: 0.87 to 0.98, medium speeds: 0.71 to 0.99). Thus, this study concluded the inter-instrument coefficient of variation never exceeded 5%, which is a generally accepted level of precision for most studies. Additionally, McClain and colleagues (2007) also tested the inter-instrument reliability in the field setting using two accelerometers worn concurrently on either hip in adult subjects. Right hip versus left hip Intraclass Correlations were high and ranged from 0.98 to 0.99. Overall paired comparisons of right hip versus left hip variables were insignificant.

McClain and colleagues (2007) also found results indicating that time spent in various intensity levels (sedentary, light, vigorous and moderate-vigorous intensity) levels displayed high inter-instrument reliability with mean coefficient variables from 0.9% to 3.5%. However, this study found a decreased inter-instrument reliability during free-living activity only at a moderate intensity levels (coefficient of variation 13.5%. Despite this reduced reliability at moderate intensity levels, only a very small effect size (0.07) was observed (McClain, Sisson & Tudor-Locke, 2007). These results are important considering many researchers frequently evaluate moderate intensity physical activity for its health benefits and further reliability tests should be performed to determine the implications.

Other studies evaluated various limbs and site placement of the ActiGraph accelerometer as a reason for low instrument reliability. Toschke and colleagues tested and replicated the off-vertical position of the device when worn near a subject's umbilicus or on their right hip (Toschke, Kries, Rosenfeld & Toschke, 2007). Overall, correlations found higher measures ($p< 0.01$) for instruments placed in front of the umbilicus compared to instruments placed at the right hip (Toschke et al., 2007). Therefore, variable placement of the ActiGraph accelerometer might be a reason for lower reliability.

Site placement reliability was also assessed in field studies where participants wore two monitors simultaneously. Some of these trials demonstrated decreased reliability at extreme values (very slow walking and fast running), but generally found high inter-instrument reliability up until a speed of 9km/hr but above this speed there was a vast underestimation of physical activity counts (11% error at 10km/h and 48% error at 16km/hr)(Brage, Wedderkopp, Franks, Anderson &

Froberg, 2003). Tudor-Locke (2002) also found variations based on site placement when the ActiGraph was used in free-living conditions (Tudor-Locke, Ainsworth, Thompson & Matthews, 2002). Further research is still necessary to determine causes for decreased reliability at different frequencies or intensities during free-living conditions.

Angle effects and positions are factor known to affect ActiGraph reliability. Metcalf et al., (2002) tested the effects of four angle positions of the accelerometer. The devices found readings on average were 6% lower when the monitor was angled 15°, readings were 16% lower when angled at 30°, and 29% lower when angled at 45°. It was concluded that in practice the ActiGraph accelerometer would supply the highest reliability when operated between 0° and 15°. These results are a substantially important especially when using ActiGraph accelerometers in overweight and obese populations where abdominal adiposity may interfere with accelerometer placement. Hemmingsson & Ekelund (2007) identified that obesity and body fatness may result in these potential measurement errors since excessive body fatness at the accelerometer attachment site may cause tilting and measurement differences leading to reduced reliability of the device (Hemmingsson & Ekelund, 2007).

Patterson and colleagues (1993) have looked at the test-retest reliability of the ActiGraph accelerometer and its sensitivity to differentiate between various physical activities (walking, running, stair climbing, knee bends) or sedentary activities (reading, typing, playing video games, etc.). Results revealed the ActiGraph accelerometer significantly differentiated between types of physical activities ($p < 0.001$) and types of sedentary activities ($p < 0.001$). Overall test-retest reliability was very high for all activities tested ($r = 0.98$). This suggests the usefulness and reliability of the ActiGraph accelerometer in free-living studies to detect physical activity levels appropriately therefore supporting the use of accelerometers for large-scale population trials (Patterson et al., 1993).

Welk, Schaben & Morrow (2004) tested accelerometer reliability by using four different accelerometer models and compared their results. Overall correlation coefficients ranged from 0.62 to 0.80. The ActiGraph accelerometer was found to have the least variability across other monitor and had the overall highest reliability when compared to the other monitors studied. In addition, the Actigraph has shown acceptable reliability when compare to other commercially available accelerometers on the market (Welk et al., 2004). Instrument reliability may also rely on the ability of the accelerometer to normalize results when worn over a several days. Matthews, Ainsworth, Thompson & Bassett, (2002) studied the number of days needed to produce reliable ActiGraph accelerometer measures. This study found the most reliable results could be anticipated once the monitor was worn for 7 consecutive days. A reliability of 90% over a 7-day period was necessary to distinguish between periods of physical activity as well as physical inactivity. However, this study also discovered that a minimum of 3 to 4 days of monitoring was necessary to assess physical activity with 80% reliability (Matthews et al., 2002). This study provided important findings that necessitate researchers to capture 7 full days of physical activity data in order to provide the most reliable results.

Overall, depending on the type of physical activity performed, intensity of the activity, attachment site of the accelerometer, (upper body versus lower body), possible tilt effects and with varying loads all may greater alter the ActiGraph’s ability to accurately capture physical activity measurements. However, identifying the weaknesses in the ActiGraph accelerometer’s reliability may actually aid in researchers ability to control for these variables in future trials.

Validity of ActiGraph

To test the capability of accelerometers in accurately detecting physical activity and energy expenditure, validation against indirect calorimetry is necessary (Plasqui & Westerterp, 2007). ActiGraph accelerometers are an established tool for objective measurement of physical activity; therefore, validation of this device for use in clinical studies is essential. Validation of the Actigraph has been established against objective physical activity measurement instruments such as doubly labeled water (Ekelund et al., 2001; Leenders, Sherman & Nagaraja, 2006; Plasqui & Westerterp, 2007), pedometers (Tudor-Locke et al., 2002), VO_2 (Brage, Wedderkopp et al., 2003; Nichols et al., 2000), and heart rate telemetry (Strath, Brage & Ekelund, 2005). The aim of validation against these other objective methods is for the increased use of accelerometer monitors for physical activity measurement in large-scale studies.

The gold standard of objective physical activity measurement under free-living conditions is the use of doubly labeled water, which can validate accelerometer measurements of total energy expenditure for accuracy. Plasqui and Westerterp (2007) recently published a review article evaluating widely marketed accelerometers and comparing their measurement results against doubly labeled water. This review article identified eight well-known and currently available accelerometers for comparisons. Of the commercially available accelerometers, only the ActiGraph repeatedly found reasonable correlations against the doubly labeled water-derived energy expenditure (Plasqui & Westerterp, 2007). Ekelund et al. (2001) also specifically studied the use the ActiGraph accelerometer against doubly labeled water in children and found moderate to high correlations with TEE ($r = 0.39$, $p <0.05$), activity energy expenditure [AEE] ($r = 0.54$, $p <0.01$), and physical activity level [PAL], ($r = 0.58$, $p <0.001$) respectively. The ActiGraph accelerometer's ability to produce highly correlated physical activity measurements when compared to the gold standard of doubly labeled water is a remarkable feat. However, a major limitation of doubly labeled water, aside from its expense, is that it only captures total energy expenditure with no evaluation of type, time or intensity of physical activity able to be determined. Thus, the ActiGraph accelerometer validation against other objective physical activity measurements that may account for these other indicators is also essentially important.

Validation of ActiGraph accelerometers against other objective measures such as oxygen consumption (VO_2) can assess acute or chronic responses to exercise. When validating the ActiGraph accelerometer against VO_2, researchers found linear results while subjects were walking, but not during running, thus indicating possible underestimates of activity at higher intensities (Brage, Wedderkopp et al., 2003). This may indicate limitations of accelerometer accuracy depending on physical activity intensity level. Other researchers found correlations between ActiGraph and acceleration established validity ($r^2 = 0.97$) however, this was only when frequency dependent filtering was restored (Brage, Brage et al., 2003). This trial found large independent variations in results, and once extreme values were controlled for, high correlations were established.

Another trial made the comparison of accelerometer validity against VO_2 in adults both in field and laboratory settings and found linear relationships. The laboratory setting found ($r^2 = 0.89$) while similarly the field setting found ($r^2 = 0.89$) (Nichols et al., 2000). However, this study also noted significant differences if field and laboratory measures compared field and laboratory settings for light and vigorous intensity activities. This may specifically indicate that field settings may not always be appropriate for accelerometer use when only measuring very light or very vigorous intensity activities. Possibly the very light activity levels may not provide enough force to register movement for the accelerometer, whereas the very high intensity activities may be unable to register the very high frequency of movement accurately.

Various physical activity levels in children looked at accelerometer validity when compared to VO_2. Contrary to these findings, Pate and colleagues validated the ActiGraph accelerometer in children and they found highly correlated results (r = 0.82) for all activities studied (Pate, Almeida, McIver, Pfeiffer & Dowda, 2006). Overall, it seems that intensity of physical activities performed may not be able to be distinguished when performing very high or very low intensity levels of activity, especially in field settings.

To date, two of the most objective and direct physical activity monitoring devices have been the use of accelerometers and heart rate monitors. Heart rate monitoring is a physiological response to physical activity and it has the ability to capture a broad range of physical activity intensity levels. Thus, researchers have often considered the validation of accelerometers against these physiological mechanisms. Validation of the ActiGraph accelerometer against heart rate monitors has been the focus of many research trials. Strath, Brage and Ekelund (2005) found the combined use of accelerometers and heart rate monitors adds to the accuracy of physical activity estimates. Melanson & Freedson (1995) also evaluated ActiGraph accelerometer validity against heart rate during treadmill activity at various speeds (r= 0.66 to 0.80). Within this study, various placement of the ActiGraph was also assessed (ankle, hip and wrist) with only significant findings when the ActiGraph accelerometer was worn on the hip (r= 0.66, p <0.01). Thus indicating that placement may be an essential key to finding the most accurate and valid physical activity measurements (Melanson & Freedson, 1995).

Some potential variables to reduce the validity of the ActiGraph accelerometer measurements exist and may be attributed to a range of conditions. When Le Masurier and Tudor-Locke, (2003) compared the ActiGraph against the Yamax pedometer, important findings addressed sensitivity and accelerometer accuracy. The ActiGraph due to its high levels of sensitivity may have a higher incidence of detecting non-steps when compared to pedometers. These erroneously detected non-steps in this particular study were discovered during motor-vehicle travel when no actual physical activity was occurring, yet accelerometers were detecting movement, possibly related to bumps or shifts of the body during travel (Le Masurier & Tudor-Locke, 2003). This 17-fold increase in steps detected is a potential threat to validity, but may only occur in sedentary individuals who wear their accelerometer extensity during motor vehicle travel. Conversely, this study also demonstrated the enhanced ability of the ActiGraph accelerometer to detect movement at very slow acceleration levels or slow speeds. This high level of sensitivity is a positive attribute for when the ActiGraph accelerometer was used in elderly populations who may have a very slow gait function that may fail to register with other pieces of equipment (Le Masurier & Tudor-Locke, 2003).

Validation of the ActiGraph accelerometer in field settings is of the utmost importance since it is the commonly used research area for large-scale population studies. The ActiGraph accelerometer has been validated for the assessment of moderate intensity physical activity in the field settings (Hendelman, Miller, Baggett, Debold & Freedson, 2000). Hendelman et al. (2000) found that during field studies, the ActiGraph accelerometer might have inabilities to detect increased energy cost from upper body movement, load carriage or changes in terrain. Thus, possible error estimates may be produced when the accelerometer attempts to assess energy expenditure in all free-living situations. Matthews and colleagues (2005) also studied whether the ActiGraph accelerometer was able to detect physical activity measures on treadmill activity at different grades. Their findings were that ActiGraph activity counts significantly correlated with energy expenditure (r = 0.66 to 0.82), VO_2 (r = 0.77 to 0.89), heart rate (r = 0.66 to 0.80), treadmill speed (r = 0.82 to 0.92), however ActiGraph activity counts were not able to discriminate against any differences in three different treadmill grades (Melanson & Freedson, 1995). This change in exercise intensity at different grades is a factor that needs further evaluation.

The participant's ability to wear the accelerometer properly, which is along a belted strap or secured with a clip, snuggly tightened around the waistband, may attribute to some of its validity errors. Improper positioning of the monitor may affect validity and accuracy of measurement. Loose fitting monitors may inaccurately measure counts of activity even though no activity is performed (Le Masurier & Tudor-Locke, 2003). In addition, a uniaxial accelerometer such as the Actigraph has inaccuracies for measuring physical activities with non-vertical displacement or with high energy to movement ratios (Hendleman et al., 2000).

Overall, despite some studies identifying possible limitations of the ActiGraph accelerometer, the majority of researchers have found the ActiGraph accelerometer to be the most valid instrument currently available on the commercial market. Thus, use of the ActiGraph accelerometers in large clinical trails has proven reasonable reliability and validity and will continue to be widely accepted and used by most researchers. Further research is needed to study these instruments within a variety of populations therefore allowing clinical trials to appropriately design research mechanisms accordingly.

Purpose of the Study

The general purpose of the present study is to compare the interviewer administered, self-reported 3-Day Physical Activity Recall (3D-PAR) questionnaire against the objective measurement data of the Actigraph accelerometer. Specifically, the correlations at baseline, 3 months and 12 months will observe: a) accuracy over time; b) BMI or impact of weight status; c) group assignment effects; d) physical activity preferences.

Rationale

Current literature continually shows some marked inconsistencies or questionable validity and reliability of both questionnaires and accelerometers. What currently has not been considered is whether participants may respond differently to self-report questionnaires when completed upon multiple occasions over time. Uncertainties also exist in whether self-reported accuracy improves after multiple questionnaire exposures or whether accuracy will actually diminish over time based the desire to please researchers while over-reporting activity levels. Additionally social bias and/or weight status may contribute to flaws in the data collection and its results.

Unknown by current literature is whether participants who are receiving physical activity interventions or treatments will differ in their ability to accurately report behaviors on self-report questionnaires. These results may vary because participants receiving group treatment may better understand physical activity parameters than previously. Also, poorly understood is whether self-report accuracy will improve over time as participants receive continuous education by study staff on aspects of physical activity and have a chance to adapt their lifestyles accordingly.

A final variable to consider is whether a participant’s body mass index or weight status is a factor that may influence a participants’ ability to self-report their physical activity behaviors accurately. Inconsistencies exist in whether a participant is able to accurately identify various bouts of physical activity and whether these bouts of physical activity are properly identified regardless of weight status.

Hypotheses

The following hypotheses will be tested comparing the self-reported versus objective measurements of physical activity.

1. Cross-sectional comparisons of 3D-PAR and ActiGraph accelerometer measures will have modest correlations at baseline.
    a. These cross-sectional comparisons of the 3D-PAR and the ActiGraph accelerometer will improve and will have higher correlations at 3 months compared to baseline.
    b. Finally, cross-sectional comparisons of the 3D-PAR and the ActiGraph Accelerometer will have the highest correlations at 12 months compared to baseline.
2. Cross-sectional comparisons of the 3D-PAR and the ActiGraph accelerometer will find overweight and obese women will have poorer correlations or will be less accurate in their self-reported physical activity levels compared with normal weight women at baseline.
    a. Comparisons will also find overweight and obese women tend become less accurate and continue to have poorer correlations on their self-reported physical

activity levels compared with normal weight women at 3 months.

b. Comparisons will also find overweight and obese women will still have poorer correlations on their self-reported physical activity levels compared with normal weight women again at 12 months.

3. Longitudinal comparisons will find overweight and obese women who participated in the physical activity intervention groups will have no difference in self-reported measurement accuracy at baseline.

    a. Longitudinal comparisons will find overweight and obese women who participated in the physical activity intervention groups will have improved accuracies on self-report measures at 3 months compared to women who participate in a control group.

    b. Longitudinal comparisons will find overweight and obese women who participated in the physical activity intervention groups will have improved accuracies on self-report measures at 12 months compared to women who participate in a control group.

4. Longitudinal comparisons of physical activity preference will find that overweight and obese women prefer nontraditional methods of physical activity compared to their lean counterparts.
    a. Overweight and obese women will prefer lifestyle, non-structured physical activity compared to lean counterparts.
    b. Overweight and obese women will accumulate physical activity through multiple bouts of non-structured activity compared to their lean counterparts.

Significance of Study

Results of the present study will enhance the understanding of physical activity patterns among women of varied weight status enrolled in a physical activity promotion studies. Women are not meeting current physical activity recommendations proposed by the ASCM and the CDC according to recent health statistics. However, it is not apparent whether current physical activity measurement techniques with their multitude of limitations can accurately capture data. Reliability and validity of both subjective and objective physical activity measurement techniques have been studied, however most often they are studied within participants of normal body weight.

Current literature is limited in evaluating characteristics that may exist between women of normal, overweight and obese body weights with the use of both the 3D-PAR and the ActiGraph accelerometer. Additionally, multiple measurement attempts over time have not been used to evaluate participants of varied weight status and their ability to self-report behaviors.

The findings of the current study may allow new insights towards the development of physical activity promotion studies to target women of varied weight status accordingly. Since obesity rates are soaring and physical activity levels among women are diminishing, new perceptions from researchers need to address these concerns with a fresh approach. Future studies may require altered applications if new findings suggest varied strategies for physical activity instruction may be essential to properly suite women of varied weight status.

CHAPTER 2

CROSS-SECTIONAL COMPARISON OF 3-DAY PHYSICAL ACTIVITY RECALLS AND ACTIGRAPH DATA AT BASELINE, 3 MONTHS AND 12 MONTHS WITHIN ALL SUBJECTS

Abstract

The purpose of this study was to compare objective and subjective methods of physical activity measurements at baseline as well as over time within the entire study population. Neither group treatment assignment nor body mass index (BMI) were taken into account at this time. The purpose of this study was to establish trends in physical activity reporting within the entire study sample regardless of weight or treatment effects. The data are part of a larger physical activity promotion study conducted at the Miriam Hospital/Brown Medical School in Providence, Rhode Island and in communities in Southeastern Massachusetts from 2002 to 2005. In this trial, 280 women, with a mean age of 47.1 years, were randomly assigned to one of three intervention groups. A randomly selected sub sample of participants simultaneously wore an ActiGraph accelerometer and completed a 3-Day Physical Activity Recall (3D-PAR) interview at baseline (n=83), 3 months (n= 174) and 12 months (n=165). The sample size increased over the course of the study due to increased funding availability. At baseline within all

participants, there was a low degree of concordance ($r= 0.09$; $p< 0.04$). However a high degree of concordance was found for all participants at both 3 months ($r= 0.26$; $p< 0.001$) and 12 months ($r= 0.43$; $p< 0.001$). Results suggest that participants' ability to self-report physical activity improves over time. This may indicate that the longer participants are enrolled in a physical activity promotion study, their ability to self-report behaviors will improve dramatically over time. Therefore, interventions tailored to increasing physical activity levels may need supplementary measurement methods to help improve data accuracy at baseline. Additionally, further research is needed to examine which factors (i.e. body weight or group assignment) influence the improvements in self-reported measurements over time but may not have been apparent at baseline.

Introduction

Physical activity levels continue to diminish while obesity rates soar especially in women (Colditz, 1999). Involving women in physical activity promotion studies educates women about the importance of physical activity as well as assists women to make activity a regular part of their routine (Dunn et al., 1999). Limitations exist in large-scale studies when using objective and subjective physical activity measurement strategies (Welk, 2002). While objective measurements are often considered the gold standard for physical activity measurement and they can be implemented with confidence; limitations are evident for their use in large-scale studies (Welk, 2002). These limitations make the use of subjective physical activity measurement techniques (i.e. questionnaires) more appealing for large trials (Durante & Ainsworth, 1996; Sallis et al., 1993). Therefore, to enhance accuracy of data collection, studies often use both subjective and objective methods to offer comparative measures and to strengthen the findings. However, the current body of literature is limited in understanding how subjective physical activity measurement, namely the 3D-PAR questionnaire, reacts when tested at multiple time points, over a one-year span, within the same population.

Thus, the purpose of this proposed study was to compare the accuracy of comparative measurement strategies at baseline and over multiple time points (3-months and 12-months). Cross-sectional comparisons used data from the 3D-PAR and 3-days of ActiGraph accelerometer measures repeated within the same sample. It was hypothesized that at baseline there would be modest correlations between subjective self-reported 3D-PAR data and objective 3-day ActiGraph accelerometry data among all participants. Additionally, these cross-sectional comparisons were hypothesized to improve in accuracy at 3 months compared to baseline. Finally, cross-sectional comparisons of the 3D-PAR and the ActiGraph Accelerometer were hypothesized to have the highest accuracies at 12 months compared to baseline or 3 months. These hypotheses speculated that all participants' accuracy of self-reported behaviors would improve over time. At this point, it could be theorized that improved accuracies in reporting ability might be attributed to the education and physical activity information provided throughout the research trial. Once the findings of these measurements are fully accessed, researchers can plan to design future physical activity promotion trials to account for these variances in accuracy over time.

Materials and Methods

Recruitment and Participant Criteria

Data obtained for this study were previously collected from 280 healthy women, ages 18 to 75 years, recruited from Providence, Rhode Island and the communities surrounding southeastern Massachusetts area from 2002 to 2005. Eligible participants had to be sedentary females who were not be participating in more than 90 minutes of purposeful moderate-intensity physical activity (i.e. walking) or more than 60 minutes of vigorous intensity activity per week. Participants enrolled for this trial also had to agree to be randomly assigned to one of three treatment interventions. Participants also had to be free of any medical problems that could impede or be exacerbated by physical activity and a Physical Activity Readiness Questionnaire (PAR-Q) was used to screen for these health problems (e.g. asthma, severe osteoarthritis, cardiovascular disease) (Napolitano et al., 2006).

Intervention Conditions

Participants were randomized into one of three intervention group assignments: (a) Choose to Move, a self-help printed booklet (n=93); (b) Jumpstart, a motivationally tailored, print-based intervention (n=95); or (c) Wellness, control group, women’s health materials (n=92).

Physical Activity Outcome Measures

ActiGraph Accelerometer. The Actigraph accelerometer, (formerly Computer Science and Applications CSA) model 7164 from Manufacturing Technology Inc. (Fort Walton Beach, Florida), is a small, noninvasive, lightweight, uniaxial instrument that can record and store acceleration as well as deceleration of movements (Actigraph LLC, 2004). The Actigraph accelerometer measures 2 x 1.6 x 0.6 in., weighs 1.5 ounces, and records accelerations from 0.05 g to 2.13 g while powered by a lithium battery (ActiGraph LLC, 2004; Welk, 2002). When worn, the accelerometer captures movement that results in acceleration. The movement then acts on a cantilevered piezoelectric beam and produces a charge proportional to the strain. The acceleration signal filters by an analog bandpass filter and digitized by and 8-bit A/D converter at a rate of 10 samples per second (ActiGraph users manual). Each signal stores data over a user-specific interval of time (i.e., 1 minute). The Actigraph initializes and downloads using a reader interface that is connected to the serial port of a computer. Actigraph data measures counts of activity per unit time and represents the level and intensity of the activity. The Actigraph accelerometer is distinctive since it can detect continuous and intermittent bouts of physical activity which is unique in capturing lifestyle as well as structured physical activity, which can be unpredictable and sporadic (Mâsse et al., 1999).

