RELIABILITY AND VALIDITY OF QUESTIONNAIRE MEASURES

OF SEDENTARY TIME IN ADOLESCENTS

by

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(Under the Direction of Ellen Evans and Michael Schmidt)

ABSTRACT

The purpose of this study was to examine the reliability and validity of questionnaire estimates of sedentary time in adolescents. Adolescents (n=98) completed Youth Risk Behavior Survey (YRBS) sedentary items and the Adolescent Sedentary Activity Questionnaire (ASAQ) twice. Actigraph GT3X+ accelerometers were used to obtain an objective measure of sedentary time as the criterion measure. Results indicated acceptable levels of reliability for the YRBS TV time item (rho=.82), but a lower estimate for the computer/video game item (rho=.68). When examined for the entire week, reliability estimates for all categories of the ASAQ were acceptable ($R\geq.70$), except for the education and travel categories. Validity evidence of the ability of the questionnaires to estimate accelerometer-determined sedentary time was poor ($r \leq .16$; Spearman's rho≤.15). In conclusion, the YRBS sedentary items and the ASAQ demonstrated moderate to good evidence of reliability and poor evidence of validity for measuring sedentary time in adolescents.

INDEX WORDS: sedentary time; questionnaires, accelerometer; Youth Risk Behavior Survey; Adolescent Sedentary Activity Questionnaire; reliability; validity

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TABLE OF CONTENTS

APPENDICES

CHAPTER 1

INTRODUCTION

Sedentary behavior is characterized by activities that involve little physical movement and low energy expenditure [1, 2]. In the past decade, research has focused on the negative health effects resulting from too much sitting [3]. The beneficial role of physical activity on cardiovascular and metabolic health has been established [4]; however, emerging evidence suggests that, independent of physical activity levels, spending too much time in sedentary behaviors increases health risks for adults. Time spent in sedentary behaviors has been shown to elicit biological mechanisms that are different from those observed during physical activity and compromise metabolic health [5, 6]. Excessive television (TV) viewing has been linked to increased adiposity in this age group although it may be partially attributable to unhealthy eating patterns that take place while watching TV [7, 8]. Excessive time spent in sedentary pursuits may also have an adverse impact on psychological health. For example, moderate evidence suggests an inverse relationship between screen time, particularly TV viewing, and self-esteem in adolescents [9, 10]. Similarly, excessive screen time may be associated with lower academic achievement [11, 12].

Physical activity levels tend to decline from childhood to adolescence [13, 14]. Among youth, adolescents generally spend ~60% of their waking time in sedentary pursuits [15]. With the high rates of overweight and obesity, and low levels of physical activity in this age group, public health efforts to improve the health of adolescents should also focus on reducing prolonged bouts of sedentary time [16]. Important for health across the lifespan, early lifestyle choices may influence a person’s health status later in life. For example, a longitudinal study showed that leading a sedentary lifestyle during one’s youth may increase the likelihood of cardiovascular and metabolic risk factors in young adulthood [8]. Thus, more research is needed targeting sedentary behaviors in the adolescent cohort.

Much research to date addressing sedentary behavior has used questionnaires that quantify screen time. As the field has advanced it has been recognized that to more accurately assess sedentary time, quantitatively and qualitatively, questions that cover the broad range of sedentary behavior should be utilized (e.g. how much time is spent sitting while traveling to and from school, completing homework, using the computer for recreational/leisure, etc.). Notably, few studies have used objective tools, such as accelerometers, to measure sedentary behavior in the adolescent population [1, 17]. Accelerometers can objectively measure sedentary time, but lack the ability to differentiate domain-specific sedentary behaviors [18]. Accelerometer methodology also requires expertise. High quality instruments are relatively expensive and thus this methodology is not always readily available. In addition to being cost-effective, questionnaires are also able to provide context to situations in which sedentary behaviors occur. Valid and reliable questionnaires are needed for studies of total and domain-specific sitting behaviors [18, 19]. Two contemporary measures of sedentary time in the adolescent cohort are 1) The Youth Risk Behavior Survey (YRBS) which is a popular instrument used in surveillance-based studies and 2) The Adolescent Sedentary Activity Questionnaire (ASAQ) which addresses domain-specific sedentary time outside of school hours [20].

Thus, in this context, the overarching goals of this study are to examine in a sample of adolescents the reliability and validity of popular instruments, the YRBS and ASAQ, using accelerometer-measured sedentary time as the criterion method for the latter.

