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The impact of Freedson bout vs. non-Freedson bout physical activity on metabolic syndrome risk in college students

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The Impact of Freedson Bout vs. Non-Freedson bout Physical Activity on Metabolic Syndrome Risk in College Students

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A Thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

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FACULTY COMMITTEE:

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Abstract

Purpose The aim of this study is to examine moderate to vigorous physical activity in Freedson bouts compared to non-Freedson bouts and their association with Metabolic Syndrome risk factors in college students.

Methods 72 subjects aged 18-26 were recruited from James Madison University. Subjects height, weight, waist circumference, blood pressure, and body composition were assessed on visit 1. Blood pressure, fasted blood glucose, and lipid profile were assessed on visit 2. Subjects wore an Actigraph GT3X+ accelerometer, which measured physical activity and sleep for 7 days and nights. Univariate Pearson correlation analyses were performed to determine the relationship physical activity variables and MetS risk factors. Variables determined to have the greatest correlation for each risk factor were used as independent variables in a step-wise, multiple linear regression to determine the best predictor for each MetS risk factor. Variables established as having the greatest correlation with MetS were evaluated as covariates. Statistical significance was set a priori at $p<0.05$.

Results Correlational analyses suggest the strongest predictors of MetS were daily average time in moderate activity, daily average MVPA, total number of Freedson bouts, total minutes in Freedson bouts, total MVPA, and total steps. Step count was the only significant predictor of waist circumference and systolic blood pressure ($R^2 = 0.07$; $p<0.05$; $R^2 = 0.14$; $p<0.01$, respectively). Total Freedson bouts was the only significant predictor for HDL ($R^2 = 0.062$; $p<0.05$). Waist circumference was significantly higher in the lowest (86.4 ± 9.6) and moderate (87.6 ± 13.4) tertile compared to the highest tertile (74.8 ± 9.4)
Conclusion Total step count has the largest influence on elevated WC and SBP risk in college students. Total Freedson bouts has the largest influence on low HDL risk in college students.
Chapter 1
Introduction

Physical activity has advantageous effects on many aspects of health. Research indicates that exercise can improve BMI, fat mass, muscle mass, cardiovascular functioning, and insulin sensitivity (4, 14, 21, 28). Exercise has also been shown to improve cognitive functioning, although the processes behind this are still not clear (8). Recommended guidelines for United States adults incorporate 150 minutes of moderate to vigorous physical activity (MVPA), 75 minutes of vigorous activity, or a combination of the two every week (45). Meeting these recommendations can have favorable effects on morbidity and mortality (21, 39).

More than half of Americans are not meeting physical activity guidelines, whereas physical inactivity is on the rise (43). Ng and Popkin et al. demonstrated this trend by examining physical activity and inactivity patterns in adults from the American Time Use Survey collected by the Bureau of Labor and Statistics 2003. They observed a drop from 216 to 173 MET hours/week from 1965 to 2005, and forecasted that by 2020 total activity will fall around 153 MET hours/week (32). Trends of decreasing physical activity were also reported from CDC data. Physical activity via self-report illustrated a 1.4% difference between 2013 where 50.2% of US adults met guidelines, to 2011, where 51.6% of adults were meeting guidelines. Adolescent physical activity shows similar patterns (46). Over recent years’ data supports a general decline in physical activity levels.

The decline of physical activity overlaps with a different, yet related, epidemic: obesity. Over the past 40 years, obesity in youth and adults has more than doubled in the
United States. Child obesity has increased from 5.0% to 12.4% in ages 2-5 years, 6.5% to 17% in ages 6-11 years, and 5.0% to 17.6% in ages 12-19 years (33). Overweight children are 2 to 10 times more likely to become overweight adults, and overweight adolescents are 4 to 22 times more likely (39). With rising obesity in youth, co-morbidities become more prevalent at younger ages (15, 22). The Bogalusa Heart study compared health risks factors of children in the 85th percentile for BMI to their gender specific, coincidental peers with normal weight. This study found that children above the 85th percentile were 2.4 times more likely to have abnormally high cholesterol levels, 3 times more likely to have higher low-density lipoprotein (LDL) levels, 3.4 times more likely to have lower HDL levels, 7.1 times more likely to have high triglyceride levels, and 4.5 times more likely to have higher blood pressure (11). Co-morbidities can be indicative of disease, including hypertension, impaired glucose tolerance, impaired fasting glucose, hyperlipidemia, and larger waist circumference (2, 23). The most prevalent condition that has been linked to these comorbidities and complications is cardiovascular disease (CVD), which remains the main cause of mortality for American adults (5, 36). CVD is also linked to metabolic conditions, such as type 2 diabetes mellitus/impaired fasting glucose, low HDL, elevated triglycerides, hypertension, and abdominal adiposity. When a clustering of 3 or more of these risks occur simultaneously, the product is Metabolic Syndrome (MetS) diagnosis (49). Those diagnosed with MetS are at about a 2-fold risk for CVD morbidity and mortality after controlling for risk factors (12, 27). This supports a need for early MetS identification and prevention. Metabolic Syndrome, as defined by the National Cholesterol Education Program’s Adult Treatment Panel III (NCEP ATP III), includes three or more of the following: waist
circumference (WC) of $\geq 102$cm men and $\geq 88$cm in women; elevated triglycerides (TG) $\geq 150$ mg/dL, low HDL-C $< 40$ mg/dL in men and $< 50$ mg/dL in women, elevated blood pressure (BP) $\geq 130$ SBP or $\geq 85$ DBP, and impaired fasting glucose (FG) $\geq 110$ mg/dL (47). A meta-analysis conducted by Galassi et al. showed that across 21 studies, individuals with MetS had increased mortality, CVD, coronary heart disease, and stroke risk compared to those without. MetS is linked to many factors and diseases that negatively affect morbidity and mortality (16). Although longevity in the US has increased over the past few centuries, more people are dying from preventable diseases such as CVD and diabetes as eluded to in the previous paragraph (37). An estimated 35% of all adults 18+ years old have MetS, per NHANES 2003-2012 analysis (1). Observing trends, NHANES 2003-2008 showed an increase in MetS prevalence from 32.9% to 36.1% in US adults 20 years and older. From 2008 to 2012, MetS prevalence decreased slightly to 34.2% in 2009/2010, but was succeeded by 34.7% in 2011/2012. Despite fluctuations in MetS prevalence, data supports a general increase in associated risk factors (7, 30).

In younger populations, MetS risk factors and diagnosis are not as predominant, however, risk factors may present in younger populations especially with the autonomy that comes with adolescence. NHANES 2001-2006 showed MetS prevalence in youth dropped from 9% in adolescents 12-19 years old, to 6.5% in 2003/2004, a subsequent rise surpassed the initial data, leaving MetS youth rate at 10.1% in 2005/2006 (24). Miller et al. (2014) examined NHANES data from 2000-2010 and found about 73% of adolescents met one criteria for MetS, and estimated 10.1% of all adolescents had MetS (29).
Prevalence of METs in adolescents, although lower than older adults, has implications to their health over the course of a lifetime.