To evaluate time spent in various activity levels, cut-points established by Freedson, Melanson & Sirard (1998) were used to classify moderate intensity physical activities. Activities that recorded below 500 $ct \cdot min^{-1}$ (inactivity) were interpreted to represent sitting or relatively stationary standing activities of less than 3 metabolic equivalents (METs) (e.g. dusting, ironing, laundry, washing dishes, etc.). Times recorded in the 500 to 1951 ct.min-1 range (moderate-1) were interpreted to represent moderate (3 to 6 METs) activities requiring lower levels of ambulation (e.g. window washing, vacuuming, gardening, yard work, tennis or softball). Times spent in the 1952 to 5724 $ct \cdot min^{-1}$ range (moderate-2) were interpreted to represent ambulatory activities between 3 and 6 METs (e.g., walking). Time spent in activities above 5725 $ct \cdot min^{-1}$ (vigorous) was interpreted as vigorous (>6 METs) ambulatory activity (e.g., running). Minute-by-minute data were summarized into daily averages for average ($ct \cdot min^{-1} \cdot d^{-1}$) and total activity counts ($ct \cdot d^{-1}$) for times when the monitor was worn and for activity durations ($min \cdot d^{-1}$) in activity levels outlined above.

Collection of Accelerometry Data. A randomly selected subset of the study population was chosen to wear the ActiGraph accelerometer for three days to enable comparisons to the 3D-PAR data. Participants were given an envelope that instructed whether they were selected to wear the ActiGraph monitor and the participants were instructed to wear the monitor on Sunday, Monday and Tuesday or Thursday, Friday and Saturday thereby including a weekend day. Participants scheduled to wear the ActiGraph monitor were also given a courtesy reminder call the evening before.

At baseline, the participants were taught how to wear the monitor, snugly at the waistline, attached with a clip and with the notch down. Participants were instructed how to find the mid-axillary line and place the ActiGraph monitor over their right hip. Participants were reminded to always wear the monitor on the right hip throughout the entire study to aid in reliability. The participants were also told to put the monitor on as soon as they awaken and remove it at bedtime and when showering or swimming. They were informed to be very careful to not drop the monitor because the sensors are very sensitive and could easily be broken. These same instructions were given to participants at both 3 month and 12 month assessments.

Each participant simultaneously completed a physical activity log documenting the on and off times of wearing the monitor. Participants were encouraged to engage in typical behaviors on the days they were wearing the monitor. Additional activities such as biking, swimming or weight training was to be documented in their dairy that they turned into study staff upon returning the monitor.

Physical Activity Recall Questionnaire (7D-PAR). The participants completed an interviewer-administered 7D-PAR (only used 3 of the 7 days collected for comparative analysis) (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR has established validity and reliability (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR is able to classify physical activities as light, moderate, hard and very hard intensity. For this study three days of PAR data was used to quantify minutes of moderate intensity physical activity that were at least 10 minutes in duration. Prior to the PAR administration, all participants partook in a 2-minute moderate intensity demonstration that was facilitated by study staff to convey a walking pace of moderate intensity. This strategy was implemented prior to the participants completing the PAR thus providing a benchmark of moderate intensity physical activity to help them gauge their responses. This 2-minute walking test was administered at baseline, 3 months, and 12 months.

At baseline, only 83 of the 280 participants completed the interview-administered PAR due to financial and staffing limitations. However, by 3 months (n= 174) and 12 months (n= 165), funding increased to allow for more of the sample population to complete the interview-administered PAR which made available more comparative data for analysis.

Data Analysis and Interpretation

All analysis were performed using SPSS (SPSS Inc., Chicago, IL, Release 14.0.). Cross-sectional comparisons of subjective physical activity measurements (3D-PAR) and objective physical activity measurements (ActiGraph accelerometers) were computed at baseline. Means and Standard Deviations were calculated to describe subject characteristics. Repeated measures analysis were computed to determine if there were any significant increases in physical activity levels captured by either the PAR or ActiGraph at any of the three time points and whether the values were significantly different from one another. Pearson product correlations were then used to compare the degree of concordance between the self-reported physical activity from the 3-Day Physical Activity Recall and objective measurements of the ActiGraph accelerometer over the three-day period. These tests were computed at baseline, 3 months and 12 months among all participants whom measurements were available.

Results

The purpose of this study was to compare women's ability to self-report their physical activity levels by use of a subjective measurement questionnaire (3D-PAR) in comparison to an objective measurement technique of the ActiGraph accelerometer. These comparative measurements were captured for 3 days at baseline, 3 months and 12 months within the entire sample population. Table 2. displays the baseline participant descriptive characteristics (n=280).

Table 2. Baseline Characteristics of Participants

Variable	N	Value
Age (yr)	280	47.1 ± 10.7
18-34	46	
35-49	107	
50-64	123	
65+	4	
Race/Ethnicity (%)		
Caucasian	265	94.6%
Hispanic/Portuguese/ Cape Verdean	78	28.0%
Weight Status (%)		
Underweight	2	< 1.0
Normal Weight	67	23.9
Overweight	105	37.5
Obese	106	37.9
Study Group		
Choose to Move	93	
Jumpstart	95	
Wellness	92	

Note: Values are Means ± Standard Deviations

Descriptive Statistics

The distribution of age range had a mean value of 47.1 ± 10.7 years. This age range distribution included 16.4% of the sample population between the ages of 18 to 34 years, 38.2% of the population was between the ages 35 to 49 years, 43.9% was between 40 to 64 years of age and only 1.4% of the sample population was ages 65 and over. Caucasians comprised 94.6% of the population followed by Hispanic/Portuguese/Cape Verdean making up 28.0% of the sample population.

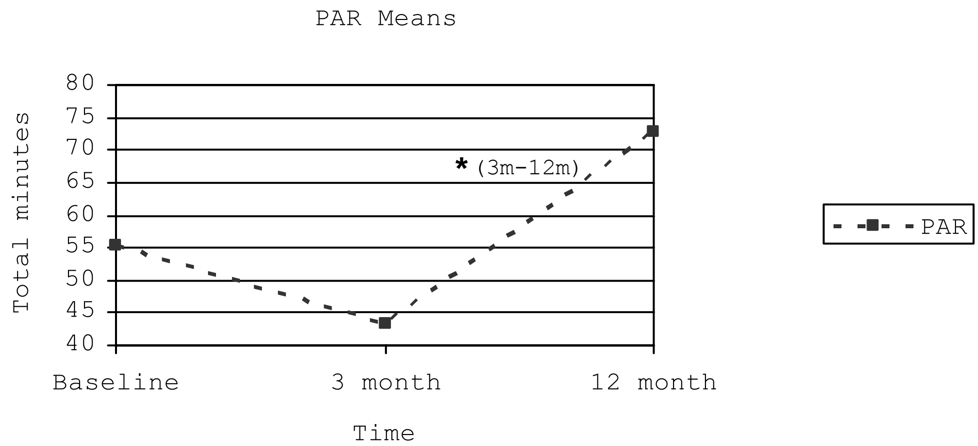
The BMI categories consisted of <1% of the sample population were in the underweight (BMI < 18.5) category and since this subset was extremely small they could not be evaluated solely, therefore they were collapsed into normal weight category in all further study analyses. Otherwise, the next smallest BMI category were normal weight (BMI ≤ 24.9) which was made up of 67 subjects or 23.9% of the sample population. Overweight subjects (BMI ≥ 25.0 or ≤29.9) included 105 participants or 37.5% of the sample. Obese subjects (BMI ≥ 30.0) consisted of 106 subjects or 37.9% of the sample population.

Finally, randomization of the group assignments included Choose to Move (93), Jumpstart (95) and Wellness (92) from the sample population. The original sample included 283 participants; however, three subjects were missing from group assignment randomization. Therefore, these subjects were not included in demographic information presented at baseline or in any further analyses.

Mean Calculations and Repeated Measures Analyses of 3D-PAR

Next, total number minutes of monitor use and total minute calculations of 3D-PAR self-report questionnaire data were computed for all available participants at baseline, 3 months and 12 months. Repeated measures were computed to detect whether significant increases or changes in the total number of minutes captured by the 3D-PAR were apparent between any of the three time points. There were 63 participants with comparative data available at each of the three time points. When baseline 3D-PAR minutes (55.40 ± 97.49) were compared to 3-month 3D-PAR minutes (43.25 ± 56.95), no significant differences in the values were found ($p= 0.24$). However, when 3-month total number of 3D-PAR minutes (43.25 ± 56.95) where compared to 12-month values (72.90 ± 76.10); they were significantly greater at 12-months ($p \leq 0.016$). Additionally, when using repeated measures analysis to compare the change in 3D-PAR minutes from baseline (55.40 ± 97.49) with the total number of 3D-PAR minutes collected at 12 months (72.90 ± 76.10) no significant differences and increases in total number of 3D-PAR minutes were detected ($p= 0.22$). Results in Figure 1.

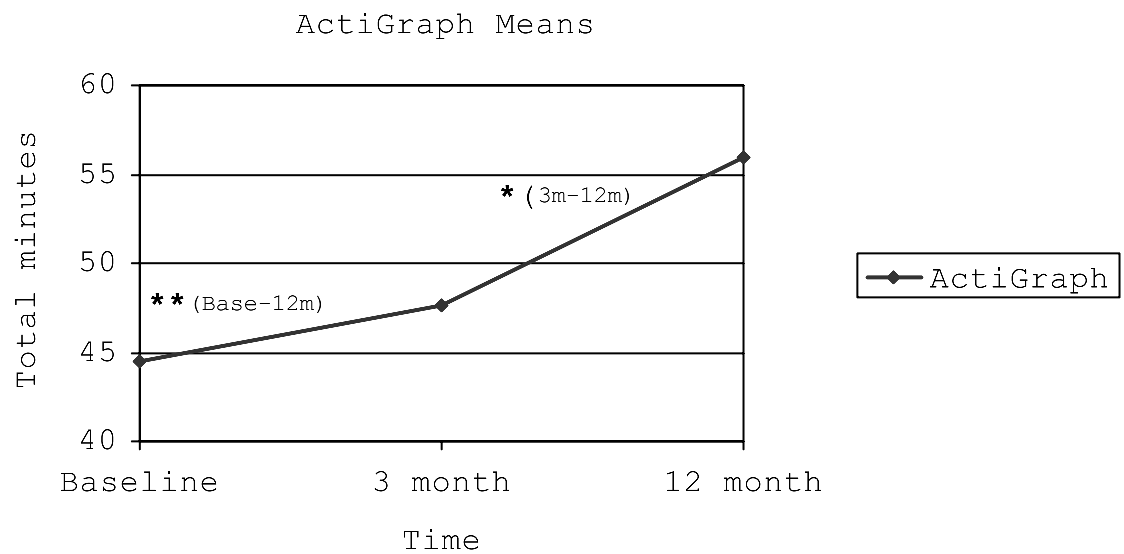
Figure 1. Repeated Measures of Total 3-Day PAR Means at baseline, 3-months and 12-months. ***Note***: *p ≤ 0.05.



Mean Calculations and Repeated Measures Analyses of ActiGraph

Next, these same tests were computed to determine if there were significant increases the total number of ActiGraph minutes between any of the three time points. There were 162 participants with data available for these measurements. No significant differences were found between the total numbers of monitor minutes from baseline (44.52 ± 37.87) to 3 months (47.60 ± 36.50). However, there were significant increases in the total number of minutes from 3 months (47.60 ± 36.5), to 12 months (55.91 ± 44.7) ($p \leq 0.015$). Additionally, baseline monitor minutes (44.52 ± 37.87) were significantly different from the total number of monitor minutes at 12 months (55.91 ± 44.7) ($p \leq 0.001$). Results are presented in Figure 2.

Figure 2. Repeated Measures of 3-Day ActiGraph Means at baseline, 3-months and 12-months. ***Note***: *$p \leq 0.05$; **$p \leq 0.001$.



Overall, these results (see Figure 1. and 2.) indicate increases in the total number of physical activity minutes participants were engaging in from the start of the study to the end time point when captured by 3D-PAR questionnaire or ActiGraph data.

Pearson Product Correlations

Additionally, Pearson product correlations were computed among all participants with available data at baseline, 3 months and 12 months. At baseline within all participants with available data, there was a low degree of concordance ($r= 0.09$; $p< 0.05$). However, higher correlations were found at 3 months between the 3D-PAR total minutes and the 3 days of ActiGraph total minutes for all available participants ($r= 0.26$; $p< 0.001$). Finally, there were also higher correlations found between the 3D-PAR total minutes and the 3 day ActiGraph total minutes found at 12 months ($r= 0.43$; $p <0.001$) among participants with data available. Results are found in Table 3. and Figure 3.

Figure 3. 3D-PAR and 3-Day ActiGraph Means and Correlations at baseline, 3 months and 12 months.
Note: *p ≤ 0.05; **p ≤ 0.01.

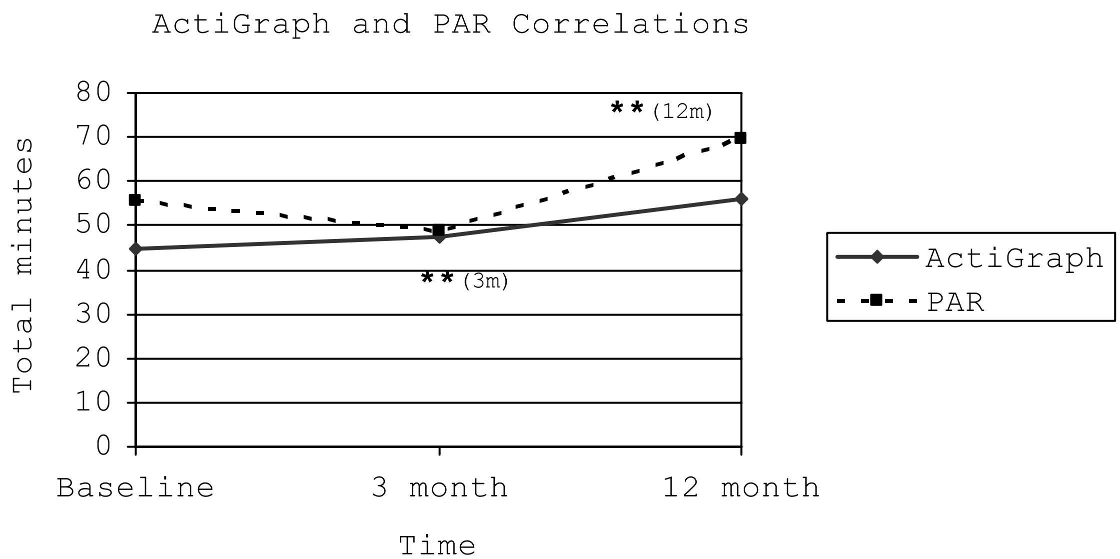


Table 3. Physical Activity Measurements and Pearson Correlations between 3D-PAR and ActiGraph Accelerometer

Time	Monitor (minutes/day)	3-Day PAR (minutes/day)	Pearson Correlation	P-Value
Baseline (n=83)	44.52 ± 37.9	55.52 ± 89.7	r=0.09	p <0.40
3 Months (n=172)	47.60 ± 36.5	48.97 ± 76.1	r=0.26**	p <0.001
12 months (n=155)	55.91 ± 44.7	69.40 ± 90.1	r=0.43**	p <0.001

Note: Values are Means ± SD. ***Note:*** *p ≤ 0.05; **p ≤ 0.01.

An anomaly was discovered at baseline within the 3D-PAR data. The average number of minutes in the self-report questionnaire was 55.52 ± 89.7, however this outlier reported 660 total minutes of physical activity at baseline. Pearson product correlations were also computed removing this outlier from the data set; however, no significant correlations were still discovered at baseline, within the entire sample population. No outliers were identified for 3 or 12 months for either 3D-PAR or ActiGraph data.

Discussion

This study provides evidence to suggest that a participants' ability to self-report physical activity levels may improve in accuracy over time among participants involved in a physical activity promotion study. When baseline 3D-PAR means were compared to 3-month 3D-PAR means through repeated measures analysis, no significant differences in the values were found. When evaluating these data points (Figure 1.), it appears that the 3-month 3D-PAR means decrease compared to the baseline mean data however there were no statistical differences. When these same repeated measures analysis were used to compare differences between the ActiGraph monitor means from baseline to 3-months there were also no significant differences found. This time, when evaluating these graphed data points (Figure 2.), a slow and steady incline in the mean ActiGraph values appeared, but were not statistically significant; however, no decline in values as was found for the 3D-PAR.

To better understand the relationships measured by either instrument, descriptive analyses were computed to compare the 3D-PAR versus ActiGraph at baseline. What is surprising is the wide discrepancy between the ranges comparing the 3D-PAR from the ActiGraph. These results identified the 3D-PAR captured physical activity minutes ranging from 0 to 660 total minutes. Whereas the ActiGraph accelerometer captured data ranging from 2 to 280 total minutes. This shows the large discrepancies in the self-reported data and potentially some subjects should have been excluded from entering the trial for being physically active prior to the intervention. In fact, four participants were identified following randomization who should have not been randomized due to activity levels exceeding the minimum standard on Day-1 of the 3D-PAR (>90 minutes). However, the original study statistician advised keeping these participants in the dataset for analysis.

These comparisons may also indicate that at baseline, participants actually may have been over-reporting their physical activity levels and this may explain the wide discrepancy between the 3D-PAR values, compared to the ActiGraph values. Additionally, these variations at baseline may explain why a low degree of concordance ($r = 0.09$; $p < 0.04$) between the 3D-PAR and ActiGraph was found with baseline correlation data. These low baseline correlations may have been linked to a participants inaccuracies in identifying their own physical activity levels upon initial enrollment in the study.

When these data points were evaluated by 3-months, the 3D-PAR continued to capture a wide range of physical activity minutes (0 to 720), whereas again the monitor minutes displayed less of a range (0 to 237). Interestingly, the 3D-PAR actually appeared to drop in physical activity levels when compared to the baseline line values, though these differences were not statistically different; however, no such drop in physical activity was represented when evaluating the ActiGraph means at 3-months. These variations may possibly be explained by the participants continued participation in the research study. Quite possibly, participants that may have been over-reporting their physical activity levels at baseline then were exposed to physical activity education and treatment intervention and by the 3-month data collection and participants may have been better able to identify and categorize their physical activity levels than they were able initially. When the correlation data between the 3D-PAR and ActiGraph monitor was compared by 3 months, all participants represented higher correlations ($r= 0.26$; $p< 0.001$). Thus, these results identify an improved accuracy of physical activity identification captured by the 3D-PAR at 3-months. Possibly, exposure to the physical activity intervention provided by the trial, allowed participants over a three month span to improve upon their base knowledge and allowed them to more accurately identify and report 3 month physical activity levels.

Next, when repeated measures analysis were used to compare 3-month 3D-PAR means to 12-month 3D-PAR means, significantly greater values were identified at 12-months (Figure 1.). In addition, when comparing 3-month ActiGraph means to 12-month ActiGraph means there were also significant increases in the means from 3 months, to 12 months (Figure 2.). When evaluating descriptive statistics available at 12 months, the 3D-PAR continued to capture a range in physical activity minutes (0 to 645) and the ActiGraph displayed a range (1 to 262). These variances may still be related to the potential for outliers to exist within the data set. Since the study protocol did not specify the course of action to carry out to properly handle outliers at any time point, it was decided that outliers should remain within the data set and analyses and reports of their presence would be indicated accordingly. The correlation data between the 3D-PAR and ActiGraph by 12 months was found to have a high degree of concordance ($r = 0.43$; $p < 0.001$). These findings suggest that participants continued enrollment in the research trial might have enabled them to have improvements in reporting accuracy after their involvement in one-year physical activity promotion trial.

Repeated measures analysis was used to compare 3D-PAR means at baseline with the total number of 3D-PAR means collected at 12 months. It was found that no significant differences and increases in total number of 3D-PAR means were detected between baseline and 12-months (Figure 1.). However, baseline ActiGraph means were found to be significantly different from the ActiGraph means by 12 months (Figure 2.). These results indicate increases in the total ActiGraph minutes participants were engaging in from the start of the study to the end time point when captured by ActiGraph monitor data but these results were not apparent when measured by the 3D-PAR questionnaire.

Overall, the findings of this study agreed with the initial hypothesis and showed that the 3D-PAR, while not perfectly correlating with objective ActiGraph accelerometer instruments at the initial baseline measure, indicate the ability to capture improvements in participants reporting accuracy over time. Additionally, the higher correlations found between the 3D-PAR questionnaires and ActiGraph measurements by 3 and 12 months indicate participants improved in their ability to identify and potentially modify their physical activity patterns appropriately when they were involved in a physical activity intervention trial.

Several limitations of this initial research trial exist. The use of the interviewer administered 3D-PAR questionnaire may have some potential limitations. While the 7D-PAR measure has been shown to be valid and reliable in previous research trials it is considering limiting because it depends on a participants ability to self-report behaviors (Blair et al., 1985; Sallis et al., 1985). Since the questionnaire was interviewer administered, there is also the possibility for interviewer error in recording data. Also, this study used a subset (3 days) of the entire 7D-PAR which may have reduced reliability and capabilities compared to the full 7 days of measurement. Additionally, due to limitations in funding, the interviewer-administered 3D-PAR was only captured on 83 of the total 280 participants at baseline due to the staffing limitations. Therefore, comparative data was not available on all participants at each time point and the results may not have been representative of the entire sample. It is worth noting that at baseline, due to this slightly smaller sample size compared to 3 or 12 months, may also have been less powered to detect these correlations initially. By 3 and 12 months, more PAR interviews were conducted; however, the entire sample population was still not captured at each time point.

Another limitation of the 3D-PAR questionnaire was that this trial did not factor in the ability of test-retest reliability that is usually captured two weeks from one another. Thus, reliability of the questionnaire can only assumed to be accurate based on previous trials and their use of the 3D-PAR. Additionally, there was no implementation if interviewer test-retest reliability within this trial. Future trials using the 3D-PAR as a main outcome measure, should design the trial to allow for test-retest reliability measures near baseline among both participants as well as administrators.