Specific Aim 1

To examine the test-retest reliability of the sedentary behavior items on the Youth Risk Behavior Survey (YRBS) and the Adolescent Sedentary Activity Questionnaire (ASAQ).

Specific Aim 2

To examine the validity of the sedentary behavior items on the Youth Risk Behavior Survey (YRBS) and the Adolescent Sedentary Activity Questionnaire (ASAQ) by measuring sedentary time using accelerometer-measured sedentary time as the criterion method.

Public Health and Scientific Related Significance

Sedentary time has been determined to be an independent risk factor for multi-dimensional health, especially in adolescents known to have high levels of this behavior. To characterize the impact of sedentary behavior on health and design effective interventions to reduce sedentary time requires reliable and valid methods to measure sedentary time. This study adds to the literature by contributing reliability and validity evidence for the sedentary behavior items on the YRBS questionnaire [21]. Reliability and validity data are also provided for the ASAQ, a popular instrument used in the adolescent population. The findings from this study add to the literature regarding 1) the acceptability of YRBS and ASAQ for assessing sedentary behavior, and 2) the selection of a method to assess sedentary behavior in health interventions.

CHAPTER 2

REVIEW OF LITERATURE

Sedentary Behavior: Associated Health Risks in Adolescents

Sedentary behavior includes activities that involve little physical movement and low energy expenditure. Sedentary behavior is most commonly thought of as sitting, but can also include sleeping, watching television (TV), lying down, and other activities that do not increase energy expenditure above resting levels. It is widely accepted that a sedentary lifestyle can have negative health consequences; however, it should be noted that when measuring total sedentary time, sleep is generally excluded because of its health benefits [1, 2].

In recent years, sedentary behavior has been considered as a distinct set of behaviors. This distinction is contrary to past definitions, which classified an individual as sedentary if he or she did not achieve sufficient amounts of moderate-to-vigorous physical activity (MVPA) [1, 3, 22]. The absence of meeting physical activity guidelines for MVPA is defined as physical inactivity; however, a person can still accumulate too much sedentary time, even if they are defined as physically active. Sedentary behavior incurs physiological responses that are distinct from the physiological responses to exercise. The differences in energy expenditure along the movement continuum can help conceptualize these biological differences. As one moves from the low to high end, energy expenditure increases. Intense exercise, which is ≥ 6 metabolic equivalents (METs), lies on the far end of the movement continuum, while sedentary behavior, which ranges from 1.0 – 1.5 METs is located on the opposite end [3, 23, 24].

Adolescents are one of the most sedentary cohorts in the United States. Based on accelerometer data from the National Health and Nutrition Examination Survey, adolescents, ages 12 – 19, spend on average 7.5 – 8.0 hours per day in sedentary pursuits [25]. Approximately 60% of the adolescent awake time is spent in sedentary behaviors [15]. Nearly 50% of adolescents in North America spend ≥2 hours/day in front of screens [26, 27]. Even though screen time makes up only a part of total sedentary behavior, some research findings suggest a positive relationship with time spent in front of a screen and adiposity [28]. Several possibilities for the relationship of adiposity and screen time that have been proposed include, increased snacking during TV time, exposure to advertisements for unhealthy foods, and the replacement of physical activity with TV viewing.

Methods for Measuring Sedentary Time

Sedentary behavior can be subjectively measured through proxy- and self-report questionnaires, and diaries. Diaries are used less frequently than other self-report methods. Self-administered, as opposed to research staff administered, questionnaires are commonly used to capture sedentary time. Parent-proxy report questionnaires may provide better behavior recall than self-report methods for younger children [29]. Much research using self-report measures has focused on TV-viewing time as a proxy measure of sedentary behavior. The reliability and validity of self-reported TV time in children are highly variable [17, 29]. Because sedentary behavior occurs in multiple forms, TV-viewing time by itself is not an appropriate measure of overall sedentary behavior [7, 8, 25]. The most commonly used instruments for research in this population include the following: 1) The International Physical Activity Questionnaire (IPAQ) which provides a single item assessment of sedentary behavior [30]; 2) The Youth Risk Behavior Survey (YRBS) that contains two items that address the amount of screen time accumulated during average school days (i.e. watching TV, using the computer, playing video games) [31]; 3) The Adolescent Sedentary Activity Questionnaire (ASAQ) is a self-report questionnaire that addresses time spent in a comprehensive range of sedentary behaviors outside of school hours [20]. As evident from this brief description, subjective measures of sedentary behavior in adolescents vary widely in their complexity of assessment. The two more commonly used methods to assess sedentary time in adolescents are the YRBS and ASAQ.