Numerous studies have examined the relationship between physical activity and Metabolic Syndrome. A meta-analysis conducted by Pattyn et al reported significantly favorable effects of dynamic endurance training on WC, HDL-C, and BP in middle aged adults (34). These findings suggest a reversal of disease in this population. A larger meta-analysis by Yamaoka and Tango et al. reviewed randomized control trial studies with a follow-up of six months or more. They reported twice the number of patients in lifestyle modification groups had resolved MetS compared to controls. Resolution attributed to improved risk factors including SBP (-6.4mmHg), DBP (-3.3mmHg), TG (-12.0mg/dL), WC (-2.7 cm), and FBG (-11.5mg/dL) (50). Overall, physical activity and purposeful exercise can have favorable effects on MetS risk factors. What is lesser known is the specific dose of activity to resolve MetS risk factors.

General recommendations state that activity needs to be accumulated in bouts of at least ten minutes and at the moderate-to-vigorous level. Few studies have observed the relationship of MetS and MVPA accumulated in bouts < 10 minutes, which are referred to as non-Freedson bouts. Glazer et al. observed 2,109 older adults with accelerometers over 5-7 days. After controlling for bouts ≥10 minutes, or Freedson bouts, activity accumulated in non-Freedson bouts, were independently related to lower triglycerides, BMI, Framingham risk score, smaller WC and a lower prevalence of obesity (17). A smaller study by Ayabe et al. examined the association of non-Freedson bouts and MetS in women ages 40-60 years old. Frequency of MVPA in 32 second bouts and 1-minute bouts were significantly positively associated with HDL-C. Total physical activity bout
frequencies of 3 and 5 minutes were significantly associated with fasting blood glucose (6). Previous studies support favorable non-Freedson bout effects on MetS in an older population, non-Freedson bout effects have yet to be examined in a younger demographic.

As previously mentioned, MetS is less prevalent in younger populations, but it is in those years that choices are made which can dictate a person’s health later in life. One-third of adolescents attend college, and during these years’ lifestyle habits can form, including unhealthy diet and decreased physical activity (26, 35). An estimated 20-30% of college students meet the minimum 30 minutes of MVPA per day, although there is still mixed data supporting both lower and higher percentages (20, 21, 25, 41). In an analysis of 67,861 college students, 49.9% reported meeting physical activity recommendations (13). Conversely, Young et al. demonstrated that out of 655 college students, 25% reported no engagement in vigorous activity, 18% reported engaging in moderate activity two times per week, 17% three times per week, and 12% five times per week (51). Although these studies report a range of activity, college students should be conscious of their total accumulation of activity throughout a week for general health benefits. Small et al. followed college students across seven semesters and reported students averaged 26 minutes per day of MVPA in their first fall semester. By fall semester of senior year, students engaged in approximately 18 minutes of MVPA per day, this equated to a 4% decrease in voluntary physical activity per semester over the course of their tenure in college (40). This trend supports the notion that students may feel they do not have time for physical activity in their daily schedules which may be the start of habit forming for some individuals.
Along with decreasing activity, college students may be susceptible to weight gain. In a meta-analysis, Crombie et al. reviewed college weight-gain studies and found an average increase of 0.7–3.1 kg over the first year of college. When observing only individuals who gained weight, the average increase was 3.1–3.4 kg (10). Huang et al. observed an almost threefold greater risk of having at least one risk factor for MetS if the student was overweight (19). Although weight is not a MetS risk factor, there seems to be a correlation that should be considered in college students.

Fitness level is another factor not directly tied to but with implications for MetS. Morrell et al. used maximal oxygen uptake (VO_{2max}) as a determinant of physical fitness, 90% of 1610 college students were categorized as average or above average. Despite this, 60% of participants had one or more MetS risk factors, 21% had two or more risk factors, and 5% had MetS (31). This suggests that even with high physical fitness values, MetS risk factors are still present in this population. One increasingly popular way to incorporate a physical activity is use of digital devices that measure steps and active minutes (44). Accelerometers provide insight regarding physical activity patterns, and can be helpful in determining caloric expenditure.

No study has reported the effects of accumulated non-Freedson bouts on MetS criteria in college students. Walking between classes, or from transportation to class may take under 10 minutes, but elicit a metabolic response as supported in Ayabe et al. and Glazer et al. (6, 17). Examining this relationship has potential to encourage bouts of physical activity that fit a college students schedule. Smaller activity bout promotion may encourage more students to take small breaks in their day to include physical activity. Therefore, the purpose of this study is to examine the relationship of total weekly minutes
of non-Freedson bout MVPA and daily total non-Freedson bout MVPA minutes on Metabolic Syndrome as defined by NCEP’s ATP III criteria.

Purpose: Examine the association between moderate to vigorous physical activity in non-Freedson bouts, and risk factors of Metabolic Syndrome in college students.

Hypothesis: It is hypothesized that MVPA in non-Freedson bouts will be associated with a lower number of Metabolic Syndrome risk factors.

Assumptions:
1. Participants will wear the physical activity monitor at all prescribed times.
2. Participants will not alter their physical activity patterns or lifestyle behaviors while being monitored.
3. Physical activity monitors (Actigraph GT3X+) will provide valid and reliable estimates of participants’ physical activity levels.

Delimitations:
1. This study will focus on college-aged students between the ages of 18-26.

Limitations:
1. Findings cannot be generalized to other age groups.
2. Blood pressure may differ between visits due to diurnal variation and potential caffeine consumption.
3. Findings rely on accurate sleep logs and proper accelerometer placement.

**Operational Definitions:**

1. **Moderate to vigorous physical activity (MVPA):** activities that require an energy expenditure of 3-6 METs.
2. **Non-Freedson bout:** Moderate to vigorous physical activity occurring in less than 10 minute bouts.
3. **Freedson bout:** Moderate to vigorous physical activity occurring in greater than or equal to 10 minute bouts.
4. **Metabolic Syndrome (MetS):** having at least three of the following criteria:
   - Central Obesity (Waist Circumference >102cm in men, >88cm in women);
   - Hypertriglyceridemia (≥150mg/dL);
   - Low HDL-C (< 40 mg/dL in men, < 50 mg/dL in women);
   - Elevated blood pressure ≥ 130/85 mmHg;
   - Elevated fasting glucose ≥ 110 mg/dL.
Chapter 2
Methodology

Study Design and Participants

Subjects between the ages of 18-26 were recruited for this study through emails, flyers, and interactions on university property. Participants were asked to attend two individual meetings at the James Madison University Human Performance Lab. During the first lab visit, subjects were given an online consent form to review and sign which provided a comprehensive description of the study, risks and benefits associated with their participation, and the way in which confidentiality was maintained (see Informed Consent attachment). After consent was obtained, each subject was given an ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, Florida) which recorded daily physical activity over 7 days and nights. Participants were also asked to record their sleep and wake times on a provided document. All procedures were approved by the JMU Institutional Review Board prior to initiation of this study.