There are also some note-worthy limitations when using the objective physical activity measurement device as the ActiGraph accelerometer. The ActiGraph accelerometer only enables the ability to capture activity movements in one plane of motion, thus this device would not capture weight bearing activities or walking up inclines. Proper monitor placement could potentially be a limitation for data capture. If the device is not properly secured or fastened or is not in-line with the mid-axiallary line of the body there could be some limitations in its ability to capture movements. Finally, using certain formulas to assign cut-points to physical activity levels can have some adherent limitations. Cut-point conversion may also have potential limitations or subjectivity that may reduce data accuracy.

Overall, there may be some indication that a persons' true activity level may be between the ability of the participant to report their activity levels by use of subjective measurements and the ability of an objective accelerometer instrument to accurately detect all physical activity. In conclusion, the findings of this study may indicate that the longer participants are enrolled in a physical activity promotion study, their ability to self-report behaviors may improve dramatically over time. Therefore, interventions tailored to increasing physical activity levels may need additional observation methods to help improve data accuracy initially at baseline. Additionally, further research is needed to examine what factors may influence improvements in self-reported measurements over time that may not have been apparent at baseline.

CHAPTER 3

COMPARISON OF 3-DAY PHYSICAL ACTIVITY RECALLS AND ACTIGRAPH CORRELATION DATA BY BODY MASS INDEX CATEGORY OVER TIME

Abstract

The purpose of this study was to determine if BMI was related to the validity of self-reported versus objective physical activity measurements. Weight status has previously been evaluated to determine a person's ability to accurately self-report behavior. The data are part of a physical activity promotion study conducted at the Miriam Hospital/Brown Medical School in Providence, RI and in communities in Southeastern Massachusetts from 2002 to 2005. In this trial, 280 women (mean age= 47.1 years), were randomly assigned to one of three physical activity intervention groups. A randomly selected sub sample of participants simultaneously wore an ActiGraph accelerometer and completed a 3-Day Physical Activity Recall (3D-PAR) at baseline (n=83), 3 months (n=174) and 12 months (n=165). At baseline, both normal weight and overweight participants had a low degree of concordance with their self-report and accelerometry data r = -0.24 (p = 0.33) and r = 0.03 (p = 0.89), respectively. However, obese women demonstrated a moderate correlation of r = 0.31 (p = 0.09). Similarly, at three

months, obese participants had high correlations between self-report and objective measures ($r = 0.58$, $p < 0.001$) compared to normal weight ($r = 0.25$, p = NS) and overweight ($r = 0.02$, p = NS) participants. By 12 months participants in all weight categories expressed a high degree of concordance with self reported and accelerometry data, normal weight ($r = 0.62$, $p < 0.001$), overweight ($r = 0.30$, $p < 0.05$) and obese groups ($r = 0.33$; $p < 0.05$). These results indicate that obese participants may have a greater ability to accurately identify and report physical activity behaviors compared to normal weight and overweight participants. However, over time, all participants involved in this physical activity promotion study improved their ability to accurately identify and report physical activity, which may be related to the on-going education regarding intensity of physical activity. Further studies need to examine the factors associated with reporting differences among participants with varied weight status.

Introduction

Currently more than 75% of Americans do not participate in regular physical activity. This is despite recent recommendations proposing all adults attain 30 minutes or more of moderate-intensity physical activity on most days of the week (Pate et al., 1995) or to accumulate 2.5 hours of moderate intensity physical activity weekly (Haskell et al., 2007; USDHHS, 2008). Recently, women have been identified as being more likely to report no leisure time physical activity compared to men and are less likely to meet current recommendations overall (CDC, 2001; USDHHS, 2001). While these physical activity levels continue to diminish, obesity rates over the past few decades have correspondingly climbed especially in women (Colditz, 1999).

In addition, despite current physical activity recommendations, it is widely understood that physical activity measurement techniques have been questioned in their abilities to accurately capture data. Currently, controversy exists in determining whether subjective physical activity measurement (i.e. questionnaires) accurately captures physical activity data when compared to objective methods (i.e. accelerometers). Limitations of subjective self-report instruments may include variables such as participant compliance, ability or accuracy to report time spent in activities, or even ability to differentiate between varying intensities of physical activity (Conway, Seale, Jacobs, Irwin, & Ainsworth, 2002). While considerations of reactivity, social recall bias and social desirability have also been found to alter the accuracy of data capture (Adams et al., 2005). Specifically, the ability to measure physical activity by self-report has also been questioned based on the participants weight status (Timperio, Salmon & Crawford, 2003). Similarly, researchers have also questioned obese women and their ability to accurately estimate caloric consumption and found that obese women tend to underestimate caloric intake while overestimating physical activity expenditure (Lichtman et al., 1992; Abbot et al., 2008).

With these current limitations of self-report measures widely known, their use within populations of varied weight status becomes even more questionable. Thus, one of the purposes for this study was specifically to compare the validity of the 3-Day Physical Activity Recall questionnaire, to the ActiGraph accelerometer when tested at multiple time points (baseline, 3 months and 12 months) within a population with varied weight status (BMI <24.9 kg/m^2, BMI >25.0 to <29.9 kg/m^2, and BMI >30.0 kg/m^2). BMI was being taken into account to determine a person's ability to accurately self-report, as well as the accuracy of self-report over time.

It was hypothesized that obese women would be found to be less accurate in their self-report ability at baseline when compared to normal weight or overweight women. Additionally over time, it was also hypothesized that obese women would continue to be less accurate in their ability to self-report physical activity behaviors at both 3 months and 12 months when compared to their leaner peers. Specifically, not only were obese women hypothesized to be less accurate in their ability to self-report behaviors, they were also hypothesized to actually over-report their physical activity at all three time points when compared to the normal weight or overweight women.

Once the influence of these varied methods (subjective versus objective measurement) are understood and the impact they offer in data capture is clear, researchers can design future physical activity promotion studies for populations of varied weight status more appropriately. This may include the use and incorporation of either subjective or objective physical activity measurement methods to capture physical activity data accordingly. Thus, they can be expectant of outcomes that may be more accurate.

Materials and Methods

Recruitment and Participant Criteria

Data obtained for this study were previously collected from a physical activity promotion study including 280 healthy women, ages 18 to 75 years. The participants were previously recruited from Providence, Rhode Island and the communities surrounding southeastern Massachusetts area from 2002 to 2005. Eligible participants had to be females with a BMI less than 40 kg/m^2. Eligible candidates also could not be participating in more than 90 minutes of purposeful moderate-intensity physical activity (i.e. walking) or more than 60 minutes of vigorous intensity activity per week. Participants enrolled for this trial also had to agree to be randomly assigned to one of three treatment interventions. Participants also had to be free of any medical problems that could impede or be exacerbated by physical activity and a Physical Activity Readiness Questionnaire (PAR-Q) was used to screen for these health problems (e.g. asthma, severe osteoarthritis, cardiovascular disease) (Napolitano et al., 2006).

Height and weight measurements were collected at each of the three visits by study staff using standard operating procedures and body mass index was calculated correspondingly.

Physical Activity Outcome Measures

ActiGraph Accelerometer. The Actigraph accelerometer, (formerly Computer Science and Applications CSA) model 7164 from Manufacturing Technology Inc. (Fort Walton Beach, Florida), is a small, noninvasive, lightweight, uniaxial instrument that can record and store acceleration as well as deceleration of movements (Actigraph LLC, 2004). The Actigraph accelerometer measures 2 x 1.6 x 0.6 in., weighs 1.5 ounces, and records accelerations from 0.05 g to 2.13 g while powered by a lithium battery (ActiGraph LLC, 2004; Welk, 2002).

When worn, the accelerometer captures movement that results in acceleration. The movement then acts on a cantilevered piezoelectric beam and produces a charge proportional to the strain. The acceleration signal filters by an analog bandpass filter and digitized by and 8-bit A/D converter at a rate of 10 samples per second (ActiGraph users manual). Each signal stores data over a user-specific interval of time (e.g., 1-minute). The Actigraph initializes and downloads using a reader interface that is connected to the serial port of a computer. Actigraph data measures counts of activity per unit time and represents the level and intensity of the activity. The Actigraph accelerometer is distinctive since it can detect continuous and intermittent bouts of physical activity which is unique in capturing lifestyle as well as structured physical activity, which can be unpredictable and sporadic (Mâsse et al., 1999).

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At baseline, the participants were taught how to wear the monitor, snugly at the waistline, attached with a clip and with the notch down. Participants were instructed how to find the mid-axillary line and place the ActiGraph monitor over their right hip. Participants were informed to always wear the monitor on the right hip throughout the entire study to aid in reliability. The participants were also reminded to put the monitor on as soon as they awaken and remove it at bedtime and when showering or swimming. They were asked to be very careful to not drop the monitor because the sensors are very sensitive and can easily be broken. They were encouraged to call study staff if they felt anything unusual happened to their monitor during their 3-day period this way study staff could either replace the monitor or indicate the mishap appropriately. These same instructions were given to participants at both 3 and 12-month assessments.

Each participant simultaneously completed a physical activity log documenting the on and off times of wearing the monitor. Participants were instructed to engage in typical behaviors on the days they were wearing the monitor. Additional activities such as biking, swimming or weight training was to be documented in their dairy that they turned into study staff upon returning the monitor.

Physical Activity Recall Questionnaire (7D-PAR). The participants completed an interviewer-administered 7D-PAR during the same period in which they were wearing the ActiGraph monitor (analysis only used 3 of the 7 days collected) (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR has established validity and reliability (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR is able to classify physical activities as light, moderate, hard and very hard intensity. Appropriately trained study staff followed the interview protocol, as it was originally outlined (Sallis et al. 1985). For this study three days of PAR data was used to quantify minutes of moderate intensity physical activity that were at least 10 minutes in duration. Prior to the PAR administration, all participants partook in a 2-minute moderate intensity demonstration that was facilitated by study staff to express walking pace of moderate intensity. This strategy was implemented prior to the participants completing the PAR thus providing a benchmark of moderate intensity physical activity to help gauge their responses. This 2-minute walking test was administered at baseline, 3-months and 12-months.

Once collected from the PAR, activities were coded into various physical activity categories and were entered in the data set as minutes of total activity. Data was entered both as a total value for each of the 3 days as well as a 3-day average. At baseline, only 83 of the 280 participants completed the interview-administered PAR due to financial limitations. However, by 3 months (n= 174) and 12 months (n= 165), funding increased to allow for more of the sample population to complete the interview-administered PAR which made available more comparative data for analysis.

Data Analysis and Interpretation

Grouping components of BMI sorted the groups by normal weight (BMI < 24.9 kg/m^2), overweight (BMI > 25.0 & < 29.9 kg/m^2), and obese subjects (BMI > 30.0 kg/m^2). Pearson product correlations were computed to compare ActiGraph accelerometer minutes to self-reported 3D-PAR minutes at baseline, 3 months and 12 months. Despite three separate days worth of data available for both 3D-PAR and accelerometer, total number of minutes (3-day average) was used in all data analyses. Partial correlations were also computed controlling for group effects at this time. Additionally ANOVA tests were computed to ensure no significant differences were apparent between the BMI categories prior to the analyses. ANCOVA tests were also computed to control for any variations the treatment assignment groups had on the data analyses. Since only BMI was evaluated at this time, it was imperative for group assignment to be covaried thereby avoiding any contributions that it may have had to the results of the data set.

All analysis was performed using SPSS (SPSS Inc., Chicago, IL, Release 14.0.). Significance was set at an alpha level of $P < 0.05$. All data are reported as the means ± SE.

Results

The purpose of this study was to compare women of varied weight status and their ability to self-report their physical activity levels by use of a subjective measurement questionnaire (3D-PAR) in comparison to an objective measurement technique of the ActiGraph accelerometer. A randomly selected sub sample of participants simultaneously wore an ActiGraph accelerometer for 3 days and completed a 3D-PAR at baseline (n=83), 3 months (n=174) and 12 months (n=165) to collect comparative measurements. Baseline descriptive statistics are summarized in Tables 4. and 5.

Participant Descriptive Characteristics

Table 4. Baseline Participant Body Mass Index Characteristics

	Time point		
	Baseline (n=83)	3-Months (n=174)	12-months (n=165)

Body Mass Index			
BMI ≤ 24.9	19	50	49
BMI ≥ 25.0 & ≤ 29.9	33	62	57
BMI ≥ 30.0	31	62	59

There were no significant differences between the BMI distributions at each of the three time points and these equal BMI distributions enabled the analysis to equally compare each of the groups. The BMI categories at baseline consisted of <1% of the sample population that was in the underweight BMI category. Since this subset was extremely small, it could not be evaluated solely, therefore the underweight category was collapsed into the normal weight category in all further study analyses. The next smallest BMI category was normal weight (BMI ≤ 24.9) which was made up of 67 subjects or 23.9% of the sample population. Overweight subjects (BMI ≥ 25.0 or ≤ 29.9) included 105 participants or 37.5% of the sample. Obese subjects (BMI ≥ 30.0) consisted of 106 subjects or 37.9% of the sample.

Means and Standard Deviations of ActiGraph and 3D-PAR by BMI

Next, both ActiGraph accelerometer and 3D-PAR mean minutes were computed for baseline, 3-months and 12-months and were sorted by BMI category. Results are illustrated in Table 5. and Figures 4. and 5.

Table 5. Mean Values of Physical Activity Measurements by 3D-PAR and ActiGraph by Body Mass Index. ***Mean Values are based on Descriptive Statistics***

	Time point		
	Baseline (n=83)	3-Months (n=167)	12-months (n=172)
BMI ≤ 24.9	(n=19)	(n=51)	(n=50)
3-Day PAR	63.05 ±69.4	48.96 ±63.1	75.84 ±107.7
ActiGraph	44.47 ±32.3	50.47 ±33.2	68.86 ±48.7
BMI ≥ 25.0 & ≤ 29.9	(n=33)	(n=61)	(n=55)
3-Day PAR	50.15 ±64.7	57.30 ±98.5	73.98 ±88.7
ActiGraph	46.81 ±45.8	51.00 ±36.2	62.04 ±50.7
BMI ≥ 30.0	(n=31)	(n=69)	(n=65)
3-Day PAR	56.61 ±120.6	41.90 ±61.6	60.85 ±77.6
ActiGraph	41.62 ±30.2	44.13 ±44.5	41.83 ±32.6

Note: Values are Means ± SD

Figure 4. 3D-PAR Means by Body Mass Index at Baseline, 3-Months and 12-Months

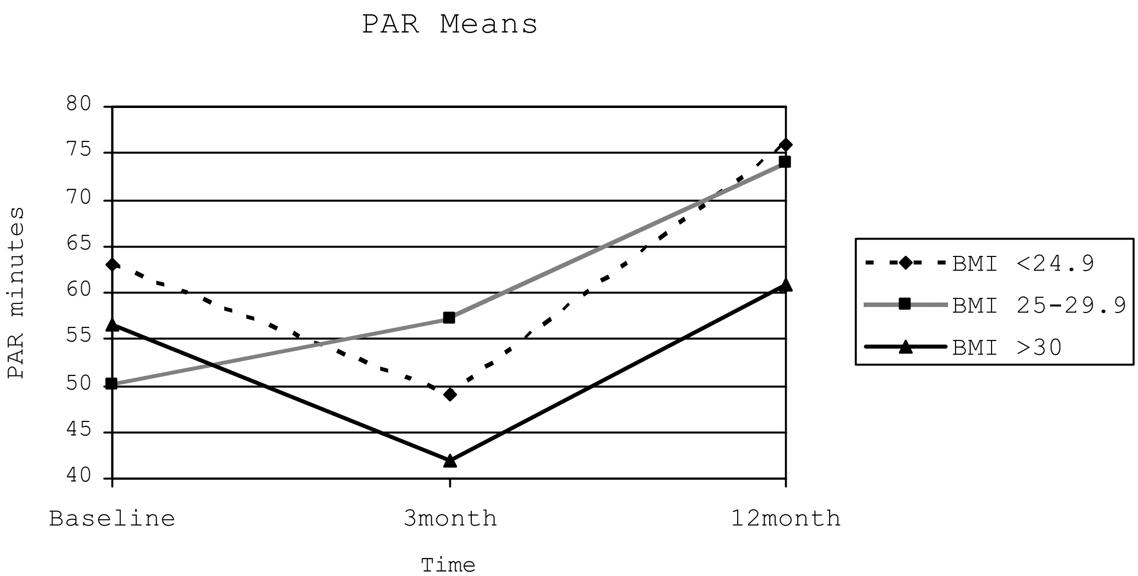
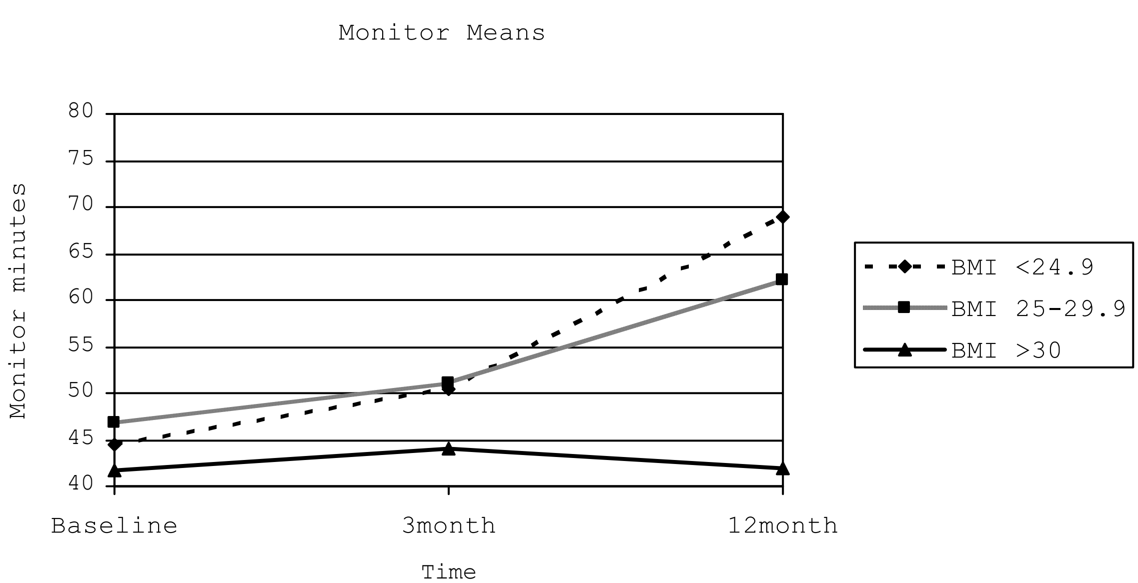


Figure 5. 3-Day ActiGraph Monitor Means by Body Mass Index at Baseline, 3-Months and 12-Months



ANOVA Tests and Repeated Measures Analyses

ANOVA tests were computed to detect significant differences among any of the BMI categories at either baseline, 3-months and 12 months. These analyses were computed for both 3D-PAR means and monitor means. No significant differences were found when evaluating 3D-PAR means at baseline, 3 and 12 months between any of the BMI categories. Similarly, no significant differences were found when evaluating ActiGraph means at baseline, 3 and 12 months among any BMI category.

Repeated measures tests, which also sorted by BMI categories were computed next to detect whether significant differences or changes in the total number of minutes captured by the 3D-PAR or monitor values were apparent between any of the three time points. These tests can detect changes in activity values found within the same individuals reported over time. It was found that among the normal weight women, 3D-PAR values recorded at 3 months were significantly different then 3D-PAR values recorded at 12 months ($p < 0.025$). This indicated significant increases in physical activity recorded on the 3D-PAR between 3 to 12 months. When repeated measures tests of monitor values were computed for normal weight women, it was found that baseline was significantly different from the 12-month value ($p < 0.014$) indicating that values from baseline significantly increased from baseline to 12 months within the normal weight women. No significant differences were found between baseline and 3 months or between 3 and 12 months among normal weight women.

Repeated measures tests were next computed for overweight women. No significant differences were found between 3D-PAR values at any of the three time points. However, significant differences were found between time points when analyzing the monitor values. There were significant differences between baseline and 12-months ($p < 0.042$) and though not significant there was a trend towards significance between 3 and 12 months ($p = 0.07$). This shows that monitor minutes were significantly increasing over time within overweight women.

Lastly, repeated measures tests were computed for obese women. No significant differences were found between 3D-PAR values at any of the three time points. Additionally, no significant differences were identified between any of the three time points when analyzing monitor data. This indicates there were no significant increases in either 3D-PAR or monitor values over time among the obese women.

Pearson Product Correlations

Additionally, Pearson product correlations sorted by BMI were computed among all participants with available data at baseline, 3 months, and 12 months.

Table 6. Correlations between 3D-PAR and ActiGraph Accelerometer by Body Mass Index

	Time point		
	Baseline (n=83)	3 months (n= 174)	12 months (n=165)
BMI ≤ 24.9	r= -0.24	r= 0.25	r= 0.62**
BMI ≥ 25.0 & ≤ 29.9	r= 0.03	r= 0.02	r= 0.30**
BMI ≥ 30.0	r= 0.31	r= 0.58**	r= 0.33*

Note: *p ≤ 0.05; **p ≤ 0.01

At baseline, both normal weight and overweight participants had a low degree of concordance with their self-report and accelerometry data r = -0.24 (p = 0.33) and r = 0.03 (p = 0.89), respectively. However, obese women demonstrated a moderate correlation of r = 0.31 (p = 0.09). Similarly, at three months, obese participants had high correlations between self-report and objective measures (r = 0.58, p < 0.001) compared to normal weight (r = 0.25, p = 0.09) and overweight (r = 0.02, p = 0.90) participants. By 12 months participants in all weight categories expressed a high degree of concordance with self reported and accelerometry data, normal weight ($r = 0.62$, $p < 0.001$), overweight ($r = 0.30$, $p < 0.05$) and obese groups ($r = 0.33$; $p < 0.05$).

One outlier was identified within the group of obese subjects who reported 660 minutes of physical activity on the PAR at baseline. However, even when this participant was temporarily removed and the statistical comparisons were re-computed, no differences in significance in correlation values were found (baseline: $r = 0.095$; $p < 0.62$; 3-month: $r = 0.35$; $p < 0.003$; 12-month: $r = 0.35$; $p < 0.005$), and thus the participant was left in the sample of results.

Finally, analyses were computed only on the sample of participants who were evaluated at each of the three time points. These analyses were important to compute to be able to detect changes within the same participants evaluated repeatedly over time. Results are presented in Tables 7. and 8.