The Youth Risk Behavior Surveillance System (YRBSS) was developed to monitor preventable health-risk behaviors that contribute to the leading causes of morbidity and mortality in youth and adults in the United States [31]. The test-retest reliability of the YRBS has been studied twice. On the 1991 YRBS, Brener et al. demonstrated substantial strength of agreement on the physical activity items, with kappa statistics ranging between .64 and .91 [32]. It should be noted that no sedentary items were included in the questionnaire. The most consistent responses across the two administrations of this questionnaire were from high school aged students [33]. Brener et al. also examined the 1999 YRBS questionnaire. Within the physical activity behaviors, one item addresses sedentary behavior (i.e., watch ≤ 2 hours of television on an average school day) [34]. A kappa statistic of 46.7% was calculated for this item, suggesting moderate strength of agreement, according to the recommendations of Landis and Koch [32]. The physical activity items had kappa statistics ranging from 41% to 84%, suggesting moderate to substantial strength of agreement. In the current study the 2015 YRBS, which contains two items that assess screen time, was used [21]. The reliability and validity of the sedentary behavior items has not been evaluated on current YRBS questionnaires.

The ASAQ was designed to measure the type, frequency, and duration of sedentary behavior in adolescents, outside of school hours. To evaluate sedentary activities in different domains, the categories assessed by this questionnaire include small screen recreation (SSR) (TV, videos/DVDs, computer for fun), education (doing homework with/without a computer, being tutored), travel (seated in a vehicle), cultural (reading, playing an instrument, crafts or hobbies), and social (sitting around with friends, talking on the telephone, religious activities). The ASAQ was developed by Hardy et al., who reported in two studies of Australian youth, that the questionnaire has acceptable test-retest reliability, as well as content and face validity [20, 35]. Hardy et al. demonstrated in their first ASAQ reliability study that total weekday and weekly sedentary activities had acceptable reliability, as shown by intraclass correlation coefficients (ICCs) of (0.71) and (0.73), respectively. Hardy et al. reported in their second ASAQ reliability study that most, but not all sedentary time categories demonstrated acceptable reliability, with most ICCs falling above 0.70. A study of Brazilian adolescents examined the test-retest reliability of the ASAQ and found it had satisfactory reproducibility, as demonstrated by most ICCs falling above 0.70; however, it should be noted that the length of time between questionnaire administrations was only four days [36]. The criterion validity of the ASAQ has not been examined previously. Similarly, the reliability of the ASAQ has not yet been examined in a cohort of American adolescents.

Regarding objective measurement of sedentary time, the ability of accelerometers to measure movement across all intensity ranges makes them useful tools for assessing time spent both in sedentary behavior and physical activity. The validity of accelerometers for measuring physical activity is well established [37-40]. Sedentary behavior can be objectively measured using several methods, including accelerometers and posture monitors. Posture monitors, such as the activPAL™, use an inclinometer function to capture changes in body position (i.e., sitting, lying, or standing), which can be useful in determining the mode of sedentary behavior. The accelerometers most often used in research are from Actigraph (Actigraph LLC, Pensacola, FL, USA). The Actigraph GT3X+ is a triaxial model that measures acceleration in three movement planes. Unlike older models the GT3X+ contains an inclinometer function. Accelerometers are the criterion method for measuring sedentary time in the current study; however, it should be noted that the inclinometer function of the GT3X+ was not used in the current study [1, 29].

There are strengths and weaknesses associated with subjective and objective measurements of sedentary time. Self-report questionnaires are cost-effective, have relatively low burden for participant and administrator, and can be used for population-based studies.

Self-report methods also have the benefit of providing information on type and context of a behavior. A limitation of self-report measures is that they often have poor validity. Cultural norms and perceived social desirability can pose another limitation to self-report measures. Concurrent behaviors (i.e. watching TV and using the computer at the same time) can make it difficult to measure specific sedentary behaviors. Single item questionnaires that are used for global assessments often ask only about screen time, so may underestimate sitting time when compared to accelerometer-measured sedentary behavior. Domain-specific questionnaires that address multiple sedentary behaviors are more accurate in measuring sitting time than single item questionnaires [41]. Accelerometry and other objective tools cannot provide information on type of behavior, and are limited in measuring some aspects of sedentary behavior [29]. Unlike current technology [29], older accelerometers do not have inclinometers, and so their inability to distinguish between lying, sitting, or standing is a limitation to sedentary behavior research. For example, standing for a long time may not be a sedentary activity, but the accelerometer may misclassify this period of non-movement as sedentary. Another benefit of accelerometry is that movement data can be stored in short time intervals, making it possible to measure sedentary time cumulatively and in bouts across many days. In sum, the use of subjective and objective research methodology in combination can enrich the information gathered due to contributions of both quantitative and qualitative data regarding sedentary behavior.