Visit 1

During the first visit, informed consent was read, discussed, and signed prior to any further documents and testing. Participants were asked to complete a health history questionnaire. Blood pressure was measured after 5 minutes of seated rest, and body mass and height was measured using a digital scale and physician’s stadiometer. Waist circumference was measured using a Gulick tape measurer and body composition was analyzed using a Dual Energy X-Ray Absorptiometer (DEXA). Succeeding all measurements, the subjects received and were instructed on proper use of the ActiGraph GT3X+ accelerometer.
Visit 2

For the second visit, participants were required to fast 8-12 hours prior to meeting for blood draws. Participants returned the accelerometer and sleep/wake log. Resting blood pressure was taken after 5 minutes of seated rest. A finger stick was taken to evaluate blood lipids and glucose using a Polymer Technology Systems lipid panel and glucose strip in conjunction with a Cardiocheck Portable Blood Test System. Lipids were measured using a 40 microliter sample whereas glucose required a 15 microliter sample. Finally, the participant completed the International Physical Activity Questionnaire (IPAQ) to assess current physical activity pattern (9).

Anthropometric Measurements

Waist circumferences were measured at narrowest measure of the torso between the iliac crest and the xiphoid process, per ACSM guidelines (3). The average blood pressure from visit 1 and visit 2 were used in assessing MetS for the participants. The DEXA analysis provided total fat and fat free mass, fat percentage, and estimated visceral fat percentage and volume.

Physical Activity

Objective physical activity measurements were downloaded from the accelerometer after the second meeting. Physical activity was measured by the ActiGraph GT3X+, a small activity monitor that collects accelerations throughout the day, which are expressed as activity counts. These counts were determined as sedentary, light activity, moderate activity, or vigorous activity using accelerometer counts. During waking hours,
the participant was instructed to wear the accelerometer at waist level in line with the right anterior axillary line during waking hours, and on their non-dominant wrist while sleeping. The ActiGraph was removed prior to any water-based activity (showering, swimming, etc.). The validity and reliability of ActiGraph GT3X+ has been previously described (18, 38). Following the subjects seven consecutive days of wear, data was downloaded from the device. Daily wear time was determined by removing periods of time 20 minutes or greater that detected no movement, including sleep validated by sleep logs. Average daily values determined from activity counts will include: energy expenditure, number of MVPA in non-Freedson bouts, total time in MVPA in non-Freedson bouts, total time in MVPA, total Freedson (1998) bout count and total time in Freedson bouts. Freedson bouts are defined as MVPA (determined by accelerometer counts per minute), for a total of 10 minutes or longer (42).

**Metabolic Syndrome (MetS) and Risks**

MetS was assessed using NCEP ATP III criteria. MetS diagnosis is met when three or more of the following risk factors are present: Central Obesity (Waist Circumference >102cm in men, >88cm in women); Hypertriglyceridemia (≥150mg/dL); Low HDL (<40 mg/dL in men, <50mg/dL in women); Elevated Blood Pressure (≥130/85mmHg); Elevated Fasting Glucose (110mg/dL) (47). Body composition and blood samples were collected as previously described for diagnosis. After all assessments, Framingham Risk Scores, a ten-year coronary heart disease prediction using an algorithm will be calculated (48).

**Statistical Analysis**
Univariate Pearson correlation analyses were performed to determine the relationship between physical activity variables and MetS. Each variable determined to have a significant correlation with MetS was used independently in a step-wise, multiple linear regression to determine the best predictors for each MetS risk factor. Each significant variable was then ranked into tertiles and ANOVA/ANCOVA was performed with each MetS risk factor. Variables that have the greatest correlation with MetS were used as covariates. Statistical significance was set \textit{a priori} at $p<0.05$. 
Chapter 3
Manuscript

The Impact of Freedson Bout vs. Non-Freedson Bout Physical Activity on Metabolic Syndrome Risk in College Students

Abstract

Purpose The aim of this study is to examine moderate to vigorous physical activity in Freedson bouts compared to non-Freedson bouts and their association with Metabolic Syndrome risk factors in college students.

Methods 72 subjects aged 18-26 were recruited from James Madison University. Subjects height, weight, waist circumference, blood pressure, and body composition were assessed on visit 1. Blood pressure, fasted blood glucose, and lipid profile were assessed on visit 2. Subjects wore an Actigraph GT3X+ accelerometer, which measured physical activity and sleep for 7 days and nights. Univariate Pearson correlation analyses were performed to determine the relationship physical activity variables and MetS risk factors. Variables determined to have the greatest correlation for each risk factor were used as independent variables in a step-wise, multiple linear regression to determine the best predictor for each MetS risk factor. Variables established as having the greatest correlation with MetS were evaluated as covariates. Statistical significance was set a priori at p<0.05.

Results Correlational analyses suggest the strongest predictors of MetS were daily average time in moderate activity, daily average MVPA, total number of Freedson bouts, total minutes in Freedson bouts, total MVPA, and total steps. Step count was the only significant predictor of waist circumference and systolic blood pressure (R²= 0.07; p<0.05; R²= 0.14; p<0.01, respectively). Total Freedson bouts was the only significant predictor for HDL (R²= 0.062; p<0.05). Waist circumference was significantly higher in
the lowest (86.4 ± 9.6) and moderate (87.6 ± 13.4) tertile compared to the highest tertile
(74.8 ± 9.4)

Conclusion Total step count has the largest influence on elevated WC and SBP risk in
college students. Total Freedson bouts has the largest influence on low HDL risk in
college students.

Introduction

Physical activity has advantageous effects on many aspects of health, including:
BMI improvement, fat mass reduction, muscle mass increases, cardiovascular functioning
improvement, and increased insulin sensitivity (1, 12, 25, 40). Recommended guidelines
for United States adults include 150 minutes of moderate intensity physical activity
(MVPA), 75 minutes of vigorous intensity physical activity, or a combination of the two
every week (63). Meeting these recommendations have favorable effects on morbidity
and mortality (2, 25).

Certain risk factors have been associated with cardiovascular disease (CVD),
which is the main cause of mortality for Americans (3, 46). Metabolic conditions, such as
type 2 diabetes mellitus/impaired fasting glucose, low HDL, elevated triglycerides,
hypertension, and abdominal adiposity are highly correlated associated with the onset of
CVD development (16, 27, 58). Additionally, a simultaneous clustering of three or more
of these risks is referred to as Metabolic Syndrome (MetS) (67). Those diagnosed with
MetS are at about a 2-fold risk for cardiovascular disease morbidity and mortality after
controlling for risk factors (10, 35). This supports a need for early MetS identification
and prevention. The American Heart Association suggests a balanced diet and ample physical activity can deter risk factors that can lead to MetS and CVD (36).