Table 7. Mean values of the 3D-PAR and ActiGraph Accelerometer only on participants evaluated at all three time points

	Time point		
	Baseline (n=63)	3-Months (n=63)	12-months (n=63)

Table 7. Continued: Mean values of the 3D-PAR and ActiGraph Accelerometer only on participants evaluated at all time points

BMI ≤ 24.9	(n=13)	(n=13)	(n=13)
3D-PAR	63.08	25.77	87.31
ActiGraph	48.38	45.77	69.46
BMI ≥ 25.0 & 29.9	(n=24)	(n=24)	(n=24)
3D-PAR	54.17	45.21	62.00
ActiGraph	51.67	50.13	65.54
BMI ≥ 30.0	(n=26)	(n=26)	(n=26)
3D-PAR	52.69	50.19	75.77
ActiGraph	47.62	43.88	58.23

Note: Values are Means

Table 8. Correlations between 3D-PAR and ActiGraph Accelerometer only on participants evaluated at all time points

	Baseline (n=63)	Time point 3 months (n=63)	12 months (n=63)
BMI ≤ 24.9	r= -0.24	r= 0.25	r= 0.50**
BMI ≥ 25.0 & ≤ 29.9	r= 0.03	r= 0.09	r= 0.40**
BMI ≥ 30.0	r= 0.31	r= 0.50**	r= 0.35**

Note: *p ≤ 0.05; **p ≤ 0.01

Pearson correlations were recomputed only using the participants with data points available at each of the three time points. These calculations are intended to detect variances within reporting accuracy among the same group of participants over time. Results in Table 8.

The main difference to illustrate between Table 6. and 8. were the correlations between participants in which data where collected at each of the three time points. Once computed, one of the differences worth highlighting was found within the group of obese women who had data available for evaluation at each of the three time points. This group demonstrated different correlation values by 12-months. The correlation values only improved slightly from ($r = 0.33$; $p < 0.05$) to ($r = 0.35$; $p < 0.01$; $n=66$). Indicating that when obese women are given the opportunity to repeat measures at each of three time points, they may demonstrate a slightly higher degree of concordance when the obese sample was evaluated as a whole.

Partial correlations were also computed at this time to evaluate differences when controlling for group effects at this time. These results indicate that even when group effects were controlled for during the partial correlation computation, the same significance of correlation values.

Discussion

These results indicate that women of varied weight status differ in their ability to accurately identify and report physical activity behaviors. The findings at baseline confirmed the initial hypothesis and identified that all women were not accurate in their ability to identify and report moderate-intensity physical activity levels when compared to actual ActiGraph recordings. Obese subjects at baseline were found to have correlations that were trending towards significance when compared to the other overweight or normal weight BMI groups at this time point. Sample sizes at baseline were slightly smaller and this may potentially affect the potential power at this baseline time point.

By 3 months, results continued to indicate that obese participants might have a slightly greater ability to accurately identify and report physical activity behaviors compared to normal weight and overweight participants. At this time point, only obese participants had a high correlation in their ability to accurately identify and report physical activity levels on the 3D-PAR questionnaire, whereas normal weight and overweight women displayed a low concordance in their results and appeared to be less accurate reporters. These results were the opposite than initially hypothesized which theorized just the opposite findings that thought obese women would be the least accurate reporters compared to the lean or overweight women.

Over time and by month 12, all participants involved in this physical activity promotion study improved their ability to accurately identify and report physical activity, which may relate to the on-going education regarding types and intensities of physical activity. These results are in partial agreement with the initial hypothesis which thought that all women would improve in their reporting ability (which they did), but the hypothesis also thought that obese women would have less improvements in their reporting accuracies at this time point when compared to the other groups (which it did not).

Overall, these results were different from originally hypothesized which thought obese women would be the least accurate reporters than the other BMI groups at all time points. No significant differences were apparent between the total numbers of minutes reported at one specific time point or by each weight status group but only the strength of the correlations for self-reported behaviors. Additionally, it cannot go without further discussion that despite obese women having the strongest correlations at each of the three time points; they were also the only weight category that did not demonstrate significant increases in monitor values over time whereas the normal weight and overweight women did. It is uncertain whether the obese women might have been better able to accurately report activities since there values were not changing over time, whereas the normal weight and overweight women were demonstrating significant increases in their activity (ActiGraph values) over time.

Further studies within this study group need to examine the factors associated with reporting differences among participants with varied weight status. During this study, participation in the treatment assignment versus control intervention groups were not evaluated. Evaluation of body mass index subgroups within each of the three treatment interventions need further assessments to determine if correlations or accuracy of self-report was indicative of the physical activity intervention or whether it was specifically related to the participants' body weight.

Thus far, researchers have found that both lifestyle and structured exercise programs may improve physical activity levels in previously sedentary adults (Dunn et al., 1999). Limitations in this area of research not only include the implementation of the exercise itself, but also limitations exist in the researchers' ability to capture or record physical activity levels due to underdeveloped research mechanisms for measurement. The combined data capturing both subjective and objective measurement mechanisms enhances measurement abilities;

however, both strategies have variances when used in a population of varied weight status.

Self-report questionnaires offer the benefit of being comparatively inexpensive, easy to distribute and relatively simple to administer especially for large scale studies (Durante & Ainsworth, 1996; Sallis & Saelens, 2000). However, self-report questionnaires are subject to limitations in their implementation within research studies. Such limitations may affect accuracy of self-report questionnaires and are contingent upon level of instruction, description of variables and recall period. Questionnaires that rely solely on participant recall have been found to have an increased capability of capturing more detailed data if shorter time periods (e.g. ≤ 3 days) are used. Shorter periods are more sensitive to patterns of change (Kriska, & Caspersen, 1997). However, this was not perfectly represented in this study population since the questionnaires were capturing 7 days of data at one time by participant recall.

Additionally, a method to strengthen data capture by questionnaire lies in the researchers' ability to provide proper instruction to participants also determines whether participants understand how to answer self-report items (Mader et al., 2006). This level of instruction was implemented into this original study protocol at each time point by demonstrating a 2-minute walk test with participants to better aid in their understanding of moderate intensity physical activity. This level of instruction hoped to achieve better participant understanding in how to score their physical activity levels on the 3D-PAR questionnaire. However, it remains unclear, even with this level of instruction why poorer correlations were found still at baseline in all weight groups. This may also indicate that even with detailed physical activity demonstrations given upon study enrollment, participants may have still been unclear as to what level and intensity was appropriate to report. By 3 and 12 months, subjects may have gotten more familiar with the reporting mechanism and structure of the questionnaire and this alone may have enhanced their reporting ability.

In addition to instructional variations in self-report questionnaires, some variables may be beyond the control of researchers. The ability to measure physical activity by self-report has also been questioned based on the participants weight status (Timperio et al., 2003). Timperio et al. found that women’s ability to accurately self-report physical activity was found only in those who were not overweight. However, the results of this present study found just the opposite results in that obese women were actually the most accurate reports at all time points in this sample set. Additionally, previous findings by Mahabir et al. (2006) concluded on 3 to 4 questionnaire methods obese women overestimated energy expenditure the most. Again, this present study reported different findings, which found obese women actually reported their physical activity level most accurately when compared to objective data capture of the ActiGraph accelerometer.

The findings of this study also differ from previous research that directly studied overweight and obese women's ability to accurately estimate caloric intake and energy expenditure. Lichtman et al. (1992) reported that obese women who were enrolled within weight loss studies often fail to lose weight because they are found to underestimate caloric intake and overestimate physical activity. Additionally, Abbot et al. (2008) reported that overweight women might possess certain psychosocial or behavior components that might increase the likeliness of these women to inaccurately self-report. Potentially, since the findings of Lichtman and Abbot were found among women enrolled within a weight loss intervention study, it could possibly explain why findings of this current study were slightly different. Perhaps when the focus is solely on weight reduction and not only on physical activity promotion, women may transform in their ability to accurately report their behaviors.

Factors such as reactivity, social recall bias and social desirability also known to skew self-report accuracy (Adams et al., 2005). Participants may unintentionally have the desire to please researchers by over-reporting amounts of physical activity due to their inabilities to achieve their exercise goals (Jakicic et al., 1997). This is known to cloud data, and produce inaccuracies; however, it is not clear in this study whether these factors were present. Other studies have found differences in physical activity levels among participants of varied weight status that directly relate to social support, self-efficacy and access to exercise facilities (Blanchard et al., 2005). These researchers found that obese individuals (both men and women) were engaging in less physical activity over time compared to normal weight or overweight individuals and these findings were direct correlations of the variables listed above. Thus, in addition to the aspects of physical activity intervention, social ecological variables also need to be considered when evaluating a population of varied weight (Blanchard et al., 2005).

Finally, exposure effects of participants enrolled in a research study notably affect responses on self-report questionnaires according to Baranowski et al. (2006). Participants may respond differently because their interpretation of questions distorts once enrolled in an intervention, thereby biasing results (Baranowski et al., 2006). This factor may additionally be true, however in the case of the study, the exposure effects of the trial may have worked to the advantage of both the researchers and the participants simply because they may have increased their knowledge about physical activity and may have altered their activity levels accordingly.

In regards to the ActiGraph accelerometer, there are some potential concerns to address within this trial. Previous research has indicated that the ActiGraph accelerometer will supply the highest reliability when operated between 0° and 15° (Metcalf, 2002). Since Hemmingsson & Ekelund (2007) identified that obesity and body fatness may result in potential measurement errors since excessive body fatness at the accelerometer attachment site may cause tilting and measurement differences leading to reduced reliability of the device (Hemmingsson & Ekelund, 2007). Additionally, these results are substantially important especially when using the ActiGraph accelerometer in overweight and obese populations where abdominal adiposity may interfere with accelerometer placement, thus potentially tilting this instrument and reducing validity within this sample population.

With these studies taken into consideration, it cannot go with out saying that despite the theory that obese participants may have a lessened degree of accuracy, this study found the contrary results. This obese population indicated an increased ability to report their physical activity levels. Further studies clearly need to evaluate the potential reasons for these findings in more detail. Also further assessment of women’s reporting abilities in the context of physical activity promotion studies are necessary in order for researchers to clearly draw conclusions about women’s body size and their ability to self-report behaviors.

CHAPTER 4

COMPARISON OF 3-DAY PHYSICAL ACTIVITY RECALLS AND ACTIGRAPH DATA CORRELATION BY GROUP ASSIGNMENT AND BODY MASS INDEX

Abstract

This study's purpose was to determine if BMI and study group assignment were related to the validity of self-reported versus objective physical activity measurements within the context of a physical activity promotion trial. Women (n= 280; mean age= 47.1), were randomly assigned to one of three intervention groups: (a) Choose to Move (CTM), self-help booklet (n=93); (b) Jumpstart, motivationally tailored, print based intervention (n=95); or (c) Wellness, women's health materials (n=92). A randomly selected subsample simultaneously wore an ActiGraph accelerometer and completed a 3-Day Physical Activity Recall (3D-PAR) at baseline, months 3 (3M) and 12 (12M). At baseline, none of the women, regardless of treatment assignment or weight status demonstrated significant correlations in their self-reported activity compared to ActiGraph data. By 3M, overweight and obese women (Wellness), demonstrated a high degree of concordance ($r= 0.58$; $p< 0.003$ & $r= 0.70$; $p< 0.002$ respectively), while obese women (Jumpstart) demonstrated a

moderate degree of concordance ($r = 0.43$; $p < 0.03$). There were no significant correlations found within the CTM group at this time. Finally, by 12M, normal weight women demonstrated a moderate degree of concordance in all three treatment assignments (CTM; $r = 0.65$; $p < 0.01$; Jumpstart; $r = 0.54$; $p < 0.02$; Wellness; $r = 0.59$; $p < 0.03$). Overweight women demonstrated a high degree of concordance only in the CTM group ($r = 0.63$; $p < 0.002$). Lastly, obese women demonstrated a moderate degree of concordance (Jumpstart) ($r = 0.50$; $p < 0.01$).

These results indicate that participants of varied weight status may vary in their ability to accurately report physical activity behaviors over time when randomized to different treatment groups. Although there were no conclusive patterns to these results, future studies should examine the extent to which women of varied weight status respond differently to treatment interventions. Further studies are needed to examine the factors associated with reporting differences among these women.

Introduction

Physical activity levels continue to diminish while obesity rates soar especially in women (Colditz, 1999). Participation in regular physical activity may be a major contributing factor in combating this obesity epidemic. It has also been found that engaging in regular physical activity is an integral component in the prevention and treatment of not only obesity but also a fundamental factor in reducing chronic disease (CDC, 2007; USDHHS, 2002; Grundy et al., 1999). Additionally, involving women in physical activity promotion studies educates women about the importance of physical activity as well as assists women to make activity a regular part of their lifestyle (Dunn et al., 1999). The public health burden of obesity and physical inactivity heightens the need for programs to promote physical activity interventions in a manner that is suitable to meet the needs of the female population.

Various studies continue to focus on finding the most advantageous avenue of a physical activity promotion or intervention. Thus far, researchers have found that both lifestyle and structured exercise programs may improve physical activity levels in previously sedentary adults (Dunn et al., 1999). Frequently face-to-face interventions are used to implement research protocols however; limitations can exist and restrict treatment modalities to smaller populations. Recently, implementation and evaluation of non face-to-face treatment modalities were being reviewed for efficacy (Marcus et al., 1998; Napolitano et al., 2006). No studies to my knowledge, specifically looked at the differences between results achieved from non-face-to-face treatment modalities when compared specifically within populations with varied weight status (normal, overweight and obese).

The data for this study were part of a physical activity promotion study that was conducted at the Miriam Hospital/Brown Medical School in Providence, RI and in communities in Southeastern Massachusetts from 2002 to 2005. In this trial, 280 women (mean age= 47.1), were randomly assigned to one of three physical activity intervention groups: (a) Choose to Move, a self-help printed booklet (n=93), (b) Jumpstart, a motivationally tailored, print based intervention (n= 95), or (c) Wellness, women's health materials. Additionally, within these group assignments, a randomly selected sub sample of participants simultaneously wore an ActiGraph accelerometer and completed a 3-Day Physical Activity Recall (3D-PAR) at baseline (n=83), 3 months (n=174) and 12 months (n=165).

The main purpose of this study was to evaluate the reporting effectiveness of physical activity behavior both by group assignment and by BMI. It was hypothesized that longitudinal comparisons would find normal weight, overweight and obese women who participated in any of the physical activity intervention groups (Choose to Move, Jumpstart or Wellness) would have no differences in their accuracy of self-reported physical activity measures compared to accelerometry data at baseline. Longitudinal comparisons were hypothesized to find overweight and obese women who participated in the physical activity intervention groups (Choose to Move or Jumpstart) would have improved accuracies on self-report physical activity measures when compared to accelerometry data by 3 months compared to those who participated in a control group (Wellness). Finally, longitudinal comparisons were hypothesized to find that overweight and obese women who participated in the physical activity intervention groups (Choose to Move or Jumpstart) would have improvements in their reporting accuracy by 12 months compared to those who participated in the Wellness groups. These hypotheses were intended to conclude that overweight and obese women, upon enrollment and group participation would be responsive to the group treatment intervention than overweight or obese women who participated in the control group.

Materials and Methods

Recruitment and Participant Criteria

Data obtained for this study were previously collected from a physical activity promotion study including 280 healthy women, ages 18 to 75 years. Eligible participants had to be sedentary females with a Body Mass Index less than 40 kg/m^2. There were two participants who were considered underweight (BMI $\leq$ 18.5). This underweight category was too small to be evaluated on its own, therefore it was collapsed into the normal BMI category. Eligible candidates also could not be participating in more than 90 minutes of purposeful moderate-intensity physical activity (i.e. walking) or more than 60 minutes of vigorous intensity activity per week. Participants enrolled for this trial also had to agree to be randomly assigned to one of three treatment interventions. Participants also had to be free of any medical problems that could impede or be exacerbated by physical activity and a Physical Activity Readiness Questionnaire (PAR-Q) was used to screen for these health problems (e.g. asthma, severe osteoarthritis, cardiovascular disease) (Napolitano et al., 2006).

Treatment Interventions

Once selected, participants were randomized into one of three intervention group assignments: (a) Choose to Move (n=93); (b) Jumpstart (n=95); or (c) Wellness (n=92).

Chose to Move. The material for this group was developed by the American Heart Association to help women adopt and maintain physical activity. Participants in this group assignment received one mailing, immediately following randomization, of the Chose to Move (CTM) booklet and a letter explaining how to use the materials. The CTM materials were a 12-week program targeted towards women; each week covered a topic of relevance from the Social Cognitive Theory and Transtheoretical model. The format of these materials was brief and concise with logs and self-help worksheets included. Participants in this group were instructed to keep track of their physical activity levels daily.

Jumpstart. Jumpstart materials were developed and validated by Miriam Hospital and Brown University (Marcus et al., 1998). Participants completed a 65-item questionnaire at baseline and prior to each assessment time point (3 and 12 months), assessing stages of change, processes of change, self-efficacy and decisional balance related to physical activity behaviors. Once study staff received the returned questionnaire, responses were entered into system computer software and tailored feedback was generated and sent to each participant. The Jumpstart intervention consisted of individually tailored feedback addressing self-efficacy, barriers, benefits, social support, goal setting (Marcus et al., 1998); a booklet matching each participant’s Stage of Motivational Readiness for Change; as well as a letter explaining how to utilize the materials. Participants in this treatment group were also instructed to keep track of their physical activity levels on a daily basis.

Wellness. This arm was the control group in which participants received one mailing of women's health information, including topics such as nutrition, cancer prevention, and sleep.

Physical Activity Outcome Measures

ActiGraph Accelerometer. The Actigraph accelerometer, (formerly Computer Science and Applications CSA) model 7164 from Manufacturing Technology Inc. (Fort Walton Beach, Florida), is a small, noninvasive, lightweight, uniaxial instrument that can record and store acceleration as well as deceleration of movements (Actigraph LLC, 2004). The Actigraph accelerometer measures 2 x 1.6 x 0.6 in., weighs 1.5 ounces, and records accelerations from 0.05 g to 2.13 g while powered by a lithium battery (ActiGraph LLC, 2004; Welk, 2002).

When worn, the accelerometer captures movement that results in acceleration. The movement then acts on a cantilevered piezoelectric beam and produces a charge proportional to the strain. The acceleration signal filters by an analog bandpass filter and digitized by and 8-bit A/D converter at a rate of 10 samples per second (ActiGraph users manual). Each signal stores data over a user-specific interval of time (i.e., 1 minute). The Actigraph initializes and downloads using a reader interface that is connected to the serial port of a computer. Actigraph data measures counts of activity per unit time and represents the level and intensity of the activity. The Actigraph accelerometer is distinctive since it can detect continuous and intermittent bouts of physical activity which is unique in capturing lifestyle as well as structured physical activity, which can be unpredictable and sporadic (Mâsse et al., 1999).

To evaluate time spent in various activity levels, cut-points established by Freedson and colleagues were used to classify moderate intensity physical activities. Activities that recorded below 500 $ct \cdot min^{-1}$ (inactivity) were interpreted to represent sitting or relatively stationary standing activities of less than 3 METs (e.g. dusting, ironing, laundry, washing dishes etc.). Times recorded in the 500 to 1951 $ct \cdot min^{-1}$ range (moderate-1) were interpreted to represent moderate (3 to 6 METs) activities requiring lower levels of ambulation (e.g. window washing, vacuuming, gardening, yard work, tennis or softball). Time spent in the 1952 to 5724 $ct \cdot min^{-1}$ range (moderate-2) was interpreted to represent ambulatory activities between 3 and 6 METs (e.g. walking). Time spent in activities above 5725 $ct \cdot min^{-1}$ (vigorous) was interpreted as vigorous (>6 METs) ambulatory activity (e.g. running). Minute-by-minute data were summarized into daily averages for average ($ct \cdot min^{-1} \cdot d^{-1}$) and total activity counts ($ct \cdot d^{-1}$) for times when the monitor was worn and for activity durations ($min \cdot d^{-1}$) in activity levels outlined above.

Collection of Accelerometry Data. A randomly selected subset of the study population was chosen to wear the ActiGraph accelerometer for three days. Participants were given an envelope that instructed whether they were selected to wear the ActiGraph monitor and the participants were instructed to wear the monitor on Sunday, Monday and Tuesday or Thursday, Friday and Saturday thereby including a weekend day. Participants scheduled to wear the ActiGraph monitor were also given a courtesy reminder call the evening before.

At baseline, the participants were instructed how to wear the monitor, snugly at the waistline, attached with a clip and with the notch down. Participants were also taught how to find the mid-axillary line and place the ActiGraph monitor over their right hip. Participants were instructed to always wear the monitor on the right hip throughout the entire study to aid in reliability. The participants were also instructed to put the monitor on as soon as they awaken and remove it at bedtime and when showering or swimming. They were asked to be very careful to not drop the monitor because the sensors are very sensitive and can easily be broken. They were reminded to call study staff if they felt anything unusual happened to their monitor during their three-day period this way study staff could either replace the monitor or indicate the mishap appropriately. These same instructions were given to participants at both 3 month and 12 month assessments.

Each participant simultaneously completed a physical activity log documenting the on and off times of wearing the monitor. Participants were advised to engage in typical behaviors on the days they were wearing the monitor. Additional activities such as biking, swimming or weight training was to be documented in their dairy that they turned into study staff upon returning the monitor.

Physical Activity Recall Questionnaire (7D-PAR). The participants additionally completed an interviewer-administered 7D-PAR during the same period in which they were wearing the ActiGraph monitor (analysis only used 3 of the 7 days collected) (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR has established validity and reliability (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR is able to classify physical activities as light, moderate, hard and very hard intensity. Appropriately trained study staff followed the interview protocol, as it was originally outlined (Sallis et al. 1985). For this study three days worth of the 7D-PAR data was used to quantify minutes of moderate intensity physical activity that were at least 10 minutes in duration. Prior to the PAR administration, all participants partook in a 2-minute moderate intensity demonstration that was facilitated by study staff to express walking pace at moderate intensity. This strategy was implemented prior to the participants completing the PAR thus providing a benchmark of moderate intensity physical activity to help gauge their responses. This 2-minute walking test was administered at baseline, 3-months and 12-months.

Once collected from the 7D-PAR, activities were coded into various physical activity categories and were entered in the data set as minutes of total activity. Three days worth of data was entered both as a total value for each of the days as well as a three-day average. At baseline, only 83 of the 280 participants completed the interview-administered PAR due to financial limitations. However, by 3 months (n= 174) and 12 months (n= 165), funding increased to allow for more of the sample population to complete the interview-administered PAR which made available more comparative data for analysis.

Data Analysis and Interpretation

Participants were sorted by treatment group assignments (Choose to Move, Jumpstart & Wellness) as well as body mass index to compare differences between groups at specific time points. ANOVA tests computed differences between the three different intervention groups and for BMI groups. Appropriate Tukey Post Hoc analyses were computed when statistical significance was detected differences in any of the group assignments. Pearson product correlations compared ActiGraph minutes to 3D-PAR minutes concordance at baseline, 3 months and 12 months. All analyses were performed using SPSS (SPSS Inc., Chicago, IL, Release 14.0.). Significance was set at an alpha level of $P < 0.05$. All data were reported as the means ± SE.