CHAPTER 3

METHODS

Experimental Design and Overview

This study was embedded in a larger study and used a secondary analysis regarding subjective and objective measures of sedentary behavior in adolescents [42]. This project used a cross-sectional design that assessed adolescent males (*n* = 32) and females (*n* = 66) who were recruited from the Athens community and surrounding areas. Participants completed two visits approximately 2 weeks apart to obtain reliability data.

Participants

A cohort of youths (*N*=200, 40% black, 60% female, 12-19 years) from communities surrounding the University of Georgia (UGA) was contacted by phone, email, and mail and asked to participate in a follow-up to previously conducted studies. All participants previously took part in one of two NIH funded clinical trials. One, which was completed in 2011, recruited youths (*N*=323, 50% black, 50% female, 9-13 yo,) from communities surrounding the University of Georgia (UGA), Purdue University (PU), and Indiana University (IU) for a randomized controlled trial examining the effect of vitamin D_3 supplementation on vitamin D metabolism [42]. The other nutrition trial, which was completed in 2013, recruited white females who took part in a randomized controlled trial involving zinc supplementation. Participants were excluded from the current study if they did not partake in any of the previous studies, if they had a musculoskeletal disorder that would limit their completion of study procedures, or were taking medications known to influence bone metabolism. Female participants who indicated they had been pregnant, or were currently pregnant were also excluded due to X-ray radiation from peripheral quantitative computed tomography (pQCT) and dual-energy X-ray absorptiometry (DXA). To be included in the current analyses, participants must have completed the subjective and objective measures of sedentary behavior at both visits.

Primary Parent Project Measures

Body Composition & Bone Status

Body composition was assessed at the first visit using dual-energy x-ray absorptiometry (DXA; Discovery A, Hologic Inc). Bone assessment at anatomical locations, and visceral and muscle fat evaluations were completed using DXA and pQCT.

Dietary Intake

Dietary intake data was assessed to evaluate macronutrient and micronutrient intakes known to influence bone status. Breakfast intake dynamics were also assessed to examine the effects of breakfast timing and macronutrient composition on body composition and metabolic outcomes. Dietary intakes were assessed using the 3-day diet record and the BEVQ-15 beverage questionnaire, and breakfast intake was assessed using a novel questionnaire. A trained interviewer, using food models to help facilitate estimation of serving sizes interviewed subjects.

Biomarkers of Health Risk

Following a 12-hour overnight fast, blood samples (30 ml) were collected. Serum samples were stored at -70 °C for analyses for biomarkers of systemic inflammation and bone health-related factors. After the blood draw, each participant was given a snack.

Muscle Capacity

Muscle capacity was examined at the second visit. Leg power was assessed using a Nottingham Leg Extensor Power Rig (Medical Engineering Unit, University of Nottingham Medical School, Nottingham, UK). Lower body strength in both the eccentric and concentric phases of muscle contraction was measuring using an isokinetic dynamometer (Biodex System Pro 4, Biodex Medical Systems, INC., New York). Forearm strength was tested using a handgrip dynamometer (Jamar Plus+ Digital Hand Dynamometer; Patterson Medical, Bolingbrook, IL).

Physical Function and Mobility

Physical function and mobility was tested using Functional Movement Screen™. Balance was assessed using the Y-Balance Test™. Walking gait was measured using a GAITRite mat (GAITRite, CIR Systems Inc., Sparta, NJ).

Primary Outcomes

Demographic, Health History, and Medical History [shared data from the parent project]

Participant demographic information, health history, and medical history were collected at the first research visit. At the second visit, standing height was measured by a stadiometer (Seca 242, SECA Corp, Hamburg, Germany) to the nearest 0.1 cm. Body mass was measured with a digital scale (Tanita WB-110A class III, Tanita Corporation, Tokyo, Japan) to the nearest 0.1 kg. Subsequently, BMI was calculated as mass divided by height squared (kg/m^2).