Overwhelming research has shown physical activity and purposeful exercise can have favorable effects on MetS risk factors (43, 68). What is lesser known is the specific dose of activity to resolve or slow the progression of co-morbidities. General recommendations suggest activity needs to be accumulated in bouts of at least ten minutes and at the moderate-to-vigorous level, commonly referred to as Freedson bouts (14, 63). The term Freedson bout is derived from research conducted by Freedson, Melanson and Sirad. They established specific activity count ranges that coincide with MET levels and determine activity intensity. Physical activity guidelines recommend MVPA in bouts of 10 minutes or more; Freedson bout is the accelerometer equivalent (14).

Few studies have observed the relationship of MetS and MVPA accumulated in non-Freedson bout minutes. Glazer et al. observed 2,109 older adults with accelerometers over 5-7 days. After controlling for Freedson bouts, activity accumulated in non-Freedson bout minutes were independently related to lower triglycerides levels, BMI, Framingham risk score, WC and prevalence of obesity (15). Correspondingly, Ayabe et al. examined the association of very small bouts of MVPA and MetS in women ages 40-60 years old. Frequency of MVPA in 32 second bouts and 1-minute bouts were positively associated with HDL-C. Total physical activity bout frequencies of 3 and 5 minutes were significantly associated with fasting blood glucose (4). Although previous studies support favorable non-Freedson bout effects on MetS in older populations, non-Freedson bout effects have yet to be examined in a younger demographic.
MetS is less prevalent in younger populations, although early lifestyle choices can dictate a person’s health later in life. One-third of adolescents attend college, and during these years’ lifestyle habits can form, including unhealthy diet and decreased physical activity (32, 44). An estimated 20-30% of college students meet the minimum 30 minutes of MVPA per day, although estimates range from 16.1% to 50% (22, 30, 44). Young et al. observed 25% of college students reported no engagement in vigorous activity, 18% reported engaging in moderate activity two times per week, 17% three times per week, and 12% five times per week (69). Small et al. followed college students across seven semesters and reported students averaged 26 minutes per day of MVPA in their first fall semester. By fall semester of senior year, students engaged in approximately 18 minutes of MVPA per day, equating to a 4% decrease in voluntary physical activity per semester over the course of their tenure in college (56). Previous research supports the notion that students may feel they do not have time for physical activity, which may be the start of unhealthy habit forming for some individuals.

No study has reported the effects of accumulated MVPA in non-Freedson bout minutes on MetS criteria in college students. Walking between classes, or from transportation to class may take under 10 minutes, but elicit a metabolic response as supported in Ayabe et al. and Glazer et al. (4, 15). Examining this relationship has potential to encourage bouts of physical activity complimentary to a college students schedule. Promotion of smaller activity bouts may encourage more students to take small breaks including physical activity. Therefore, the purpose of this study is to examine the relationship of total weekly minutes of Freedson bout minutes compared to non-Freedson bout MVPA minutes on MetS risk factors.
Methods

Study Design and Participants

72 subjects between the ages of 18 and 26 were recruited for this study through emails, flyers, and interactions on university property. Participants attended two individual meetings at the James Madison University Human Performance Lab. All participants provided written informed consent and the protocol was approved by the James Madison University Institutional Review Board.

Visit 1

During the first visit, informed consent was read, discussed and signed prior to any further documents and testing. Participants were asked to complete a health history questionnaire. Blood pressure was measured after 5 minutes of seated rest, and body mass and height was measured using a digital scale and physician’s stadiometer. Waist circumference was measured using a Guilick tape measurer and body composition was analyzed using a GE Lunar Dual Energy X-Ray Absorptiometer (DEXA). Succeeding all measurements, the subjects received and were instructed on proper use of the ActiGraph GT3X+ accelerometer.

Visit 2

Subjects returned to the lab seven days succeeding the first visit. For the second visit, participants were required to fast 8-12 hours prior to meeting for blood draw and resting blood pressure was taken after 5 minutes of seated rest. Polymer Technology
Systems lipid panel and glucose strips were used in conjunction with a Cardiochek Portable Blood Test System for assessment. The participant completed the International Physical Activity Questionnaire (IPAQ) to assess subjective physical activity habits (9).

**Measures:**

*Physical Activity.* Physical activity was measured by the ActiGraph GT3X+, a small activity monitor that collects accelerations throughout the day, which are expressed as activity counts. These counts were categorized as: sedentary, light activity, moderate activity, or vigorous activity. Activity counts were summarized over a 60 second epoch.

The validity and reliability of ActiGraph GT3X+ has been previously described (20, 31, 51). Subjects were instructed to wear the Actigraph GT3X+ at waist level in line with the right anterior axillary line during waking hours, and on their non-dominant wrist while sleeping. Subjects were asked not to wear the accelerometer during bathing or swimming. Following the subjects seven consecutive days of wear, data was downloaded from the device. Daily wear time was determined by removing periods of time 20 minutes or greater that detected no movement, including sleep validated by sleep logs. Average daily values were determined from activity counts and included: time spent in sedentary, light, moderate and vigorous activity, number of non-Freedson bout MVPA, total time non-Freedson bout MVPA, total time in MVPA, total Freedson (1998) bout count, total time in Freedson bouts, and step counts.

**Metabolic Syndrome (MetS).** MetS was assessed using NCEP ATP III criteria. MetS diagnosis is met when three or more of the following risk factors are present: central
obesity (waist circumference >102cm in men, >88cm in women); hypertriglyceridemia (≥150mg/dL); low HDL (<40 mg/dL in men, <50mg/dL in women); elevated blood pressure (≥130/85mmHg); elevated fasting glucose (110mg/dL)(67).

**Statistical Analysis**

Univariate Pearson correlation analyses were performed to determine the relationship between physical activity variables and MetS. Each variable determined to have a significant correlation with MetS was used independently in a step-wise, multiple linear regression to determine the best predictors for each MetS risk factor. Each significant variable was then ranked into tertiles and ANOVA/ANCOVA was performed with each MetS risk factor. Variables that have the greatest correlation with MetS were used as covariates. Statistical significance was set *a priori* at *p*<0.05.

**Results**

Seventy-two participants (24 male, 48 female) had valid measures of objective physical activity (Table 1). Out of the sample, two subjects were found to have MetS, therefore analyses were performed on individual MetS risk factors. The number of MetS risk factors per subject ranged from 0 to 4. Two subjects met the criteria for elevated systolic blood pressure, 8 for elevated waist circumference, 7 for elevated triglycerides, and 14 for low HDL. No subject had elevated fasted blood glucose.