Results

The purpose of this study was to compare women's ability to self-report their physical activity levels by use of a subjective measurement questionnaire (3D-PAR) in comparison to an objective measurement technique of the ActiGraph accelerometer. This study took into consideration the participants BMI and their treatment assignments to compare their degree of concordance in physical activity measurement. These comparative measurements were captured for 3 days at baseline, 3 months and 12 months. First, the number of participants in each category were computed and stratified by body mass index as well as and group assignment. Baseline stratification had slightly smaller group representation due to the fewer sample of participants with available 3D-PAR data. Results are displayed in Table 9.

Participant Descriptive Statistics

Table 9. Participant Characteristics with 3D-PAR and ActiGraph Accelerometer by Group Assignment and Body Mass Index

	Treatment Group		
	Choose to Move (n=93)	Jumpstart (n= 95)	Wellness (n=92)
BMI ≤ 24.9			
Baseline	8	6	5
3-Month	15	19	14
12-Month	16	20	14
BMI ≥ 25.0 & ≤ 29.9			
Baseline	14	6	13
3-Month	19	17	25
12-Month	21	16	19
BMI ≥ 30.0			
Baseline	11	13	7
3-Month	20	27	17
12-Month	18	27	16

Mean Values, Standard Deviations and Pearson Product Correlations by Group and BMI

Next, still stratifying the sample population by group assignment and BMI, means and standard deviations for both ActiGraph monitor minutes as well as 3D-PAR minutes were computed. Additionally represented in these results are the

Pearson product correlation values within each treatment group at each of the three time points. Results are displayed in Tables 10., 11., and 12.

Table 10. Means for 3D-PAR and ActiGraph by Choose to Move group assignment and BMI. ***Means are based on Descriptive Statistics***

	Measurements			
	3-Day PAR	ActiGraph	Pearson Correlation	P-Value
Choose to Move (n=93)				
Baseline				
BMI ≤ 24.9	78.50	46.18	r=-0.34	0.41
BMI ≥ 25.0 ≤ 29.9	39.29	51.96	r= 0.53	0.86
BMI ≥ 30.0	52.27	44.14	r= 0.02	0.96
3 Months				
BMI ≤ 24.9	51.47	53.00	r= 0.21	0.49
BMI ≥ 25.0 & ≤ 29.9	50.26	51.75	r= 0.36	0.13
BMI ≥ 30.0	38.96	33.00	r= 0.32	0.17
12 Months				
BMI ≤ 24.9	75.00	76.07	r= 0.65*	0.013
BMI ≥ 25.0 & ≤ 29.9	72.43	73.00	r= 0.63**	0.002
BMI ≥ 30.0	98.25	45.28	r= 0.21	0.43

Note: Values are Means per Group
Note: *p ≤ 0.05
**p ≤ 0.01

Within the Choose to Move group treatment arm when stratified by BMI, statistical significance was not found until 12 months. AT the 12-month time point the normal weight and overweight women both indicated a high degree of concordance in their ability to accurately report their physical activity levels (BMI ≤ 24.9; r= 0.65*; p<0.01 and BMI ≥ 25.0 & ≤ 29.9; r= 0.63**; p< 0.002).

Table 11. Means for 3D-PAR and ActiGraph by Jumpstart group assignment and BMI. ***Means are based on Descriptive Statistics***

	Measurement			
	3D-PAR	ActiGraph	Pearson Correlation	P-Value
Jumpstart (n=95)				
Baseline				
BMI ≤ 24.9	50.00	43.86	r=-0.09	0.85
BMI ≥ 25.0 & ≤ 29.9	60.00	57.00	r=-0.00	0.99
BMI ≥ 30.0	31.92	41.48	r=-0.19	0.54
3 Months				
BMI ≤ 24.9	50.24	44.32	r=-0.70	0.78
BMI ≥ 25.0 & ≤ 29.9	96.76	54.94	r=-0.19	0.48
BMI ≥ 30.0	48.39	49.89	r= 0.43*	0.03
12 Months				
BMI ≤ 24.9	56.60	57.45	r= 0.54*	0.02
BMI ≥ 25.0 & ≤ 29.9	89.56	62.35	r= 0.12	0.67
BMI ≥ 30.0	56.61	51.85	r= 0.50*	0.01

Note: Values are Means per Group
Note: *p ≤ 0.05
**p ≤ 0.01

Within the Jumpstart group assignment, statistical significance was found at both 3 and 12 months. At the 3-month time point the obese women both indicated a moderate degree of concordance in their ability to accurately report their physical activity levels (BMI ≥ 30.0; r= 0.43*; p < 0.03). By 12 months both normal weight and obese women indicated a moderate degree of concordance in their reporting abilities (BMI ≤ 24.9; r= 0.54*; P <0.01 and BMI ≥ 30; r= 0.50*; P < 0.01). Thus, obese women participating in a treatment group may appear to have an increased ability to accurately self-report physical activity levels at 3 and 12 months compared to normal weight and overweight groups at all time points.

Table 12. Means for 3D-PAR and ActiGraph by Wellness group assignment and BMI. ***Means are based on Descriptive Statistics***

	Measurements			
	3D-PAR	ActiGraph	Pearson Correlation	P-Value
Wellness (n=92)				
Baseline				
BMI ≤ 24.9	54.00	43.40	r=-0.06	0.92
BMI ≥ 25.0 & ≤ 29.9	57.31	35.73	r= 0.14	0.66
BMI ≥ 30.0	109.29	33.65	r= 0.54	0.21

Table 12. Continued: Means for 3D-PAR and ActiGraph by Wellness group assignment and BMI

	Measurements			
	3D-PAR	ActiGraph	Pearson Correlation	P-Value
3 Months				
BMI ≤ 24.9	43.21	56.00	r= 0.48	0.08
BMI ≥ 25.0 & ≤ 29.9	33.40	44.04	r= 0.58**	0.003
BMI ≥ 30.0	39.75	49.53	r= 0.70**	0.002
12 Months				
BMI ≤ 24.9	52.14	56.14	r= 0.59*	0.033
BMI ≥ 25.0 & ≤ 29.9	84.89	60.98	r= 0.19	0.46
BMI ≥ 30.0	31.67	41.38	r= 0.42	0.10

Note: Values are Means per Group
Note: *p ≤ 0.05
**p ≤ 0.01

Within the Wellness or control group assignment, statistical significance was found again at both 3 and 12 months. At the 3-month time point the overweight and obese women both indicated a high degree of concordance in their ability to accurately report their physical activity levels (BMI ≥ 25.0 & ≤ 29.9; r= 0.58**; p< 0.03 and BMI ≥ 30.0; r= 0.70**; p< 0.002 respectively). However, by 12 months only normal weight women were the weight category to indicate a moderate degree of concordance in their reporting abilities (BMI ≤ 24.9; r= 0.59*; p< 0.033). Taken together these results are a little unclear in their findings of overweight and obese women demonstrating a high degree of concordance at 3 months, but no longer by 12 months.

Discussion

This study was designed to evaluate the effect of group assignment on reporting ability over time and by BMI. The results of this study were found to vary between group assignment and BMI therefore, making it difficult to draw definitive conclusions. It had been originally hypothesized that at baseline, no significant differences would be found based on BMI or treatment group. This hypothesis was found to be true; no significant differences were found at baseline regardless of treatment group or BMI stratification. Since random group assignment had occurred in this trial and treatment intervention had not yet been initiated by baseline, these results would be as anticipated.

The next hypothesis theorized that by 3-months, overweight and obese women participating in the treatment groups (Choose to Move and Jumpstart) would demonstrate higher degrees of concordance in their ability to accurately self-report physical activity behaviors when compared to overweight or obese women in the control group (Wellness). This hypothesis was rejected based on the findings of this study. Only the obese women who participated in the Jumpstart group had a moderate degree of concordance by 3-months, whereas both overweight and obese women in the Wellness group demonstrated high degrees of concordance ($r= 0.58^{**}$; $p< 0.01$ and $r= 0.70^{**}$; $p< 0.01$ respectively). These findings are inconclusive at this time and further studies would be necessary to determine why the treatment within the control arm potentially demonstrated greater effectiveness in communicating physical activity education. Also it would need to be further evaluated why this type of treatment enabled overweight and obese women to better identify and self-report physical activity behaviors at this time point.

Lastly, it was originally hypothesized that overweight and obese women participating in the treatment assignment (Choose to Move and Jumpstart) would demonstrate a higher degree of concordance in their ability to self-report behaviors by 12-months when compared to overweight and obese women who participated in the control group (Wellness). These results are in agreement with the initial hypothesis. It was found that overweight women in CTM and obese women in Jumpstart demonstrated either high or moderate degrees of concordance (CTM-overweight $r= 0.63^{**}$; $p< 0.01$ and Jumpstart-obese $r= 0.50^{*}$; $p< 0.05$ respectively). Neither overweight nor obese women participating in the Wellness group demonstrated significant correlations by 12-months, while normal weight women at this time point also have significant concordance. This provides some evidence for the differences in reporting ability by weight status. Only overweight and obese women who were randomly assigned to a physical activity treatment arm by 12 months demonstrated a high or moderate degree of concordance.

It is also worth mentioning that the normal weight women clearly indicated moderate degrees of concordance by 12-months in each of the three treatment assignments but not at baseline or 3-months. Potential interpretations of these findings would be that normal weight women might have an increased ability over time to accurately identify and self-report physical activity behaviors overtime regardless of their treatment assignment. It may be further interpreted that normal weight women may possess differences in their ability to accurately report activity without reliance or dependence on their participation in a physical activity promotion trial.

Overall, the findings for the overweight and obese women within the context of this study are somewhat inconclusive. Overweight and obese women appeared to be most responsive at 3-months to the Wellness group assignment in their ability to accurately identify and report physical activity behaviors. However, these findings did not carry out until 12-months since no significant correlations were found. Additionally, overweight women were found to have the highest degree of concordance at 12-months within the Choose to Move group whereas the obese women demonstrated no significant correlations within this treatment assignment at any time point. Since overweight women were found to have no significant correlations within the Jumpstart intervention, it is unclear why then obese women demonstrated modest correlations at both 3 and 12 months within this treatment intervention. Finally, both Wellness and Jumpstart groups were found to have the highest correlations for both overweight and obese women, yet since this a control arm these findings were not anticipated regardless of weight status. Potentially, some of the limitations that were apparent in this sub-study were related to the very small number of participants available once the groups were first spilt by treatment, but then split again by BMI. Some groups were found to have a few as five participants with comparative date available thereby these analyses were greatly underpowered. Quite possibly differences may have been found if both Choose to Move and Jumpstart physical activity treatment arms were collapsed together, then compared to the Wellness group, but given the current pattern of results, the further examination of these data were not yet undertaken.

Further studies need to be conducted with a greater number of participants in each subgroup to be able to determine why women of varied weight status may demonstrate the ability to accurately identify and report physical activity behaviors at certain time points however do not results in significant trends over time. Also, by potentially stratifying the group randomization process along with BMI and current baseline activity levels, may allow these potential trends to be further explored.

It is possible that this “avis effect” which discussed a reactive nature of behavior and improvements within control arms of intervention where they were otherwise unlikely to occur (Napolitano et al., 2006; Thomas et al., 2005). Also identified in the parent trial, via focus groups, researchers found women in the Wellness group deduced the study goal was to increase physical activity levels (Napolitano et al., 2006). Women in the Wellness group also reported they wanted to “prove” their abilities to increase their physical activity levels by the 12-month end of the study to impress upon study staff as to how well they had done (Napolitano et al., 2006). Thus, their potential “proving” of physical activity levels may have influenced their reporting accuracy. Also, due to this awareness of treatment effects, this may help explain why women regardless of their weight status showed increased abilities to report their activity levels. However, it was still inconclusive why these trends occurred sometimes at 3-months, but were longer apparent by 12 months. Further research needs to evaluate the effects the physical activity intervention materials and evaluate their effectiveness in the populations of varied weight status.

CHAPTER 5

COMPARISON OF PHYSICAL ACTIVITY PREFERENCE BY BODY MASS INDEX CATEGORY

Introduction

Physical activity can be defined as “any bodily movement by skeletal muscles that results in energy expenditure” (Casperson et al., 1985) and may include anything from occupational activities, discretionary activities, optional household tasks, socially desirable activities and activity for physical fitness and health promotion (FAO/WHO/UNU, 2001). The proposed physical activity guidelines are intended to assist the American population in evaluating their current physical activity levels and modifying their activity levels accordingly.

Existing guidelines indicate that moderate-intensity physical activity is an appropriate dose considered safe and effective for disease prevention (Haskell et al., 2007; Lee & Paffenbarger, 2000; Pate, 1995; USDHHS, 1996). The current physical activity guidelines are as follows: at least 30 minutes of moderate-intensity physical activity should be accumulated on most, preferably all, days of the week (Haskell et al., 2007; Pate et al., 1995) or 2.5 hours per week (USDHHS, 2008). Adults could alternately try to engage in vigorous-intensity physical activity three or more days per week, 20 minutes per session (Haskell et al., 2007; USDHHS, 2002) for the same health benefits. Otherwise, aim for a total of one hour and 15 minutes of vigorous intensity activity per week according to the recent release of updated guidelines (Haskell et al., 2007; USDHHS, 2008). Through the development of these physical activity guidelines, health organizations continually strive to promote Americans to initiate or increase current levels of physical activity for the benefit their health.

Engaging in regular physical activity is an integral component in the prevention and treatment of obesity and thereby a fundamental factor in reducing chronic disease (CDC, 2007; Grundy et al., 1999; USDHHS, 2002). Research has shown that women are more prone to the consequences of all cause and cardiovascular mortality based on their weight status and physical activity levels compared to men (Farrell, Braun, Barlow, Cheng & Blair, 2002; Kesaniemi et al, 2001; Oguma, Sesso, & Paffenbarger, 2002). It is also known that despite the benefits of physical activity, overweight or obese individuals are more physically inactive, compared to their leaner peers (Adams, Der Anaian, DuBose, Kirtland & Ainsworth, 2003; Cooper, Page, Fox & Misson, 2000; Davis, Hodges & Gillham, 2006). Between both sexes, walking is the most frequently reported activity (37.7% for men and 52.5% for women). Additionally, among women the most commonly reported activities were, aerobics (8.7%), gardening (8.2%), and using exercise machines (6.0%)(CDC, 2008h). Despite these statistics, physical activity preferences by weight category have not been deciphered.

The purpose for this study was to evaluate the types and quality of the physical activities in which the sample population engaged. Longitudinal comparisons of physical activity preference were evaluated specifically by body mass index (normal weight, overweight and obese participants). It was hypothesized that comparisons would find that overweight and obese women prefer nontraditional methods of physical activity (i.e. lifestyle) compared to their lean counterparts who may prefer more traditional forms of physical activity (i.e. structured). It was also hypothesized that overweight and obese women would prefer lifestyle, non-structured physical activity (i.e. gardening, housework, chores) compared to lean counterparts who may prefer structure activities (aerobics, walking, running, sports). Finally, it was hypothesized that overweight and obese women would accumulate physical activity through multiple bouts of non-structured activity compared to their lean counterparts who may accumulate physical activity in one long continuous bout.

These theories may help researchers design physical activity promotion studies in the future geared to meet the specific needs of women of all body types and weight categories. Future interventions could then be designed to include both lifestyle and structure physical activity interventions based on the populations studied. The types of promotion studies, if specifically designed to meet the preferences of all weight categories, may additionally have the opportunity to impact women's physical activity patterns long beyond the scope of the study intervention.

Materials and Methods

Recruitment and Participant Criteria

Data obtained for this study were previously collected from a physical activity promotion study including 280 healthy women, ages 18 to 75 years. The participants were previously recruited from Providence, Rhode Island and the communities surrounding southeastern Massachusetts area from 2002 to 2005. Eligible participants had to be sedentary females with a BMI less than 40 kg/m^2. Two participants were found to be underweight according to BMI calculations (BMI $\leq$ 18.5). Since this weight category was too small to be evaluated individually, therefore the underweight category was collapsed into the normal weight BMI category for all future analyses. Eligible candidates also could not be participating in more than 90 minutes of purposeful moderate-intensity physical activity (i.e. walking) or more than 60 minutes of vigorous intensity activity per week. Participants enrolled for this trial also had to agree to be randomly assigned to one of three treatment interventions. Participants also had to be free of any medical problems that could impede or be exacerbated by physical activity and a Physical Activity Readiness Questionnaire (PAR-Q) was used to screen for these health problems (e.g. asthma, severe osteoarthritis, cardiovascular disease) (Napolitano et al., 2006).

Height and weight measurements were collected at each of the three visits by study staff using standard operating procedures and body mass index was calculated correspondingly.

Physical Activity Outcome Measures

ActiGraph Accelerometer. The Actigraph accelerometer, (formerly Computer Science and Applications CSA) model 7164 from Manufacturing Technology Inc. (Fort Walton Beach, Florida), is a small, noninvasive, lightweight, uniaxial instrument that can record and store acceleration as well as deceleration of movements (Actigraph LLC, 2004). The Actigraph accelerometer measures 2 x 1.6 x 0.6 in., weighs 1.5 ounces, and records accelerations from 0.05 g to 2.13 g while powered by a lithium battery (ActiGraph LLC, 2004; Welk, 2002).

When worn, the accelerometer captures movement that results in acceleration. The movement then acts on a cantilevered piezoelectric beam and produces a charge proportional to the strain. The acceleration signal filters by an analog bandpass filter and digitized by and 8-bit A/D converter at a rate of 10 samples per second (ActiGraph users manual). Each signal stores data over a user-specific interval of time (i.e., 1 min). The Actigraph initializes and downloads using a reader interface that is connected to the serial port of a computer. Actigraph data measures counts of activity per unit time and represents the level and intensity of the activity. The Actigraph accelerometer is distinctive since it can detect continuous and intermittent bouts of physical activity which is unique in capturing lifestyle as well as structured physical activity, which can be unpredictable and sporadic (Mâsse et al., 1999).

To evaluate time spent in various activity levels, cut-points established by Freedson and colleagues were used to classify moderate intensity physical activities. Activities that recorded below 500 $ct \cdot min^{-1}$ (inactivity) were interpreted to represent sitting or relatively stationary standing activities of less than 3 METs (e.g. dusting, ironing, laundry, washing dishes etc.). Time recorded in the 500 to 1951 $ct{\cdot}min^{-1}$ range (moderate-1) were interpreted to represent moderate (3 to 6 METs) activities requiring lower levels of ambulation (e.g. window washing, vacuuming, gardening, yard work, tennis or softball). Time spent in the 1952 to 5724 $ct{\cdot}min^{-1}$ range (moderate-2) was interpreted to represent ambulatory activities between 3 and 6 METs (e.g. walking). Time spent in activities above 5725 $ct{\cdot}min^{-1}$ (vigorous) was interpreted as vigorous (>6 METs) ambulatory activity (e.g. running). Minute-by-minute data were summarized into daily averages for average ($ct{\cdot}min^{-1}{\cdot}d^{-1}$) and total activity counts ($ct{\cdot}d^{-1}$) for times when the monitor was worn and for activity durations ($min{\cdot}d^{-1}$) in activity levels outlined above.

Collection of Accelerometry Data. A randomly selected subset of the study population was chosen to wear the ActiGraph accelerometer for three days. Participants were given an envelope that instructed whether they were selected to wear the ActiGraph monitor and the participants were instructed to wear the monitor on Sunday, Monday and Tuesday or Thursday, Friday and Saturday thereby including a weekend day. Participants scheduled to wear the ActiGraph monitor were also given a courtesy reminder call the evening before.

At baseline, the participants were educated how to wear the monitor, snugly at the waistline, attached with a clip and with the notch down. Participants were instructed how to find the mid-axillary line and place the ActiGraph monitor over their right hip. Participants were asked to always wear the monitor on the right hip throughout the entire study to aid in reliability. The participants were also reminded to put the monitor on as soon as they awaken and remove it at bedtime and when showering or swimming. They were informed to be very careful to not drop the monitor because the sensors are very sensitive and could easily be broken. They were asked to call study staff if they felt anything unusual happened to their monitor during their three-day period this way study staff could either replace the monitor or indicate the mishap appropriately. These same instructions were given to participants at both 3 month and 12 month assessments.

Each participant simultaneously completed a physical activity log documenting the on and off times of wearing the monitor. Participants were encouraged to engage in typical behaviors on the days they were wearing the monitor. Additional activities such as biking, swimming or weight training were to be documented in their diary that they turned into study staff upon returning the monitor.

Physical Activity Recall Questionnaire (7D-PAR). The participants completed an interviewer-administered 7D-PAR during the same period in which they were wearing the ActiGraph monitor (analysis only used 3 of the 7 days collected) (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR has established validity and reliability (Blair et al., 1985; Sallis et al., 1985). The 7D-PAR is able to classify physical activities as light, moderate, hard and very hard intensity. Appropriately trained study staff followed the interview protocol, as it was originally outlined (Sallis et al. 1985). For this study three days worth of the 7D-PAR data was used to quantify minutes of moderate intensity physical activity that were at least 10 minutes in duration.

Prior to the PAR administration, all participants partook in a 2-minute moderate intensity demonstration that was facilitated by study staff to express walking pace at moderate intensity. This strategy was implemented prior to the participants completing the PAR thus providing a benchmark of moderate intensity physical activity to help gauge their responses. This 2-minute walking test was administered at baseline, 3-months and 12-months.

Once collected from the 3D-PAR, activities were coded into various physical activity categories and were entered in the data set as minutes of total activity. Data were entered both as a total value for each of the three days as well as a three-day average.

Coding of Physical Activity Data from 3D-PAR. Original 3D-PAR activities were coded based on their reported description into the database. For these analyses, new variables were adding taking into account for these codes. “Structured” and “unstructured” activities were added to further define these physical activity variables for these analyses. Structured activities were computed if number of minutes was greater than 30 minutes of moderate intensity activity or 20 minutes of vigorous intensity activity for walking. Additionally, activities such as sports (cycling, kayaking, swimming, golf, volleyball) were coded as structured activities as were dancing, hiking, and jogging or gym activity. Unstructured activities were coded for activities that were less than 30 minutes of moderate intensity or less than 20 minutes of vigorous intensity physical activity for walking. Other unstructured activities included occupation related, yardwork, gardening, or housework. The Compendium of Physical Activities was referenced for defining and deciphering these activity variables (Ainsworth et al., 2000).