*Univariate Correlation Analysis*
Univariate analysis results are presented in Table 2-3. The variables determined to have the strongest influence on MetS risk factors were daily average time in moderate activity, daily average MVPA, total number of Freedson bouts, total minutes in Freedson bouts, total MVPA, and total steps. Total Freedson bouts, total minutes in Freedson bouts, total MVPA, and total steps were correlated with waist circumference and systolic blood pressure. Total minutes in Freedson bouts was also correlated with HDL. There were no correlations between any physical activity measurements and blood glucose or triglycerides.

**Stepwise Linear Regression Analysis**

Stepwise linear regression results are presented in Table 3. Step counts was the only significant predictor of systolic blood pressure and waist circumference ($R^2 = 0.07; p<0.05; R^2 = 0.14; p<0.01$, respectively). Total number of Freedson bouts was the only significant predictor of HDL ($R^2 = 0.062; p<0.05$). There were no significant correlations between non-Freedson bout physical activity and MetS risk factors.

**ANOVA/ANCOVA Analysis**

The mean counts $\pm$ standard deviations for weekly step counts tertiles were 42492.1 $\pm$ 6795.7, 59261.3 $\pm$ 4891.6, and 82160 $\pm$ 10787.8 for low, moderate, and high, respectively. When examining by tertile, waist circumference was significantly higher in the lowest (86.4 $\pm$ 9.6) and moderate (87.6 $\pm$ 13.4) tertile compared to the highest tertile (74.8 $\pm$ 9.4) (Figure 1). There were no significant differences in tertiles of systolic blood pressure, HDL, or total metabolic syndrome risk factors (Figures 2-3).
Discussion

This study was conducted to examine the association between MVPA in non-Freedson bout minutes and MetS risk factors in college students. Contrary to previous literature we did not find associations between non-Freedson bout MVPA and MetS or associated risk factors. Previous literature has suggested non-Freedson bouts are a beneficial method to reducing MetS risk factors, primarily in older populations (4, 15, 26, 59). Subsequently, we suggested that shorter bouts may have a favorable effect on young adults. Boreham et al. illustrated favorable effects of small bouts in untrained college age females. After 8 weeks of 2-5 bouts of 2-minute stair climbs per week, subjects had significantly improved $\text{VO}_{2\text{max}}$ and LDL (7). This suggests stair climbing occurring in non-Freedson bouts can have an impact on metabolic processes. Holman, Carson and Janssen observed ≥5 minute and ≥10 minute bouts in adolescents and determined both had a similar ability in distinguishing normal and high cardiometabolic risk score (21). Despite some literature in favor of non-Freedson bouts, Freedson bouts currently have greater support in the literature (63). Strath et al. demonstrated that both non-Freedson bouts and Freedson bouts had a significant association with a smaller WC and BMI, however the Freedson bouts had a significantly stronger association (59). It appears that continuous longer bouts, as well as shorter bouts may have a positive role in metabolic processes.

Non-Freedson bouts minutes seem to affect older populations rather than college students. This may be explained by the lower physical activity levels of older compared to younger adults. Ward et al. reported about a 10% decrease in those meeting physical
activity guidelines from ages 18-24 compared to 25-64. By the 75+ age group the percentage of those who met guidelines was halved (65). Similarly, Anderssen et al. observed physical activity in 18-30 year olds and re-measured activity seven years later, at which time physical activity had decreased by 30% (2). Sparling et al. evaluated physical activity in recent college alumni who graduated between 1988 and 1996 with an average age of 30 years. When alumni were asked to recall physical activity as a college senior 43.1% reported being “regular exercisers”, 39.5% being “irregular exercisers”, and as alumni 44% described themselves as being “less active now” (57). Church et al. proposed that reductions in physical activity may be related to vocation. From 1960 to 2008, occupation availability with a moderate to vigorous MET level have decreased from 48% to 20%, whereas both sedentary and lightly active jobs have increased (8). This may be one of the underlying reasons why literature has demonstrated non-Freedson bouts as beneficial for older adults, and why the present study did not see such a relationship. It is proposed that with less physical activity accumulated in bouts, the non-Freedson bouts may have a stronger role in preventing MetS which may help explain why we did not see a non-Freedson bout effect on risk factors related to MetS in our population.

This study was the first to examine non-Freedson bouts and MetS in college students. Although non-Freedson bouts did not influence MetS risk factors, results from the current study suggest that other physical activity variables may have a stronger influence on the development of MetS risk factors in college students. Data from the present study suggest that a combination of physical activity habits are ideal for potentially reducing MetS risk factors. Results indicate that total step counts was the only
predictor of WC. These findings extend results of Sisson et al. who examined step counts and physical activity in adults. Subjects who took an additional 1,000 steps per day were more likely to have a lower WC (54). Similarly, Park et al. observed physical activity behaviors in older adults over a year and reported MetS was less likely to be present in those who reached 8,000-10,000 steps per day, with a duration of 20-30 minutes/day at an intensity of >3 METs. Additionally, the lower three step count quartiles had a 1.8-4.3 greater risk of MetS. Lower quartile mean counts were 3,400, 5,600, and 7,400 steps per day, with durations of 4, 12, and 19 minutes per day above 3 METs (42). Although total MetS risk, rather than WC was associated in Park et al., this may be explained by a median age of 74.5 observed in Park et al. compared to the median age of 22 in the present study (42). Our observations suggest that lower step counts may be a significant predictor of a higher WC in young adults. This is not an unexpected finding, rather it strengthens previous studies have suggested that step counts are associated with waist circumference in other populations (11, 13, 17, 50). Step counts was also found to be a significant predictor of SBP in young adults, which supports prior observations in other populations (18, 38, 62). It is speculated that the more steps a person takes, the less sedentary time an individual will accumulate. Sedentary time has been positively associated with WC and SBP (19, 33). Additionally, subjects in the present study spent about 58 minutes in MVPA per day. This is almost double the amount recommended by current guidelines (63). Reaching 30 minutes of at least moderate activity corresponds to ~3,000 to 4,000 steps, whereas a typical day excluding sport or exercise typically falls between 6,000 to 7,000 steps per day. For the present sample, the highest step count tertile had an average of 11,700 steps per day (62). This illustrates that the highest step
count tertile was potentially more likely to be engaging in purposeful exercise. Purposeful exercise at the moderate level or higher has been shown to effectively reduce WC and SBP (6, 34, 47).

Previous literature demonstrates average healthy adults take between 7,000 and 13,000 steps per day (61). Currently a goal of 10,000 steps per day is becoming more popular, and arguably most beneficial (52). In addition to being an easy number to remember, some studies have shown subjects who reach this step count threshold have lower body fat and blood pressure than counterparts who accumulated less steps (18, 61). Another benefit of 10,000 steps is a higher caloric expenditure of about 300-400 kcal, whereas 30 minutes of moderate activity is about 150 kcal (18, 64). Additionally, Wilde et al. determined when women added a 30-minute walk to their average day, daily steps increased from 7,220 to 10,030. This supports current US public health guidelines of reaching 30 minutes of MVPA in cases where walking is the main exercise mode (66).