Data Analysis and Interpretation

All analyses were performed using SPSS (SPSS Inc., Chicago, IL, Release 16.0.). Significance was set at an alpha level of $P < 0.05$. All data were reported as the means ± SE. Data were sorted by weight categories by BMI (normal weight, overweight and obese). ANOVA tests with Tukey Post Hoc analyses were computed to compare all BMI categories and the physical activity variable (i.e. Meeting physical activity guidelines (MetRec) versus Meeting physical activity guidelines without including household activities (MetRecWo); structured versus non-structured minutes of activity; moderate intensity versus vigorous intensity). The purpose of these analyses were to discover patterns of physical activity within a complex set of variables. These analyses also serve to simplify the many physical activity variables present within the data set and allow for patterns and underlying relationships to be observed within these variables. Repeated measures analyses were also computed to detect changes over time within a set of variables among the BMI categories.

Results

The purpose of this study was to compare women of varied weight status and their preferences for physical activity as captured by a self-report subjective measurement questionnaire (3-Day Physical Activity Recall). PAR coding categories are summarized in Tables 13.0. and 14.0. Responses were categorized by the number of times the participant partook in each activity.

Table 13. Sample Responses on 3D-PAR of Physical Activities

Item	Item Description	Endorsed (%)
	Bike	.3
	Bike & Weights	.3
	Chop tree/move brush/digging	.1
	Chores taking care animals	.9
	Chores taking care animals/ Groceries/housework	.1
	Clean barn, feed animals	.1
	Clean	1.6
	Cleaned garage/moved furniture	.1
	Close pool/yardwork	.1
	Cultivating	.1
	Cut brush	.1
	Cut brush/load truck	.1
	Cut brush/rake	.1
	Dancing	.2
	Daycare-lifting kids	.4
	Delivering papers at work	.1
	Dig in garden	.1
	Dig/pull roots	.1
	Dig/rake	.2
	Dig/shovel/plant	.1
	Dig/weed	.3
	Digging	.6
	Digging trenches/carrying wood	.1

Table 13. Continued: Whole Sample Physical Activity Types

Item	Item Description	Endorsed (%)
	Dog walking/put in kennel	.1
	Edging	.1
	Elliptical/jog	.1
	Exercise bike and weights	.1
	Housework	.3
	Kayaking	.1
	Landscaping	.1
	Mop floors	.3
	Mopping/sweeping	.1
	Move medium cart up/down stairs	.1
	Move wood into house	.2
	Move load cases	.3
	Moved boxes	.1
	Moved swing	.1
	Moved totes	.1
	Mow lawn	1.3
	Mulching	.1
	Nautilus	.2
	Opening boxes	.1
	Patient care	.4
	Push lawn mower	1.2
	Push Stroller	.2
	Rake	2.5
	Real volleyball	.1
	Resistance machine	.1
	Scrub floors	1.2
	Shovel	.2
	Stairs	.2
	Surfing	.2
	Sweep	.5
	Taebo/stepper	.1
	Treadmill	1.0
	Trim bushes	.1
	Unload truck	.2
	Vacuum	4.3
	Walking	3.4
	Wash floors	.6
	Weed	.6

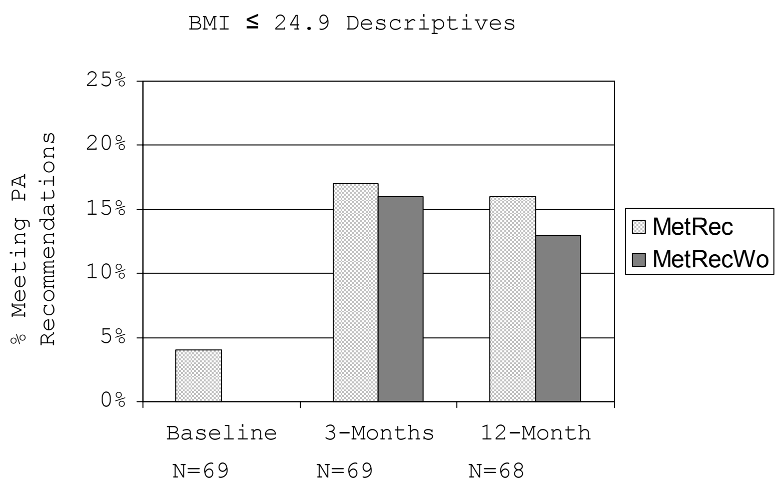
These multitudinous responses were consolidated into the 3D-PAR coding categories as originally defined in the original study protocol. Participant responses as well as the total number of times they partook in each activity are described in Table 14.

Table 14.0. Original Coding Categories for PAR Activity Types

PAR Code	Description	N
2	Walking	668
4	Hiking	1
6	Jogging	18
8	Cycling	40
10	Swimming	6
16	Golf	3
20	Occupation-Work/School	103
22	Gardening	17
24	Yard work	94
26	Housework	204

Next, due to the large number of responses of various activities participated in it was important to evaluate how much time was actually spent engaging in each activity. It was also important to decipher from these findings whether or not study participants were actually meeting the physical activity recommendations based on their reported activity levels (Haskell et al., 2007; USDHHS, 2008). Participant responses were next categorized including all activity (MetRec) and categorized excluding all household activity chores (MetRecWo). Figures 6., 7. and 8. are participant responses sorted by participant body mass index as well as time point (baseline, 3-months and 12-months).

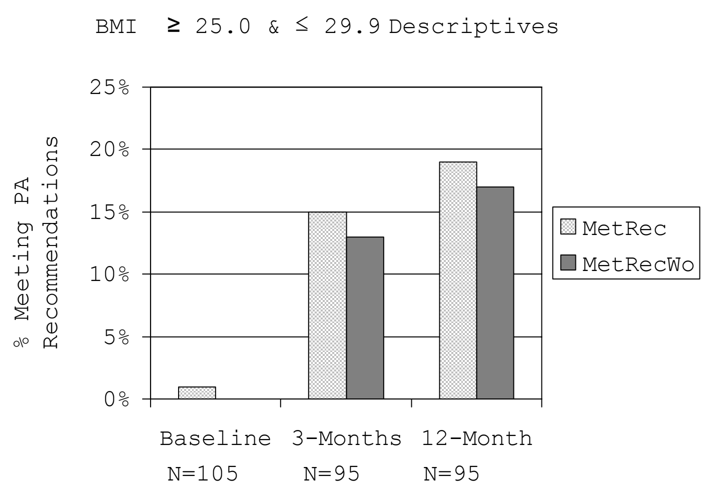
Figure 6. Normal Weight Participants and Recommended Physical Activity Levels



Based on the findings presented in this graph, it is important to identify at baseline 4% of the sample identified themselves as meeting physical activity guidelines initially, however when distinguishing between the types of activities engaged in without the inclusion of household chores 0% of the population of normal weight women were found to meet physical activity guidelines. At 3-month 17% MetRec and 16% MetRecWo still met the physical activity recommendations without inclusion of household chores. Finally, by 12-months 16% MetRec while 13% still MetRecWo.

Next, overweight women were evaluated for their ability to meet physical activity recommendations at each of the three time points (both with the inclusion of household chores and without). Results in Figure 7.

Figure 7. Overweight Participants and Recommended Physical Activity Levels

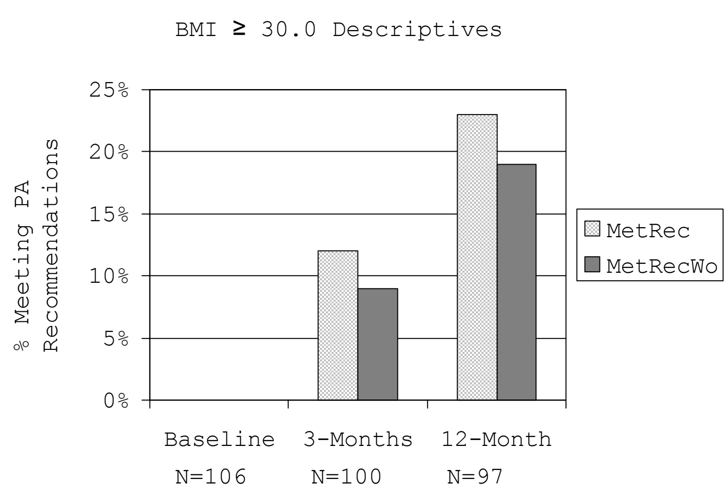


Based on the findings within this graph, it was found that at baseline 1% of the overweight women were found to meet physical activity recommendation s (MetRec) with the inclusion of household chores while 0% MetRecWo inclusion of chores. By 3-

months, 15% MetRec while only 13% MetRecWo household work. Finally, by 12-months, 19% of overweight women MetRec while 17% reported to MetRecWo.

Finally, obese were women were evaluated in their ability to meet physical activity recommendations at each of the three time points (with and without the inclusion of household chores). Results in Figure 8.

Figure 8. Obese Participants and Recommended Physical Activity Levels



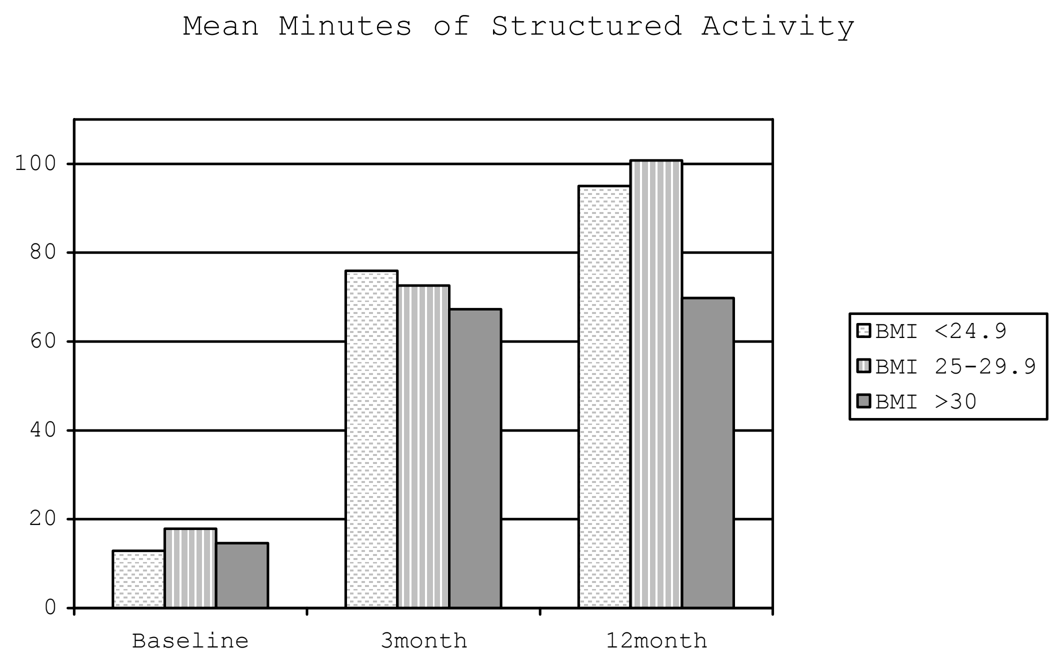
Based on the findings of this graph, at baseline 0% of obese women reported to be meeting physical activity recommendations with or without the inclusion of household chores. By 3-months, 12% of obese women MetRec while only 9%

MetRecWo inclusion of household chores. Finally, by 12-months 23% of obese reported to have MetRec with 19% still MetRecWo chores.

Analysis of Structure Versus Unstructured Physical Activities by BMI

Next, evaluations of the types of physical activities being reported by all women were analyzed. These next analyses use the newly coded variables that sort physical activities into structured or unstructured values. First, mean minutes of Structured activities were evaluated at each of the three time points (baseline, 3-months and 12-months) while taking into account body mass index sorting components. Results are shown in Figures 9. and Figure 10.

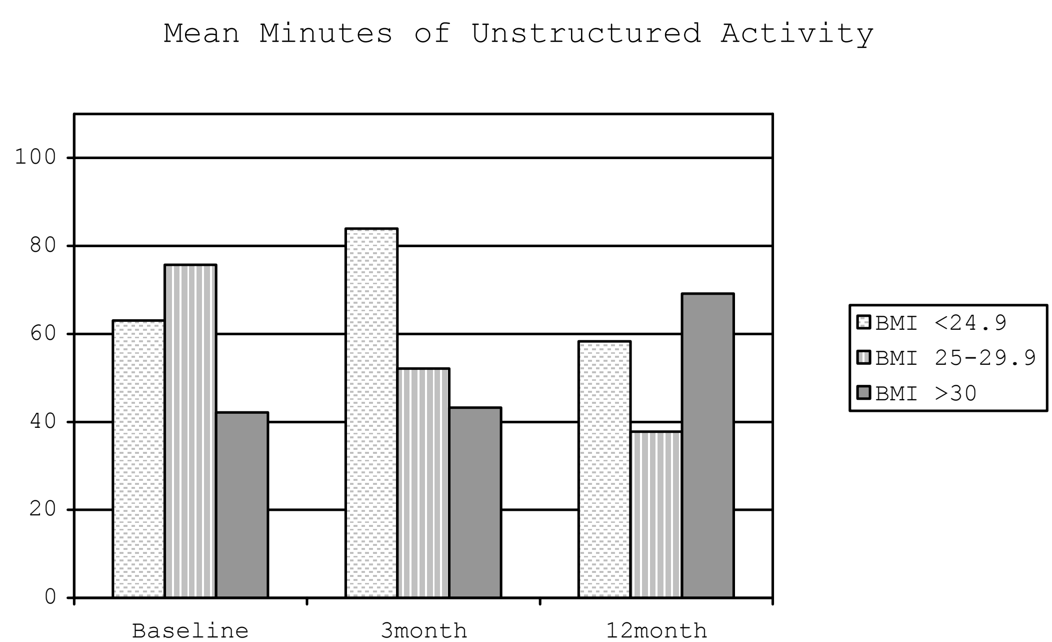
Figure 9. Total Mean Minutes of Structured Activity Sorted by Body Mass Index. ***Mean values are based on Descriptive statistics***



When evaluating the results in Figure 9., ANVOA tests were computed to determine if any of the groups were significantly different from one another at any of the three time points. It was found that regardless of time point the total minutes of structured physical activity were not significantly different from one another regardless of BMI. Repeated measures analyses were computed to detect significant differences in the number of structured activity minutes accumulated within a BMI group at any of the three time points. Of the BMI categories, the only group to display statistically significant differences was the obese women. It was found that obese women were engaging in statistically more minutes of structured physical activity by 12-months compared to baseline (p< 0.048).

Next total numbers of unstructured physical activity minutes were evaluated for differences based on Body Mass Index and results are presented in Figure 10.

Figure 10. Total Mean Minutes of Unstructured Activity Sorted by Body Mass Index. ***Mean values are based on Descriptive Statistics.***

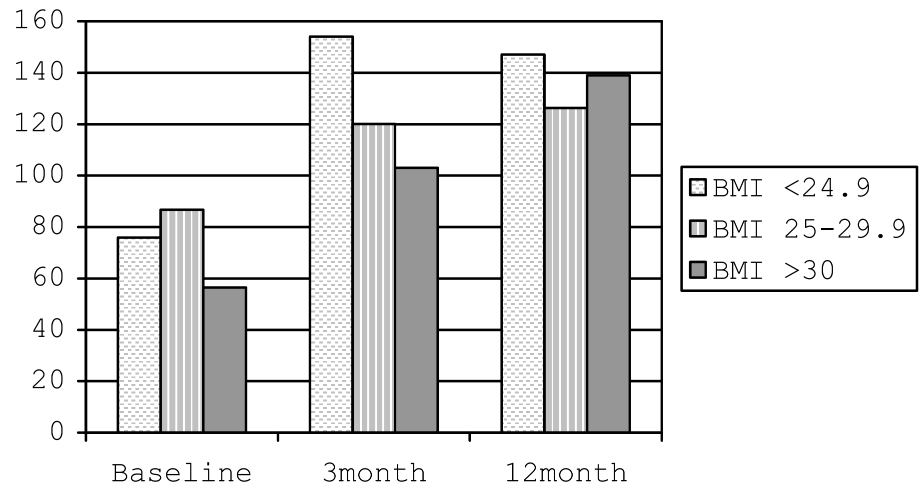


When evaluating the results in Figure 10., ANVOA tests with Tukey Post Hoc analyses were computed to determine if any of the groups were significantly different from one another at any of the three time points. At each time point baseline, 3-months, and 12-months, the total numbers of minutes of unstructured physical activity minutes were not significantly different from one another regardless of BMI. However at the 3-month time point, normal weight and obese women neared statistical significance (p= 0.061) in that normal weight women were reporting more unstructured physical activity minutes at three months compared to obese women. Repeated measures analyses were computed, however they were unable to detect any statistically significant changes in the total number of unstructured physical activity minutes over time within any BMI category.

Analysis of Moderate Versus Vigorous Intensity Physical Activity Minutes by BMI

Next, total minutes of moderate intensity physical activity as reported on the 3D-PAR were evaluated for differences within BMI groups. ANOVA tests with Tukey Post Hoc analyses were computed to evaluate these findings. Results are displayed in Figure 11.

Figure 11. Mean Minutes of Moderate Intensity Physical Activity by Body Mass Index. ***Mean values are based on Descriptive Statistics.***

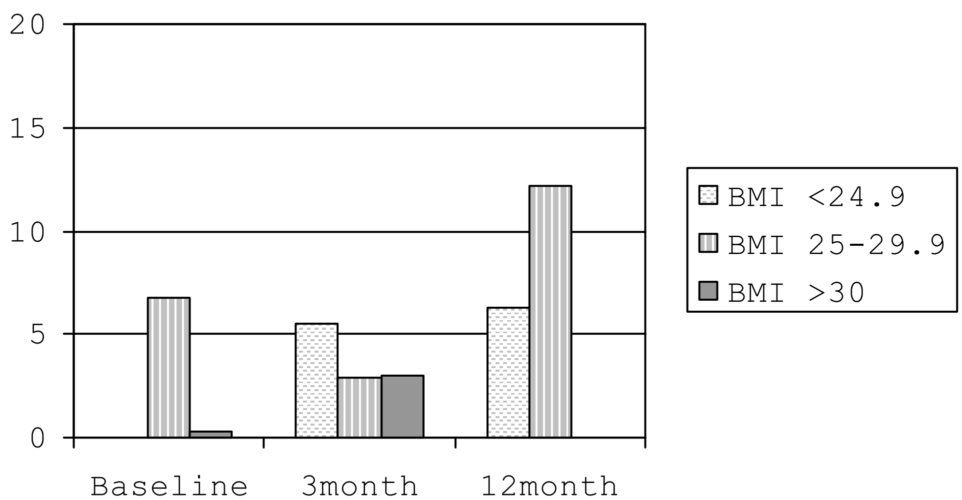


Based on these findings, ANOVA tests with Tukey Post Hoc analyses determined there were no differences between the BMI groups and their total minutes of moderate intensity physical activity at either baseline or at 12-months. However, at 3-months, it was found that there were statistical differences between the normal weight and obese women in the total number of moderate intensity physical activity minutes reported ($p < 0.039$). Thus, the normal weight women were reporting more minutes of moderate intensity activity then were obese women at three months.

Repeated measures analysis were computed to determine significant differences in the total number moderate intensity physical activity minutes accumulated by each BMI category at each time point. No statistical differences were found between baseline, 3-months and 12-months within any of the BMI categories.

Next, total minutes of vigorous intensity physical activity as reported on the PAR were evaluated for differences within BMI groups. ANOVA tests with Tukey Post Hoc analyses were computed to evaluate these findings. Figure 12. represents the total number of vigorous intensity physical activity sorted by Body Mass Index at each time point.

Figure 12. Mean Minutes of Vigorous Intensity Physical Activity by Body Mass Index. ***Mean values are based on Descriptive Statistics.***



Based on these findings, Tukey Post Hoc analyses determined there were no differences between the BMI groups and their total minutes of vigorous intensity physical activity at either baseline, 3-months or at 12-months. Additionally, repeated measures analyses were unable to detect significant differences over time among any of the BMI categories at any time point.

Discussion

Despite the benefits of physical activity, overweight or obese individuals are found to be more physically inactive, compared to their leaner peers (Adams et al., 2003; Cooper et al., 2000; Davis et al., 2006). There may be apparent limitations among women of varied weight status to participate in some forms of physical activity compared to their leaner peers (Napolitano et al., 2008). Perhaps these limitations may also further limit overweight or obese women’s ability to meet physical activity recommendations as outline by the CDC and USDHHS. Recent statistics have discovered that walking is the most frequently reported and preferred activity between both sexes (37.7% for men and 52.5% for women). Additionally, among women the most commonly reported activities were, aerobics (8.7%), gardening (8.2%), and using exercise machines (6.0%)(CDC, 2008h). In spite of these statistics, physical activity preferences by weight category have not been deciphered. This study attempted to evaluate the preferences for physical activity within women participating within a physical activity promotion study.

The results of this study indicated that women of varied weight status might have different preferences in their manner of engaging in physical activity. It was first evaluated whether women were meeting physical activity recommendations with or without the inclusion of household chores. The results indicated that all three weight categories (normal weight, overweight and obese) women had more women who were meeting recommendations by both 3 and 12 months when compared to baseline both with and without inclusion of household chores. Even more interesting was that obese women were the only weight category to demonstrate a increase between 3 months to 12 months in the number of women who were meeting physical activity recommendations both with and without the inclusion of household chores.

Next, engaging in structured versus unstructured minutes of physical activity were compared by BMI. The only statistical findings within these analyses were that obese women were the only BMI category to demonstrate statistically significant increases in their minutes of structured physical activity by 12-months compared to baseline values. No other weight category demonstrated statistically significant increases in total minutes over time. However, it is important to mention there were no statistical differences between the total numbers of structured minutes the obese women were reporting by 12-months compared to the other BMI categories. No statistically significant findings were discovered when evaluating the total number of unstructured minutes of physical activity among the BMI categories.

These findings among obese women were not as originally hypothesized which thought obese women would engage in less structured activities and more unstructured activities compared to the other weight categories. These results may have some apparent limitations when evaluating "structured" versus "unstructured" activities. Potentially, some women may have been engaging in structured physical activities for less than 30 minutes (which was the cut off for structured activity coding) and vise versa; some women may have engaged in "unstructured" activities for greater than 30 minutes. Thus, some potential bias in the coding strategy may have occurred through the analyses that would require further research within this area.

Lastly, the differences in total number of moderate or vigorous intensity physical activity minutes were compared by BMI category. When evaluating the total minutes of moderate intensity physical activity, statistically significant differences were found between the total activity minutes between normal weight and obese women only at the three month time point. Normal weight women were reporting more minutes of moderate intensity physical activity compared to obese women. However, these findings were no longer statistically significant by 12 months. No statistically significant findings were discovered comparing the vigorous intensity minutes and BMI category. This is different from what was hypothesized, as we suspected obese women might opt for lower intensity activities. It is of note that obese women by 12-months did not report to be engaging in any vigorous intensity physical activity, yet these findings were not statistically different from the other BMI groups.