To our knowledge, we are the first to report that total step counts have a greater influence on WC and SBP than other physical activity variables in young adults. Step counts may be the strongest correlated variable in preventing high WC and SBP in this population due to an educational campus environment. Many universities deter their students from bringing a car to campus, and additionally campus parking can be very limited. Some campuses promote active modes of transportation through walkability (23, 53, 55). On most campuses walking is a feasible mode of transportation which may allude to high correlation of steps to MetS risk factors. In a study conducted by Sisson, James and Tudor-Locke, students at a “fair” walkability rated campus took less steps and spent less time in MVPA than students at a different nearby campus rated as having good
walkability (55). Walkability can greatly impact college student physical activity throughout the day. In a study conducted at a community college students reported they were more likely to walk and bike if there were safer routes and better lighting (48). This is supported by Young, Surts and Ross who illustrated that only 17% of commuter college students were engaging in moderate PA three times per week, whereas non-commuter schools report a slightly higher average of 20-30% of students who meet guidelines (22, 30, 44, 69). Campus walkability and safety of routes is shown to impact student physical activity, this may be another reason why we did not see a non-Freedson bout effect in the present study.

Our results indicate that total Freedson bouts was a significant predictor of HDL. Total Freedson bouts was also correlated with, but not a significant predictor of WC and SBP. Additionally, total Freedson bouts was correlated with total number of MetS risk factors. These findings extend current literature that supports the 2008 Physical Activity Guidelines which recommend accumulating physical activity in bouts of 10 minutes or greater (39, 63). It is suggested that total Freedson bouts may have the greatest impact on HDL and total MetS risk factors. Physical activity has shown to be positively associated with HDL (5, 16). Mechanisms pertaining to physical activity and HDL increases are not fully understood, although it is known that increases in HDL are coupled with increases in lipoprotein lipase (LPL) activity, which can be stimulated by exercise (29, 60). Acute exercise studies have illustrated that LPL activity increases with energy demands of endurance exercise (28, 49). Additionally, triglycerides are the primary fuel for endurance exercise, depleted intramuscular triglycerides may trigger the synthesis or secretion of LPL in the muscle, thus potentially increasing HDL (24, 28, 49). This
supports our findings of Freedson bout frequency as the only significant predictor of HDL.

This study demonstrated prevalence of MetS and respective risk factors in a very active sample. Physical activity levels from the present study is among the higher levels of MVPA and step counts when compared to other studies with similar populations (37, 41, 45). This is the first study known to date that has observed a relationship between MVPA and step counts of this magnitude and MetS risk factors in a sample of young adults.

This study has several strengths, including the use of an objective, valid and reliable measure of physical activity. It is also the first study to our knowledge that examined potential influences of physical activity in non-Freedson bout periods on MetS in young adults. However, this study is subject to limitations which should be considered when interpreting results. Subjects used self-reported sleep logs to differentiate physical activity during waking hours and this study was also cross-section in nature thus cause-and-effect cannot be concluded.

In conclusion, our results emphasize the importance of physical activity to MetS risk. Results indicate a larger influence of step counts on WC and SBP, whereas total number of Freedson bouts have a greater influence on HDL and total Met risk factors in young adults. It is proposed that in college students a grand sum of physical activity accumulated in steps and Freedson bouts is most important in reducing MetS risk.
Manuscript References


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49. Sady SP, Thompson PD, Cullinane EM, Kantor MA, Domagala E, Herbert PN. Prolonged exercise augments plasma triglyceride clearance. *JAMA*


Williams L. Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in
adults (Adult Treatment Panel III) final report. *Communication*


<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>20.3 (1.6)</td>
</tr>
<tr>
<td>BMI</td>
<td>24.7 (4.7)</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>82.9 (12.3)</td>
</tr>
<tr>
<td>Percent Body Fat (%)</td>
<td>31.5 (10.3)</td>
</tr>
<tr>
<td>Average Systolic Blood Pressure</td>
<td>118.1 (10.2)</td>
</tr>
<tr>
<td>Average Diastolic Blood Pressure</td>
<td>75.5 (7.6)</td>
</tr>
<tr>
<td>Blood Glucose (mg/dL)</td>
<td>81.2 (6.9)</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>93.4 (36.0)</td>
</tr>
<tr>
<td>Low-Density Lipoprotein (mg/dL)</td>
<td>77.3 (22.8)</td>
</tr>
<tr>
<td>High-Density Lipoprotein (mg/dL)</td>
<td>58.7 (14.2)</td>
</tr>
<tr>
<td>Total Cholesterol (mg/dL)</td>
<td>154 (27.8)</td>
</tr>
<tr>
<td>Total Cholesterol/HDL</td>
<td>2.7 (0.7)</td>
</tr>
</tbody>
</table>

**Physical Activity Variables**

| Steps per Day                                | 8750.7 (2593.7) |
| Total Steps                                  | 61305.2 (18123.4) |
| Freedson Bouts per week                      | 10.4 (7.8)      |
| Freedson Bout Total (min)                    | 165.6 (133.3)   |
| Light Intensity per Day (min)                | 206.3 (59.8)    |
| Moderate Intensity per Day (min)             | 54.3 (20.7)     |
| Vigorous Intensity per Day (min)             | 40.9 (6.0)      |
| Very Vigorous Intensity per Day (min)        | 3.3 (0.6)       |
| MVPA per Day (min)                           | 57.9 (23.4)     |
| Total MVPA (min)                             | 405.4 (163.7)   |
| Total Non-Freedson Bout MVPA (min)           | 237.4 (77.1)    |
### Table 2. Initial Correlations between Physical Activity Variables and Metabolic Syndrome Risk Factors

<table>
<thead>
<tr>
<th></th>
<th>Light Activity Minutes</th>
<th>Moderate Activity Minutes</th>
<th>Vigorous Activity Minutes</th>
<th>MVPA</th>
<th>Total Step Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist Circumference</td>
<td>0.30*</td>
<td>-0.27*</td>
<td>-0.217</td>
<td>-0.302*</td>
<td>-0.38*</td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>0.052</td>
<td>-0.282*</td>
<td>-0.013</td>
<td>-0.259*</td>
<td>-0.267*</td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>0.037</td>
<td>-0.017</td>
<td>-0.137</td>
<td>-0.052</td>
<td>-0.065</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>0.024</td>
<td>-0.169</td>
<td>-0.096</td>
<td>-0.179</td>
<td>0.195</td>
</tr>
<tr>
<td>HDL</td>
<td>-0.146</td>
<td>0.143</td>
<td>0.132</td>
<td>0.167</td>
<td>-0.099</td>
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</tbody>
</table>