This information is important when considering the future of physical activity promotion trials among women. Future studies should examine the types of activities preferred by women of each weight status. If it is known that normal weight, overweight and obese women may select different preferred activity types, then future interventions may need to be tailored accordingly. Based on the findings from the current study, it was discovered that there were some apparent differences over time in women's ability to increase physical activity levels and meet recommendations when compared prior to enrollment. Additionally, possibly through the physical activity intervention obese women demonstrated changes in their total minutes engaging in structured activity types over time. Further research is still needed to discover why these patterns may have been apparent at certain time points, but not all time points within the different BMI categories.

CHAPTER 6

GENERAL DISCUSSION

Introduction

A vicious circle between physical inactivity and obesity exists and has recently been illustrated by Pietliainen and colleagues (2008). They described physical inactivity as causal and secondary to the development of obesity while noting a marked decline in activity levels results in concomitant weight gain (Pietliainen et al., 2008). They further describe this chain of events to be continuous and self-perpetuating, remaining undeterminable which stage would be most affected by intercession. Furthermore, this recurring cycle of physical inactivity and obesity continues the incidence of health consequences and further economic burden, leaving the need for intervention to remain (Pietliainen et al., 2008).

This desire and urgency to further understand physical activity levels (or inactivity levels), especially among women, has become apparent. Physical activity promotion studies are considered one of the most influential mechanisms to combat not only obesity but also disease prevention. Despite the primary intentions of these types of studies, length of time, material delivery methods, measurement devices, and disparities within the population may all adversely affect study outcomes.

Every intervention study enhances the body of literature and may be influential in future study development. The general purpose of the present study was to compare the interviewer administered, self-reported 3D-PAR questionnaire against the objective measurement data of the Actigraph accelerometer. Specifically, the correlations at baseline, 3 months and 12 months will observe: a) accuracy over time; b) BMI or impact of weight status; c) group assignment effects; d) physical activity preferences. Some of the primary findings discovered through this dissertation will potentially add valuable information to future researchers and more broadly to the greater health benefit of women.

Summary of Findings

Current literature continually shows some marked inconsistencies in the validity and reliability of both questionnaires and accelerometers, while this study has further evaluated both variables. This study also intended to address some of the apparent uncertainties that exist with the use of self-reported questionnaires. Specifically, it was intended to ascertain whether self-report accuracy improves or diminishes upon multiple questionnaire exposures within the same population.

This study also desired clarification on whether a participant’s body mass index or weight status was a factor that influenced a participants’ ability to self-report their physical activity behaviors accurately. Since inconsistencies exist in whether overweight or obese women are credited as poor reporters, this study hoped to clarify whether participants were able to accurately identify various bouts of physical activity. This study was also hopeful to determine whether reporting accuracy was influenced by weight status and whether this contributed to the flaws in the data collection or its results.

More importantly, since the current literature is uncertain whether participants who are receiving physical activity interventions or treatments will differ in their ability to accurately report behaviors on self-report questionnaires this study was hoping to answer some of these questions. It was also intended to clarify whether self-report accuracy improved over time since participants continued to receive education by study staff on aspects of physical activity and had the chance to adapt their lifestyles accordingly. Also, it was important to decipher whether these bouts of physical activity were properly identified regardless of weight status.

The following hypotheses were tested comparing the self-reported versus objective measurements of physical activity. It was found that cross-sectional comparisons of 3D-PAR and ActiGraph accelerometer measures did not have significant correlations at baseline. Yet, these comparisons improved and high correlations were found at both 3 and 12 months compared to baseline in the entire study sample.

Next cross-sectional comparisons of the 3D-PAR and the ActiGraph accelerometer found only obese women had a modest degree of concordance at baseline though not statistically significant. Obese women were the only weight category at 3-months to demonstrate a high degree of concordance while no other weight category demonstrated these results.

Finally, by 12 months, normal and overweight women had a high degree of concordance and obese women demonstrated a moderate degree of concordance. These results suggest that obese women were the only weight category able to demonstrate accuracy at all three time points. Despite obese women demonstrating some degree of correlation at each time point, they are also the only BMI category that did not demonstrate statistically significant increases in their physical activity levels (ActiGraph means) over the 12-month time span.

Longitudinal comparisons were tested next when looking at group assignment as well as body mass index. These results found overweight demonstrated a high degree of concordance in reporting ability only at 12-months within the Choose to Move group; and a high degree of concordance at 3-months within the Wellness group. Obese women who participated in the Jumpstart group demonstrated a moderate degree of concordance at both 3 and 12-months. Obese women also demonstrated a high degree of concordance by 3-months in the Wellness group. These results were unanticipated within the Wellness group. It might need further evaluation to determine why some of the most accurate results occurred in the control group and only at 3-months.

Finally, comparisons of physical activity preference were evaluated to find whether overweight and obese women preferred nontraditional methods of physical activity compared to their lean counterparts. It was found that statistically more women within each BMI category were able to meet physical activity recommendations at both 3 and 12 months compared to baseline. It was also discovered that obese women demonstrated statistically significant increases by 3 and 12 months in their total number of minutes participating in structured physical activity levels while these results were not found among the other weight categories. This finding is the opposite than was hypothesized which thought overweight or obese women would prefer unstructured physical activity minutes compared to normal weight women. Finally, no differences were found between overweight or obese women and their total number of moderate or vigorous intensity activity levels over time.

Overall, the results of this study can enhance the understanding of physical activity patterns among women of varied weight status enrolled in a physical activity promotion studies. While women are not meeting current physical activity recommendations proposed by the ACSM and the CDC according to recent health statistics it is now important to evaluate the instrumentation and its appropriateness within the study population tested.

Perhaps now, the current body of literature can be enhanced in evaluating characteristics that may exist among women of normal, overweight and obese body weights with the use of both the Physical Activity Recall and the ActiGraph accelerometer. Though a multitude of limitations in activity measurement and data capture will continue to exist there may be a new understanding that these methods may indeed be more accurate within participants than previously anticipated. Validity of both subjective and objective physical activity measurement techniques can now be considered to have support for there use within participants of varied body weight. Additionally, since this study used multiple measurement attempts over time within a population of varied weight status and found overall, their ability to self-report behaviors improved greatly over time when involved in a physical activity promotion study.

Several strengths exist overall in this study. This study's design used both subjective and objective physical activity measurements in a relatively larger sample size with ease. These comparative measured enabled a multitude of conclusions to be drawn from both forms of measurement. An additional strength of this trial was the length of time. A yearlong intervention gave researchers the opportunity to observe participants and their change in activity patterns over the course of time. Thus, the impact of these results may have been more insightful than a very short intervention. Additionally, the ability to have designed a study to focus solely on women, at a time in which there has been increased urgency considering the decline in physical activity levels among women. Thus, important implications can be drawn from this study results that might help combat the increased prevalence of heart disease risk through physical activity interventions (CDC, 2008e; Oguma, et al., 2002; Pate et al., 1995; Purath, 2006; USDHHS, 2002). Furthermore, there was very little attrition within the sample set which enabled the study population to be observed for the entirety of the trial. This marginal attrition rate maintained 94.3% at month 3 and 92.9% at month 12 can also provide evidence that varied types of intervention may meet the needs of this population over a long-term time span.

Within this entire study, there are also important limitations that require discussion. The sample was predominantly Caucasian, and middle-to-upper income which can make reproducibility or generalization of results somewhat limiting. However, the findings of this trial can provide a basis for future studies to be re-evaluated within a sample of mixed genders, races, socioeconomic status and education levels. Other limitations include the limited reliability and validity as previously discussed using either self-report subjective measures or limitations of objective measurements. It is also felt that these limitations would be present in other trials despite the best intentions to limit. The reliability of both measures could have been verified had they been re-tested after 2-weeks from the initial baseline visit (with both participants and interviewers); however, this was not the design of the original study protocol. Other limitations regarding how to handle outliers was not addressed in the original study protocol, therefore it was decided for use of these secondary data analyses, to leave outliers within the data sets. Outliers therefore may alter the findings as previously reported in this dissertation.

In conclusion, the findings of this current study may allow new insights towards the development of physical activity promotion studies to target women of varied weight status accordingly. Since obesity rates are soaring and physical activity levels among women are diminishing, new perceptions from researchers need to address these concerns with a fresh approach. Future studies may require altered applications if new findings suggest varied strategies for physical activity instruction may be essential to properly suite women of varied weight status.

REFERENCES

Abbot, J.M., Thomson, C.A., Ranger-Moore, J., Teixeira, P.J., Lohman, T.G., Taren, D.L. et al. (2008). Psychosocial and behavioral profile and predictors of self-reported energy underreporting in obese middle-aged women. ***Journal of the American Dietetic Association, 108(1)***, 114-119.

Adams, S.A., Der Ananian, C.A., DuBose, K.D., Kirtland, K.A., & Ainsworth, B.E. (2003). Physical activity levels among overweight and obese adults in South Carolina. ***Southern Medical Journal, 96***, 539-543.

Adams, S.A., Matthews, C.E., Ebbeling, C.B., Moore, C.G., Cunningham, J.E., Fulton, J., et al. (2005). The effect of social desirability and social approval on self-reports of physical activity. ***American Journal of Epidemiology, 161***, 389-398.

Ainsworth, B.E. (2000a). Issues in the assessment of physical activity in women. ***Research Quarterly for Exercise and Sport***, 71, S37-42.

Ainsworth, B.E. (2000b). Challenges in measuring physical activity in women. ***Exercise and Sport Science Reviews,*** 28, 93-96.

Ainsworth, B.E., Bassett, D.R., Strath, S.J., Swartz, A.M., O'Brien, W.L., Thompson, R.W., et al. (2000). Comparison of three methods for measuring the time spent in physical activity. ***Medicine and Science in Sports and Exercise***, 32, S457-64.

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., Irwin, M.L., Swartz, A.M., Strath, S.J. et al. (2000). Compendium of physical activities: an update of activity codes and MET intensities. ***Medicine and Science in Sports and Exercise, 32***, S498-504.

Allor, K.M., & Pivarnik, J.M. (2001). Stability and convergent validity of three physical activity assessments. ***Medicine and Science in Sports and Exercise, 33***, 671-676.

American College of Sport's Medicine. ACSM's Resource Manual for Guidelines for Exercise Testing and Prescription. Philadelphia: Lippincott Williams & Wilkins, 2001.

Argiropoulou, E.C., Michalopoulou, M., Aggeloussis, N., & Avgerinos, A. (2004). Validity and reliability of physical activity measures in Greek high school age children. *Journal of Sports Science and Medicine*, 3, 147-159.

Ball, K., Owen, N., Salmon, J., Bauman, A., & Gore, C.J. (2001). Associations of physical activity with body weight and fat in men and women. *International Journal of Obesity and Related Metabolic Disorders, 25*, 914-919.

Baranowksi, T., Allen, D.D., Masse, L.C., & Wilson, M. (2006). Does participation in an intervention affect responses on self-report questionnaires? *Health Education Research, 21*, i98-109.

Baranowski, T. (1988). Validity and reliability of self-report measures of physical activity: an information-processing prospective. *Research Quarterly for Exercise and Sport*, 59, 314-327.

Barlow, C.E., Kohl, H.W., Gibbons, L.W., & Blair, S.N. (1995). Physical fitness, mortality and obesity. *International Journal of Obesity and Related Metabolic Disorder*s, *19*, S41-44.

Blair, S.N., & Brodney, S. (1999). Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Medicine and Science in Sports and Exercise, 31*, S646-662.

Blair, S.N., Goodyear, N.N., Gibbons, L.W., & Cooper, K.H. (1984). Physical fitness and incidence of hypertension in healthy normotensive men and women. *The Journal of the American Medical Association, 252*, 487-490.

Blair, S.N., Haskell, W.L., Ho, P., Paffenbarger, R.S., Vranizan, K.M., Farquhar, J.W., et al. (1985). Assessment of habitual physical activity by a seven-day recall in a community survey and controlled experiments. *American Journal of Epidemiology, 122*, 794-804.

Blanchard, C.M., McGannon, K.R., Spence, J.C., Rhodes, R.E., Nehl, E., Baker, F. et al. (2005). Social ecological correlated of physical activity in normal weight, overweight, and obese individuals. *International Journal of Obesity,* 29, 720-726.

Bonnefoy, M., Normand, S., Pachiaudi, C., Lacour, J.R., Laville, M., & Kostka, T. (2001). Simultaneous validation of ten physical activity questionnaires in older men: a doubly labeled water study. *Journal of the American Geriatrics Society, 49*, 28-35.

Bowles, H.R., FitzGerald, S.J., Morrow, J.R., Jackson, A.W., & Blair, S.N. (2004). Construct validity of self-reported historical physical activity. *American Journal of Epidemiology, 160*, 279-286.

Brach, J.S., Simonsick, E.M., Kritchevsky, S., Yaffe, K., Newman, A.B., & Health, Aging and Body Composition Study Research Group. (2004). The association between physical function and lifestyle activity and exercise in the health, aging and body composition study. *Journal of the American Geriatrics Society, 52*, 502-509.

Brage, S., Brage, N., Wedderkopp, N., & Froberg, K. (2003). Technical reliability and validity of the CSA accelerometer: Should we re-calibrate or re-think? *Medicine and Science in Sports and Exercise, 35*, S283.

Brage, S., Wedderkopp, N., Franks, P.W., Andersen, L.B., & Froberg, K. (2003). Reexamination of validity and reliability of the CSA monitor in walking and running. *Medicine and Science in Sports and Exercise, 35*, 1447-1454.

Brown, W., Bauman, A., Chey, T., Trost, S., & Mummery, K. (2004). Comparison of surveys used to measure physical activity. *Australian and New Zealand Journal of Public Health, 28*, 128-134.

Brown, W.J., Trost, S.G., Bauman, A., Mummery, K., & Owen, N. (2004). Test-retest reliability of four physical activity measures used in population surveys. *Journal of Science and Medicine in Sport, 7*, 205-215.

Caspersen, C.J., Powell, K.E., & Christenson, G.M. (1985). Physical activity, exercise, and physical fitness. ***Public Health Reports***, 100, 125-131.

Centers for Disease Control and Prevention (CDC). (2006). Health Behaviors of Adults: United States, 2002-2004. ***Vital Health and Statistics,*** 10, 230.

Centers for Disease Control and Prevention (CDC). (2007). Prevalence of regular physical activity among adults--United States, 2001 and 2005. ***Morbidity and Mortality Weekly Report, 56***, 1209-1212.

Centers for Disease Control and Prevention. (2008a). Trend Data- No Leisure Time Physical Activity. Retrieved February 19th, 2008 from http://apps.nccd.cdc.gov/brfss/Trends/TrendData.asp

Centers for Disease Control and Prevention. (2008b). Leisure Time Physical Activity- All Adults. Retrieved March 16, 2008 from http://www.cdc.gov/nchs/data/series/sr_10/sr10_230.pdf

Centers for Disease Control and Prevention. (2008c). Leisure Time Physical Activity- Age. Retrieved February 19th, 2008 from http://apps.nccd.cdc.gov/brfss/index.asp

Centers for Disease Control and Prevention. (2008d). Body Weight Status- All Adults. Retrieved February 19, 2008 from http://apps.nccd.cdc.gov/brfss/Trends/TrendData.asp BRFSS, 2002

Centers for Disease Control and Prevention. (2008e). Leisure Time Physical Activity-Sex. Retrieved February 19, 2008 from http://apps.nccd.cdc.gov/brfss/list.asp?cat=OB&yr=2006&qkey=4409&state=All

Centers for Disease Control and Prevention. (2008f). FY 2008 President’s Budget Centers for Disease Control and Prevention- Detail Table. Retrieved February 22, 2008 from http:// www.cdc.gov/fmo/PDFs/FY_2008_Presidents_Budget_Detail_table.pdf

Centers for Disease Control and Prevention. (2008g). Estimated Adult Obesity-Attributable Percentages and Expenditures, by State (BRFSS 1998-2000). Retrieved March 18, 2008 from http://www.cdc.gov/nccdphp/dnpa/obesity/economic_consequences.htm

Centers for Disease Control and Prevention. (2008h). Prevalence of Leisure-Time Physical Activity Among Overweight Adults ---United States, 1998. Retrieved July 28, 2008 from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4915a4.htm

Clemes, S.A., Griffiths, P.L., & Hamilton, S.L. (2007). Four-week pedometer-determined activity patterns in normal weight and overweight UK adults. *International Journal of Obesity, 31*, 261-266.

Colditz, G.A. (1999). Economic costs of obesity and inactivity. *Medicine and Science in Sports and Exercise, 31*, S663-667.

Computer Retrieval of Information on Scientific Projects (CRISP). (2008). National Institute of Health and Department of Health and Human Services. Retrieved February, 2008 from http://crisp.cit.nih.gov

Conway, J.M., Irwin, M.L., & Ainsworth, B.E. (2002). Estimating energy expenditure from the Minnesota Leisure Time Physical Activity and Tecumseh Occupational Activity questionnaires - a doubly labeled water validation. *Journal of Clinical Epidemiology, 55*, 392-399.

Conway, J.M., Seale, J.L., Jacobs, D.R., Irwin, M.L., & Ainsworth, B.E. (2002). Comparison of energy expenditure estimates from doubly labeled water, a physical activity questionnaire, and physical activity records. *American Journal of Clinical Nutrition, 75*, 519-525.

Cooper, A.R., Page, A., Fox, K.R., & Misson, J. (2000). Physical activity patterns in normal, overweight and obese individuals using minute-by-minute accelerometry. *European Journal of Clinical Nutrition, 54*, 887-894.

Crouter, S.E., Churilla, J.R., & Bassett, D.R. (2006). Estimating energy expenditure using accelerometers. *European Journal of Applied Physiology, 98*, 601-612.

Crouter, S.E., Clowers, K.G., & Bassett, D.R. (2006). A novel method for using accelerometer data to predict energy expenditure. ***Journal of Applied Physiology, 100***, 1324-1331.

Davis, J.N., Hodges, V.A., & Gillham, M.B. (2006). Physical activity compliance: differences between overweight/obese and normal-weight adults. ***Obesity, 14***, 2259-2265.

Dinger, M.K., & Behrens, T.K. (2006). Accelerometer-determined physical activity of free-living college students. ***Medicine and Science in Sports and Exercise, 38***, 774-779.

DiPietro, L. (1995). Physical activity, body weight, and adiposity: an epidemiologic perspective. javascript:lRL('2','Exercise and sport sciences reviews')***Exercise and Sport Sciences Reviews, 23***, 275-303.

Dishman, R.K., & Steinhardt, M. (1988). Reliability and concurrent validity for a 7-d re-call of physical activity in college students. ***Medicine and Science in Sports and Exercise, 20***, 14-25.

Dubbert, P.M., Vander Weg, M.W., Kirchner, K.A., & Shaw, B. (2004). Evaluation of the 7-day physical activity recall in urban and rural men. ***Medicine and Science in Sports and Exercise, 36***, 1646-1654.

Dunn, A.L., Marcus, B.H., Kampert, J.B., Garcia, M.E., Kohl, H.W., & Blair, S.N. (1999). Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial. ***The Journal of the American Medical Association, 281***, 327-334.

Durante, R., & Ainsworth, B.E. (1996). The recall of physical activity: using a cognitive model of the question-answering process. ***Medicine and Science in Sports and Exercise, 28,*** 1282-1291.

Ekelund, U., Sjostrom, M., Yngve, A., Poortvliet, E., Nilsson, A., Froberg, K. et al. (2001). Physical activity assessed by activity monitor and doubly labeled water in children. ***Medicine and Science in Sports and Exercise, 33***, 275-281.

Esliger, D.W., Probert, A., Gorber, S.C., Bryan, S., Laviolette, M., & Tremblay, M.S. (2007). Validity of the Actical accelerometer step-count function. *Medicine and Science in Sports and Exercise*, *39*, 1200-1204.

Esliger, D.W., Temblay, M.S., & Copeland, J.L. (2003). Does frequency (HZ) and acceleration of movement affect the reliability of the MTI (CSA) ActiGraph? *Medicine and Science in Sports and Exercise*, *35*, S285.

Farrell, S.W., Braun, L., Barlow, C.E., Cheng, Y.J., & Blair, S.N. (2002). The relation of body mass index, cardiorespiratory fitness, and all-cause mortality in women. *Obesity Research, 10*, 417-423.

Fogelholm, M., Hiilloskorpi, H., Laukkanen, R., Oja, P., Van Marken Lichtenbelt, W., & Westerterp, K. (1998). Assessment of energy expenditure in overweight women. *Medicine and Science in Sports and Exercise, 30,* 1191-1197.

Food and Agriculture Organization of the United Nations (2001). Human energy requirements: Report of a Joint FAO/WHO/UNU Expert Consultation. *Food and Nutrition Technical Report Series.*

Freedson, P.S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and Science in Sports and Exercise, 30*, 777-781.

Gross, L.D., Sallis, J.F., Buono, M.J., Roby, J.J., Nelson, J.A. (1990). Reliability of interviewers using the Seven-Day Physical Activity Recall. *Research Quarterly for Exercise and Sport*, *61*, 321-325.

Grundy, S.M., Blackburn, G., Higgins, M., Lauer, R., Perri, M.G., & Ryan, D. (1999). Physical activity in the prevention and treatment of obesity and its comorbidities. *Medicine and Science in Sports and Exercise, 31*, S502-8.

Guinhouya, C.B., Hubert, H., Soubrier, S., Vilhelm, C., Lemdani, M. & Durocher, A. (2006). Moderate-to-vigorous physical activity among children: discrepancies in accelerometry-based cut-off points. *Obesity, 14*, 774-777.

Hagstromer, M., Oja, P., & Sjostrom, M. (2007). Physical activity and inactivity in an adult population assessed by accelerometry. *Medicine and Science in Sports and Exercise, 39*, 1502-1508.

Ham, S.A., Reis, J.P., Strath, S.J., Dubose, K.D., & Ainsworth, B.E. (2007). Discrepancies between methods of identifying objectively determined physical activity. *Medicine and Science in Sports and Exercise, 39*, 52-58.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., & Franklin, B.A., et al. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise, 39*, 1423-1434.

Hayden-Wade, H.A., Coleman, K.J., Sallis, J.F., & Armstrong, C. (2003). Validation of the telephone and in-person interview versions of the 7-day PAR. *Medicine and Science in Sports and Exercise, 35*, 801-809.

Hemmingsson, E., & Ekelund, U. (2007). Is the association between physical activity and body mass index obesity dependent? *International Journal of Obesity, 31*, 663-668.

Hendelman, D., Miller, K., Baggett, C., Debold, E., & Freedson, P. (2000). Validity of accelerometry for the assessment of moderate intensity physical activity in the field. *Medicine and Science in Sports and Exercise, 32*, S442-9.

Irwin, M.L., Ainsworth, B.E., & Conway, J.M. (2001). Estimation of energy expenditure from physical activity measures: determinants of accuracy. *Obesity Research*, *9*, 517-525.

Irwin, M.L., Tworoger, S.S., Yasui, Y., Rajan, B., McVarish, L., LaCroix, K. et al. (2004). Influence of demographic, physiologic, and psychosocial variables on adherence to a yearlong moderate-intensity exercise trial in postmenopausal women. *Preventative Medicine, 39*, 1080-1086.

Isaacs, A.J., Critchley, J.A., Tai, S.S., Buckingham, K., Westley, D., Harridge, S.D. et al. (2007). Exercise Evaluation Randomised Trial (EXERT): a randomised trial comparing GP referral for leisure centre-based exercise, community-based walking and advice only. *Health Technology Assessment, 11*, 1-165.

Jacobi, D., Perrin, A.E., Grosman, N., Dore, M.F., Normand, S., Oppert, J.M. et al. (2007). Physical activity-related energy expenditure with the RT3 and TriTrac accelerometers in overweight adults. ***Obesity, 15***, 950-956.

Jacobs, D.R., Ainsworth, B.E., Hartman, T.J., & Leon, A.S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. ***Medicine and Science in Sports and Exercise, 25***, 81-91.

Jago, R., Baranowski, T., Yoo, S., Cullen, K.W., Zakeri, I., Watson, K. et al. (2004). Relationship between physical activity and diet among African-American girls. ***Obesity Research***, ***12*** 55S-63S.

Jakicic, J.M., Polley, B.A., & Wing, R.R. (1998). Accuracy of self-reported exercise and the relationship with weight loss in overweight women. ***Medicine and Science in Sports and Exercise, 30***, 634-638.

Jakicic, J.M., Winters, C., Lang, W., & Wing, R.R. (1999). Effects of intermittent exercise and use of home exercise equipment on adherence, weight loss, and fitness in overweight women: a randomized trial. ***The Journal of the American Medical Association, 282***, 1554-1560.

Johnson-Kozlow, M., Sallis, J.F., Gilpin, E.A., Rock, C.L., & Pierce, J.P. (2006). Comparative validation of the IPAQ and the 7-Day PAR among women diagnosed with breast cancer. ***International Journal of Behavioral Nutrition and Physical Activity***, ***3***, 7.

Kahn, E.B., Ramsey, L.T., Brownson, R.C., Heath, G.W., Howze, E.H., Powell, K.E. et al. (2002). The effectiveness of interventions to increase physical activity. A systematic review. ***American Journal of Preventative Medicine, 22***, 73-107.

Kesaniemi, Y.K., Danforth, E., Jensen, M.D., Kopelman, P.G., Lefebvre, P., & Reeder, B.A. (2001). Dose-response issues concerning physical activity and health: an evidence-based symposium. ***Medicine and Science in Sports and Exercise, 33***, S351-358.

Kuller, L.H., Kriska, A.M., Kinzel, L.S., Simkin-Silverman, L.R., Sutton-Tyrrell, K., Johnson, B.D., et al. (2007). The clinical trial of Women on the Move through Activity and Nutrition (WOMAN) study. ***Contemporary Clinical Trials*, *28***, 370-381.

Kumahara, H., Schutz, Y., Ayabe, M., Yoshioka, M., Yoshitake, Y., Shindo, M. et al. (2004). The use of uniaxial accelerometry for the assessment of physical-activity-related energy expenditure: a validation study against whole-body indirect calorimetry. ***The British Journal of Nutrition*, *91***, 235-243.

Le Masurier, G.C., & Tudor-Locke, C. (2003). Comparison of pedometer and accelerometer accuracy under controlled conditions. ***Medicine and Science in Sports and Exercise, 35***, 867-871.

Lee, I.M. (2007). Dose response relation between physical activity and fitness: Even a little is good; More is better. ***The Journal of the American Medical Association, 297***, 2137-2139.

Lee, I.M., Hsieh, C.C., & Paffenbarger, R.S. (1995). Exercise intensity and longevity in men. The Harvard Alumni Health Study. ***The Journal of the American Medical Association, 273***, 1179-1184.

Lee, I.M., & Paffenbarger, R.S. (2000). Associations of light, moderate, and vigorous intensity physical activity with longevity. The Harvard Alumni Health Study. ***American Journal of Epidemiology, 151***, 293-299.

Lee, I.M., & Paffenbarger, R.S. (1996). How much physical activity is optimal for health? Methodological considerations. ***Research Quarterly for Exercise and Sport, 67***, 206-208.

Lee, I.M., Sesso, H.D., Oguma, Y., & Paffenbarger, R.S. (2003). Relative intensity of physical activity and risk of coronary heart disease. ***Circulation, 107***, 1110-1116.

Lee, I.M., & Skerrett, P.J. (2001). Physical activity and all-cause mortality: what is the dose-response relation? ***Medicine and Science in Sports and Exercise, 33***, S459-71; discussion S493-4.

Leenders, N.Y., Sherman, W.M., & Nagaraja, H.N. (2006). Energy expenditure estimated by accelerometry and doubly labeled water: do they agree? *Medicine and Science in Sports and Exercise, 38*, 2165-2172.

Lichtman, S.W., Pisarska, K., Berman, E.R., Pestone, M., Dowling, H., Offenbacher, E. et al. (1992). Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *New England Journal of Medicine, 327(27),* 1893-1898.

Mader, U., Martin, B.W., Schutz, Y., & Marti, B. (2006). Validity of four short physical activity questionnaires in middle-aged persons. *Medicine and Science in Sports and Exercise, 38*, 1255-1266.

Mahabir, S., Baer, D.J., Giffen, C., Clevidence, B.A., Campbell, W.S., Taylor, P.R. et al. (2006). Comparison of energy expenditure estimates from 4 physical activity questionnaires with doubly labeled water estimates in postmenopausal women. *American Journal of Clinical Nutrition, 84*, 230-236.

Marcus, B.H., Bock, B.C., Pinto, B.M., Forsyth, L.H., Roberts, M.B., & Traficante, R.M. (1998). Efficacy of an individualized, motivationally-tailored physical activity intervention. *Annuals of Behavioral Medicine, 20*, 174-180.

Mâsse, L.C., Fulton, J.E., Watson, K.L., Kohl, H.W., Blair, S.N. et al. (1999). Detecting bouts of physical activity in a field setting. *Research Quarterly for Exercise and Sport, 70*, 212-219.

Matthews, C.E., Ainsworth, B.E., Hanby, C., Pate, R.R., Addy, C., Freedson, P.S. et al. (2005). Development and testing of a short physical activity recall questionnaire. *Medicine and Science in Sports and Exercise, 37*, 986-994.

Matthews, C.E., Ainsworth, B.E., Thompson, R.W., & Bassett, D.R. (2002). Sources of variance in daily physical activity levels as measured by an accelerometer. *Medicine and Science in Sports and Exercise, 34*, 1376-1381.

McClain, J.J., Sisson, S.B., & Tudor-Locke, C. (2007). Actigraph accelerometer interinstrument reliability during free-living in adults. *Medicine and Science in Sports and Exercise, 39*, 1509-1514.

McGinnis, J.M. (1992). The public health burden of a sedentary lifestyle. *Medicine and Science in Sports and Exercise, 24*, S196-200.

McGinnis, J.M., & Foege, W.H. (1993). Actual causes of death in the United States. *The Journal of the American Medical Association, 270*, 2207-2212.

Melanson, E.L., & Freedson, P.S. (1995). Validity of the Computer Science and Applications, Inc. (CSA) activity monitor. *Medicine and Science in Sports and Exercise, 27*, 934-940.

Meriwether, R.A., McMahon, P.M., Islam, N., & Steinmann, W.C. (2006). Physical activity assessment: validation of a clinical assessment tool. *American Journal of Preventative Medicine*, *31*, 484-491.

Metcalf, B.S., Curnow, J.S., Evans, C., Voss, L.D., & Wilkin, T.J. (2002). Technical reliability of the CSA activity monitor: The EarlyBird Study. *Medicine and Science in Sports and Exercise, 34*, 1533-1537.

Mora, S., Lee, I.M., Buring, J.E., & Ridker, P.M. (2006). Association of physical activity and body mass index with novel and traditional cardiovascular biomarkers in women. *Journal of the American Medical Association*, *295*, 1412-1419.

Napolitano, M.A., Whiteley, J.A., Papandonatos, G., Dutton, G., Farrell, N.C., Albrecht, A. et al. (2006). Outcomes from the women's wellness project: a community-focused physical activity trial for women. *Preventative Medicine, 43*, 447-453.

Napolitano, M.A. (2008, October). *Barriers to Physical Activity among Women: Differences based on Weight Status*. Poster session presented at the annual meeting of the Obesity Society, Phoenix, AZ.

Nichols, J.F., Morgan, C.G., Chabot, L.E., Sallis, J.F., & Calfas, K.J. (2000). Assessment of physical activity with the Computer Science and Applications, Inc., accelerometer: laboratory versus field validation. *Research Quarterly for Exercise and Sport, 71*, 36-43.

Nichols, J.F., Morgan, C.G., Sarkin, J.A., Sallis, J.F., & Calfas, K.J. (1999). Validity, reliability and calibration of the TriTrac accelerometer as a measure of physical activity. *Medicine and Science in Sports and Exercise, 31*, 908-912.

Ogden, C.L., Carroll, M.D., Curtin, L.R., McDowell, M.A., Tabak, C.J., & Flegal, K.M. (2006). Prevalence of overweight and obesity in the United States, 1999-2004. *Journal of the American Medical Association*, *295*, 1549-1555.

Oguma, Y., Sesso, H.D., Paffenbarger, R.S., & Lee, I.M. (2002). Physical activity and all cause mortality in women: a review of the evidence. *British Journal of Sports Medicine, 36*, 162-172.

Paffenbarger, R.S., Blair, S.N., Lee, I.M., & Hyde, R.T. (1993). Measurement of physical activity to assess health effects in free-living populations. *Medicine and Science in Sports and Exercise, 25*, 60-70.

Paffenbarger, R.S., Hyde, R.T., Hsieh, C.C., & Wing, A.L. (1986). Physical activity, other life-style patterns, cardiovascular disease and longevity. *Acta medica Scandinavica.Supplementum, 711*, 85-91.

Paffenbarger, R.S., & Lee, I.M. (1996). Physical activity and fitness for health and longevity. *Research Quarterly for Exercise and Sport, 67*, S11-28.

Pate, R.R., Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C. et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association, 273*, 402-407.

Pate, R.R., Ross, R., Dowda, M., Trost, S.G. (2003). Validation of a 3-Day Physical Activity Recall Instrument in Female Youth. *Pediatric Exercise Science, 15*.

Patterson, S.M., Krantz, D.S., Montgomery, L.C., Deuster, P.A., Hedges, S.M., & Nebel, L.E. (1993). Automated physical activity monitoring: validation and comparison with physiological and self-report measures. *Psychophysiology, 30*, 296-305.

Plasqui, G., & Westerterp, K.R. (2007). Physical activity assessment with accelerometers: an evaluation against doubly labeled water. *Obesity*, *15*, 2371-2379.

Plasqui, G., & Westerterp, K.R. (2006). Accelerometry and heart rate as a measure of physical fitness: cross-validation. *Medicine and Science in Sports and Exercise, 38*, 1510-1514.

Pober, D.M., Staudenmayer, J., Raphael, C., & Freedson, P.S. (2006). Development of novel techniques to classify physical activity mode using accelerometers. *Medicine and Science in Sports and Exercise, 38*, 1626-1634.

Purath, J. (2006). Comparison of the traits of physically active and inactive women. *Journal of the American Academy of Nurse Practitioners, 18*, 234-240.

Rabin, B.A., Brownson, R.C., Kerner, J.F., & Glasgow, R.E. (2006). Methodologic challenges in disseminating evidence-based interventions to promote physical activity. *American Journal of Preventative Medicine, 31*, S24-34.

Rasmussen, L.B., Matthiessen, J., Biltoft-Jensen, A., & Tetens, I. (2007). Characteristics of misreporters of dietary intake and physical activity. *Public Health Nutrition, 10*, 230-237.

Rauh, M.J., Hovell, M.F., Hofstetter, C.R., Sallis, J.F., &Gleghorn, A. (1992). Reliability and validity of self-reported physical activity in Latinos. *International Journal of Epidemiology, 21*, 966-971.

Reis, J.P., Dubose, K.D., Ainsworth, B.E., Macera, C.A., & Yore, M.M. (2005). Reliability and validity of the occupational physical activity questionnaire. *Medicine and Science in Sports and Exercise, 37*, 2075-2083.

Richardson, M.T., Ainsworth, B.E., Jacobs, D.R., & Leon, A.S. (2001). Validation of the Stanford 7-day recall to assess habitual physical activity. *Annals of Epidemiology, 11*, 145-153.

Rodriguez, G., Beghin, L., Michaud, L., Moreno, L.A., Turck, D., & Gottrand, F. (2002). Comparison of the TriTrac-R3D accelerometer and a self-report activity diary with heart-rate monitoring for the assessment of energy expenditure in children. *The British Journal of Nutrition, 87*, 623-631.

Rosenberg, M., Bull, F.C., Braham, R., Cowper, K., & Booth, M. (2002). Assessing the accumulation of moderate-intensity physical activity in adults. *Medicine and Science in Sports and Exercise, 34*, S207.

Rzewnicki, R., Vanden Auweele, Y., & De Bourdeaudhuij, I. (2003). Addressing over reporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutrition*, *6*, 299-305.

Sallis, J.F., Haskell, W.L., Wood, P.D., Fortmann, S.P., Rogers, T., Blair, S.N. et al. (1985). Physical activity assessment methodology in the Five-City Project. *American Journal of Epidemiology, 121*, 91-106.

Sallis, J.F., Strikmiller, P.K., Harsha, P.D., Feldman, H.A., Ehlinger, S., Stone, E.J. et al. (1996). Validation Of interviewer- and self-administered physical activity checklists for fifth grade students. *Medicine and Science in Sports and Exercise, 28*, 840-851.

Sallis, J.F. & Saelens, B.E. (2000). Assessment of physical activity by self-report: status, limitations, and future directions. *Research Quarterly for Exercise and Sport*, 71, S1-14.

Sarkin, J.A., Nichols, J.F., Sallis, J.F., & Calfas, K.J. (2000). Self-report measures and scoring protocols affect prevalence estimates of meeting physical activity guidelines. *Medicine and Science in Sports and Exercise, 32*, 149-156.

Schmidt, M.D., Freedson, P.S., & Chasan-Taber, L. (2003). Estimating physical activity using the CSA accelerometer and a physical activity log. *Medicine and Science in Sports and Exercise, 35*, 1605-1611.

Schutz, Y., Weinsier, S., Terrier, P., & Durrer, D. (2002). A new accelerometric method to assess the daily walking practice. *International Journal of Obesity and Related Metabolic Disorders, 26*, 111-118.

Sharpe, P.A., Granner, M.L., Hutto, B., Ainsworth, B.E., & Cook, A. (2004). Association of body mass index to meeting physical activity recommendations. *American Journal of Health Behavior, 28*, 522-530.

Shephard, R.J. (2003). Limits to the measurement of habitual physical activity by questionnaires. *British Journal of Sports Medicine, 37*, 197-206.

Speck, B.J., & Looney, S.W. (2006). Self-reported physical activity validated by pedometer: a pilot study. *Public Health Nursing*, *23*, 88-94.

Strath, S.J., Bassett, D.R., Ham, S.A., & Swartz, A.M. (2003). Assessment of physical activity by telephone interview versus objective monitoring. *Medicine and Science in Sports and Exercise, 35*, 2112-2118.

Strath, S.J., Bassett, D.R., & Swartz, A.M. (2003). Comparison of MTI accelerometer cut-points for predicting time spent in physical activity. *International Journal of Sports Medicine, 24*, 298-303.

Strath, S.J., Brage, S., & Ekelund, U. (2005). Integration of physiological and accelerometer data to improve physical activity assessment. *Medicine and Science in Sports and Exercise, 37*, S563-71.

Swartz, A.M., Bassett, D.R., Moore, J.B., Thompson, D.L., & Strath, S.J. (2003). Effects of body mass index on the accuracy of an electronic pedometer. *International Journal of Sports Medicine, 24*, 588-592.

Swartz, A.M., Strath, S.J., Bassett, D.R., O'Brien, W.L., King, G.A., & Ainsworth, B.E. (2000). Estimation of energy expenditure using CSA accelerometers at hip and wrist sites. *Medicine and Science in Sports and Exercise, 32*, S450-6.

Taylor, C.B., Coffey, T., Berra, K., Iaffaldano, R., Casey, K., & Haskell, W.L. (1984). Seven-day activity and self-report compared to a direct measure of physical activity. *American Journal of Epidemiology, 120*, 818-824.

Thomas, J.R., Nelson, J.K., Silverman, S.J. (2005). Research Methods in Physical Activity. Human Kinetics Publishers.

Timperio, A., Salmon, J., & Crawford, D. (2003). Validity and reliability of a physical activity recall instrument among overweight and non-overweight men and women. *Journal of Science and Medicine in Sport, 6*, 477-491.

Toschke, J.A., Kries, R., Rosenfeld, E. & Toschke, A.M. (2007). Reliability of physical activity measures from accelerometry among preschoolers in free-living conditions. *Clinical Nutrition, 26*, 416-420.

Troiano, R.P. (2007). Large-scale applications of accelerometers: new frontiers and new questions. *Medicine and Science in Sports and Exercise, 39*, 1501.

Treuth, M.S., Sherwood, N.E., Butte, N.F., McClanahan, B.,Obarzanek, E., Zhou, A. et al. (2003). Validity and reliability of activity measures in African-American girls for GEMS. *Medicine and Science in Sports and Exercise, 35*, 532-539.

Tudor-Locke, C., Ainsworth, B.E., Thompson, R.W., & Matthews, C.E. (2002). Comparison of pedometer and accelerometer measures of free-living physical activity. *Medicine and Science in Sports and Exercise, 34*, 2045-2051.

Tudor-Locke, C., Ainsworth, B.E., Whitt, M.C., Thompson, R.W., Addy, C.L., & Jones, D.A. (2001). The relationship between pedometer-determined ambulatory activity and body composition variables. *International Journal of Obesity and Related Metabolic Disorders, 25*, 1571-1578.

Tudor-Locke, C., Henderson, K.A., Wilcox, S., Cooper, R.S., Durstine, J.L., & Ainsworth, B.E. (2003). In their own voices: definitions and interpretations of physical activity. ***Women's Health Issues, 13***, 194-199.

U.S. Department of Health and Human Services (1996). ***Physical activity and health: a report of the Surgeon General***. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

U.S. Department of Health and Human Services (2002). ***HHS Report Promotes Benefit of Physical Activity in Older Americans:*** U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion (2000). ***Healthy People 2010: Leading Health Indicators.*** Retrieved June 22nd, 2008 from http://www.healthypeople.gov/Document/tableofcontents.htm.

U.S. Department of Health and Human Services (2008). ***HHS announces physical activity guidelines for Americans:*** U.S. Department of Health and Human Services. Retrieved October 10th, 2008 from http://www.hhs.gov/news.

Wang, Y.C., Colditz, G.A., & Kuntz, K.M. (2007). Forecasting the obesity epidemic in the aging U.S. population. ***Obesity, 15***, 2855-2865.

Ward, D.S., Evenson, K.R., Vaughn, A., Rodgers, A.B., & Troiano, R.P. (2005). Accelerometer use in physical activity: best practices and research recommendations. ***Medicine and Science in Sports and Exercise, 37***, S582-8.

Washburn, R.A., Jacobsen, D.J., Sonko, B.J., Hill, J.O., & Donnelly, J.E. (2003). The validity of the Stanford Seven-Day Physical Activity Recall in young adults. ***Medicine and Science in Sports and Exercise, 35***, 1374-1380.

Wei, M., Kampert, J.B., Barlow, C.E., Nichaman, M.Z., Gibbons, L.W., Paffenbarger, R.S., et al. (1999). Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men. ***Journal of the American Medical Association, 282***, 1547-1553.

Welk, G.J. (2002). ***Physical Activity Assessments for Health-Related Research.*** Champaign, IL: Human Kinetics.

Welk, G.J., Schaben, J.A., & Morrow, J.R. (2004). Reliability of accelerometry-based activity monitors: A generalizability study. ***Medicine and Science in Sports and Exercise, 36***, 9-

Westerterp, K.R. (1999). Assessment of physical activity level in relation to obesity: current evidence and research issues. ***Medicine and Science in Sports and Exercise, 31***, S522-525.

Whaley, M.H. & Blair, S.N. (1995). Epidemiology of physical activity, physical fitness and coronary heart disease. ***Journal of Cardiovascular Risk, 2***, 289-295.

Wickel, E.E., Welk, G.J., & Eisenmann, J.C. (2006). Concurrent validation of the Bouchard Diary with an accelerometry-based monitor. ***Medicine and Science in Sports and Exercise, 38***, 373-379.

Wilkinson, S., Huang, C.M., Walker, L.O., Sterling, B.S., & Kim, M. (2004). Physical activity in low-income postpartum women. ***Journal of Nursing Scholarship, 36***, 109-114.

Withers, R.T., Brooks, A.G., Gunn, S.M., Plummer, J.L., Gore, C.J., & Cormack, J. (2006). Self-selected exercise intensity during household/garden activities and walking in 55 to 65-year-old females. ***European Journal of Applied Physiology, 97***, 494-504.

Wolin, K.Y., Glynn, R.J., Colditz, G.A., Lee, I.M., & Kawachi, I. (2007). Long-term physical activity patterns and health-related quality of life in U.S. women. ***American Journal of Preventative Medicine, 32***, 490-499.

Yore, M.M., Ham, S.A., Ainsworth, B.E., Kruger, J., Reis, J.P., Kohl, H.W., et al. (2007). Reliability and validity of the instrument used in BRFSS to assess physical activity. ***Medicine and Science in Sports and Exercise, 39***, 1267-1274.

Yoshioka, M.,Ayabe, M.,Yahiro, T.,Higuchi, H.,Higaki, Y., St-Amand, J., et al. (2005). Long-period accelerometer monitoring shows the role of physical activity in overweight and obesity. ***International Journal of Obesity, 29***, 502-508.