* p<0.05  
** p<0.01
<table>
<thead>
<tr>
<th></th>
<th>Number of Freedson Bouts</th>
<th>Freedson Bout Minutes</th>
<th>Total MVPA</th>
<th>Total non-Freedson bout MVPA</th>
<th>Total Step Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist Circumference</td>
<td>-0.35**</td>
<td>-0.32**</td>
<td>-0.30**</td>
<td>-0.06</td>
<td>-0.38*</td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>-0.24*</td>
<td>-0.25*</td>
<td>-0.26*</td>
<td>-0.09</td>
<td>-0.267*</td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>-0.05</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.12</td>
<td>-0.065</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>-0.15</td>
<td>-0.13</td>
<td>-0.18</td>
<td>-0.17</td>
<td>-0.099</td>
</tr>
<tr>
<td>HDL</td>
<td>0.25*</td>
<td>0.21</td>
<td>0.17</td>
<td>-0.04</td>
<td>0.195</td>
</tr>
</tbody>
</table>

* p<0.05
** p<0.01
<table>
<thead>
<tr>
<th>Table 4. Predictive Value of Physical Activity Variables on MetS Risk Factors</th>
<th>( \beta )</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waist Circumference (cm)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steps per Day</td>
<td>-0.38</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Systolic Blood Pressure (mmHg)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steps per Day</td>
<td>-0.267</td>
<td>0.023</td>
</tr>
<tr>
<td><strong>HDL (mg/dL)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Freedson Bouts</td>
<td>0.248</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Total MetS Risk Factors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Freedson Bouts</td>
<td>-0.262</td>
<td>0.026</td>
</tr>
</tbody>
</table>
**Figure 1.** The Effect of Total Step Count Tertiles on Waist Circumference

*High step counts waist circumference is significantly lower than moderate and low (p<0.05)*
Figure 2. The Effect of Total Step Count on Systolic Blood Pressure
Figure 3. The Effect of Total Freedson Bouts on HDL
Appendix A:

Informed Consent
James Madison University  
Department of Kinesiology  
Informed Consent

**Purpose**

You are being asked to volunteer for a research project conducted by Dr. Trent Hargens from James Madison University entitled, “The Association Between Sleep Quality, Physical Activity, and Risk of Developing the Metabolic Syndrome”.

The primary goal of this study is to examine whether sleep quality and/or physical activity amount impacts the risk of developing the Metabolic Syndrome. This may provide a clearer picture into which factors have a stronger influence in the possible development of the Metabolic Syndrome.

The Metabolic Syndrome is the name for a group of risk factors that raises your risk for heart disease and other health problems, such as diabetes and stroke. Those risk factors include:

- Abdominal Obesity
- Elevated Triglycerides
- Low HDL Cholesterol
- Impaired Fasting Glucose
- Elevated Blood Pressure

**Experimental Procedures**

You will be asked to visit the Human Performance Laboratory (HPL) in Godwin Hall 2 times over the course of about 7 – 10 days. For visit one, you will need to be fasted for at least 8-12 hours. Your total time commitment for participation in this study will be approximately 2 hours. You will be asked to wear a device (an accelerometer) on your waist during the day for a period of 7 days, while wearing the same device on your wrist at night while you sleep. Detailed information on each visit is provided below:

**Visit 1**

Before any test is given, you will be asked to complete a screening form and an informed consent, to insure that you meet the study criteria, that you do not have any factors that would disqualify you from participation. Upon completion of the informed consent, you will be asked to complete a short health history questionnaire providing information about your characteristics and health. You will then be asked complete 3 standardized questionnaires about snoring, your physical activity patterns, and risk for cardiovascular disease.

You will then have your blood pressure, height, weight, and waist circumference measured. After that, your body composition will be analyzed via a Dual-energy x-ray absorptiometer (DEXA). The DEXA scan will allow us to measure your percent body
fat. The DEXA is much like an X-ray machine. The DEXA will scan your entire body very slowly; so, you will need to lie on a table without moving for almost 10 minutes, while the DEXA is passed over your entire body. You will feel no discomfort associated with this test. Lastly, you will have your blood drawn to assess part of your lipid profile as well as your blood glucose levels.

At the end of this first visit you will also be given instructions on wearing the accelerometer. An accelerometer is a small device that is to be worn on your waist during the day and on your wrist while in bed.

Visit 2

Approximately 7-10 days after Visit 1, you will be asked to return to the HPL for your final visit. During this visit you will return the accelerometers and have your blood pressure measured. You will also be asked to complete 1 additional short questionnaire assessing your physical activity habits over the previous 7 days.

Risks

There are no risks associated with wearing an accelerometer. Also, there is no risk associated with heart rate, blood pressure, height, weight, and waist circumference measures. You will not be asked to change any of your personal habits during the course of the study. Measurements with associated risks include: the DEXA scan and treadmill exercise test.

The amount of radiation that you will receive in the DEXA exam is less than the amount you will receive during a transatlantic flight, and is equal to about 1/20 of a chest x-ray. If you are female, you should not be pregnant for this study because of risks from the DEXA scan radiation to the embryo or fetus. If you feel that you might be pregnant, inform the research staff immediately.

Benefits

Participation may include knowledge about your health status. You will receive information on your body composition, including percent body fat and bone mineral density, an assessment of your blood lipid and glucose levels, an assessment of your sleep quality, an assessment of your physical activity level, and cardiovascular fitness. Indirect benefits of participating in this study will be helping the researchers better understand the relationship between sleep quality, physical activity, and the Metabolic Syndrome.

Inquiries

If you have any questions or concerns or you would like to receive a copy of the final aggregate results of this study, please contact Dr. Trent Hargens at hargenta@jmu.edu or (540) 568-5844.
Questions about Your Rights as a Research Subject
Dr. David Cockley
Chair, Institutional Review Board
James Madison University
(540) 568-2834
cocklede@jmu.edu

Confidentiality
All data and results will be kept confidential. You will be assigned an identification code. At no time will your name be identified with your individual data. The researcher retains the right to use and publish non-identifiable data. All data will be kept secured in a locked cabinet. All electronic data will be kept on a password-protected computer. Final aggregate results will be made available to participants upon request.

Freedom of Consent
Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind.

I have read this consent form and I understand what is being requested of me as a participant in this study. I freely consent to participate. I have been given satisfactory answers to my questions. The investigator provided me with a copy of this form. I certify that I am at least 18 years of age. By clicking "Yes" to the question below and submitting this confidential online survey, I am consenting to participate in this research. Do you provide consent to participate in the research study entitled, "The Association Between Sleep Quality, Physical Activity, and Risk of Developing the Metabolic Syndrome"?

☐ Yes
☐ No

Please enter your name here

Please enter today's date
Appendix B:

Medical and Health History Form
Medical and Health History Form

Name: ___________________  Date of Birth: ___________________
Ethnicity: ______________
Height: ________ ft  Weight: ______ pounds
Gender: Female__________  Male________
Campus Address: ____________________________
Campus Telephone Number: ___________________  Campus Email Address: __________________________
Address for Permanent Residence:

Person to contact in case of emergency:

Relationship: ______________  Daytime Telephone: ______________  Home Telephone: ______________

Primary Care Physician: ___________________  Telephone: ______________

Medical History
Please indicate any current or previous conditions or problems you have experienced or have been told by a physician you have had:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease or any heart problems:</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Rheumatic fever:</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Respiratory disease or breathing problems:</td>
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<tr>
<td>Circulation problems:</td>
<td>___</td>
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<td>Kidney disease or problems:</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Urinary problems:</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Reproductive problems:</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Musculoskeletal problems:</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Fainting or dizziness, especially with exertion:</td>
<td>___</td>
<td>___</td>
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<tr>
<td>Neurological problems/disorders:</td>
<td>___</td>
<td>___</td>
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<td>High blood pressure:</td>
<td>___</td>
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<td>Low blood pressure:</td>
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<td>___</td>
</tr>
<tr>
<td><strong>High</strong> blood cholesterol:</td>
<td>___</td>
<td>___</td>
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<tr>
<td>Diabetes:</td>
<td>___</td>
<td>___</td>
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</table>
Thyroid problems: ____________________________
Eating disorders (bulimia, anorexia): ____________________________
Allergies: ____________________________

If "yes" to any of the above please indicate the date, explain, and describe:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Please list any hospitalizations/operations/recent illnesses (Type/Date):

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Do you ever feel faint, short of breath, or chest discomfort with exertion? Yes: ________ No: ________
If "yes", please explain:

________________________________________________________________________

Are there any orthopedic limitations you have that may restrict your ability to perform hard running exercise or intense strength-type exercises? (back, hips, knees, ankles) Yes ________ No ________
If "yes" please explain:

________________________________________________________________________
________________________________________________________________________

Family Health History
Has anyone in your family (blood relatives only) been diagnosed or treated for any of the following?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Relationship</th>
<th>Age</th>
</tr>
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<td>High blood pressure</td>
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<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Health Habits
Do you add salt to your food? Yes _____ No _____ Are you on any special type of diet? Yes _____ No _____
If “yes” please describe ___________________________________________
__________________________________________
Do you drink caffeinated beverages? Yes _____ No _____ How many cups per day?
__________________________________________
Do you drink alcoholic beverages? Yes _____ No _____ How many drinks per week?
__________________________________________
What is the average number of drinks that you consume on the weekend? _________
Did you use tobacco products in the past (more than 12 months ago)? Yes ________ No ________

Sleep Habits Evaluation
Do you have episodes of parasomnias (disorders such as sleep walking, sleep talking, night terrors, body rocking, bedwetting that will cause partial or full awakening)? Yes______ No______
Do you show signs of sleep disturbances (such as insomnia, daytime sleepiness) when you are anxious, stressed? Yes__________ No__________
Do you have difficulties to fall asleep if a certain object or a certain situation is absent such as listening to the radio, watching the television, etc? Yes__________ No__________
Do you have difficulties to fall asleep earlier or later of your usual bedtime? Yes_______ No_______
__________________________________________
Do you wake up at night to get a little snack? Yes______ No__________
If “yes”, do you think that the snack is helping you to go back to sleep? Yes______ No__________
Do you have hallucinations (vivid images that look like dreams occurring when you sleep) or find yourself physically weak or paralyzed for a few seconds? Yes_______ No_______
__________________________________________

Tonsils and Adenoids evaluation questionnaire
Do you have a history of recurrent tonsillitis which is an inflammation of the tonsils (clusters of tissue that lie in bands on both sides of the back of the throat) caused by an infection? In tonsillitis, the tonsils are enlarged, red, and often coated either partly or entirely? Yes________
No__________________________________________
Did you ever have inflammation of the adenoids (single clump of tissue in the back of the nose) causing a blockage of the back of the nose, chronic and recurrent fluid or infections of your ears, or chronic or recurrent sinus infections?  Yes  No

Did you have tonsillectomy (tonsils removed) or adenoidectomy (adenoids removed)? Yes  No

Medications
Please list all medications (prescription and over-the-counter) you are currently taking or have taken in the past week:

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

Please sign to indicate the above information is correct:

Print Name ___________________________ Signature ___________________________ Date ____________

Follow Up Review and Interview by: ___________________________  Signature of Project Staff Member ___________________________ Date ____________
Appendix C:

International Physical Activity Questionnaire Short Form (IPAQ-SF)
INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

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

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

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?
   
   _____ days per week
   
   □ No vigorous physical activities → Skip to question 3

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

   _____ hours per day
   _____ minutes per day

   □ Don’t know/Not sure

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

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

   _____ days per week

   □ No moderate physical activities → Skip to question 5

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.
4. How much time did you usually spend doing moderate physical activities on one of those days?

_____ hours per day
_____ minutes per day

☐ Don't know/Not sure

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

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

_____ days per week

☐ No walking  →  Skip to question 7

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

_____ hours per day
_____ minutes per day

☐ Don't know/Not sure

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

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

_____ hours per day
_____ minutes per day

☐ Don't know/Not sure

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

Physical Activity Monitor Instructions & Log
Physical Activity Monitor Instructions & Log

- Please do your normal activities while wearing the monitor. Try to refrain from intentionally increasing your physical activity beyond what you “normally” do while wearing the monitor.
- During normal waking hours the monitor should be placed on your belt or waistband at the midline of the thigh (if you wear a belt, clips the monitor to the belt, otherwise just clip it to your waistband).
- At night while in bed, the monitor should be worn on the wrist of your non-dominant arm.
- The monitor should be worn at all times except when swimming or showering.
- Thank you for participating in this research study

Name

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Please report if you did not have the monitor on for the whole day (list day, reason, and how long it was not on). If none, check here ____.

Please report any days you performed a planned bout of exercise (list day, type of exercise, and how long you performed the activity). If none, check here ____.

Please report any days you performed activities that did not require a lot of moving around, but rather more arm activities (list day, type of activity, and how long you performed the activity). If none, check here ____.

Comment on any unusual or atypical physical activities (activities that you do not usually participate in on a regular basis) you performed during the past week. If none, check here ____.
References


39. Singh AS, Mulder C, Twisk JWR, Van Mechelen W, Chinapaw MJM. Tracking of


44. Tudor-Locke C. Research Digest Taking Steps Toward Increased Physical Activity: Using Pedometers to Measure and Motivate President’s Council on Physical Fitness and Sports. 2002;