Sedentary Behavior (Subjective)

Sedentary behavior was subjectively measured using the sedentary behavior items from the Youth Risk Behavior Survey (YRBS) and the Adolescent Sedentary Activity Questionnaire

(ASAQ). The items on the YRBS that were used in this study examine how much time is spent watching TV during an average school day, and how many hours per day are spent playing video/computer games and using a computer for recreation/leisure. The ASAQ measures how sedentary time is accumulated by asking participants to report how long they spend sitting during various activities before and after school during a normal week and a normal weekend. The items on the ASAQ examine time spent sitting in different domains, such as, screen time, travel, crafts and hobbies, sitting with friends, and practicing a musical instrument. The ASAQ also addresses multiple modes of screen time, including watching TV, DVDs/videos, using the computer for recreation/leisure, and using the computer for homework. The YRBS and ASAQ were administered at two visits approximately 7-14 days apart. The YRBS sedentary behavior items and the ASAQ can be found in Appendix B.

Sedentary Behavior (Objective)

Sedentary behavior was objectively measured using a tri-axial Actigraph GT3X+ accelerometer (Actigraph, LLC, Fort Walton Beach, FL). As described in the previous chapter, the GT3X+ measures acceleration in three planes over a user-defined time interval. The summed squared values are stored as activity counts. The inclinometer function on the Actigraph GT3X+ was not used in the current study [43]. Participants were instructed to wear the accelerometer on their right hip for seven consecutive days during all waking time, excluding water-based activities, or during participation in contact sports that risked damaging the device. Three weekly text messages were sent to remind participants to wear the activity monitor. These messages were sent throughout the week and on the weekend, at a time specified as the typical wake-up time in the morning. Text messages did not contain any personal information nor were they encrypted or secure during their transmission. The following is the specific text message that was sent: *‘Good morning! Please wear your activity monitor all day except when doing anything with water. Record on and off times on your log. Have a great day!’*

Regarding data reduction, to be considered a valid representation and included in analyses, accelerometers must have been worn for at least 3 weekdays and 1 weekend day, for a minimum of 600 minutes per day. Based on results from Trost et al., [44] which cross-validated Evenson et al. [45] cut points in children and adolescents, a threshold of ≤100 counts per minute was used to calculate sedentary time. Sedentary behavior measured with the GT3X+ accelerometer was used as the criterion measure of sedentary time. In order to assess evidence of validity of the YRBS sedentary items and ASAQ, accelerometer-measured sedentary time was examined in both bouts and in total time. The purpose behind comparing bouts of sedentary time and total amount of sedentary time was to determine if one expression of sedentary time from the accelerometer had a stronger association with questionnaire-measured sedentary behavior.

Statistical Analysis

Statistical analyses were conducted using SPSS version 22 (IBM Corp: Armonk, NY). Prior to analysis, data for all primary outcomes were assessed for normality using conventional methods. Primary Aim 1: 1) Test-retest reliability of the Youth Risk Behavior Survey (YRBS) was analyzed in two ways: (a) Spearman's rho and Wilcoxon signed-rank tests were used to provide an estimate of repeatability for both sedentary items (TV time and computer/video game time); (b) Proportion of agreement (Pa) and modified Kappa statistics were calculated when the TV time item was categorized as watching ≤ 2 hours/day and > 2 hours/day [32]. 2) On the Adolescent Sedentary Activity Questionnaire (ASAQ), time spent in each category of sedentary time and total sedentary time (the sum of all categories of sedentary time) were calculated for weekdays, weekend days, and all days. Subsequently, Spearman's rho and Wilcoxon signed-rank test were calculated to examine test-retest reliability [46]. Primary Aim 2: Accelerometer measured sedentary time (weekday, weekend and total time) was considered the criterion measure of sedentary behavior in order to examine evidence of validity of the YRBS sedentary items and the ASAQ using the following: 1) Regression analysis was used to estimate questionnaire-measured sedentary time from accelerometer measures of total, weekday, and weekend sedentary time (R, R^2, SEE); 2) Spearman's rho in order to examine the agreement between questionnaire-measured sedentary time and accelerometer-measured sedentary time; 3) Wilcoxon signed-rank tests to examine median differences between questionnaire-measured sedentary time and accelerometer-measured sedentary time; 4) Modified Bland-Altman to compare the differences between questionnaire-measured sedentary time and accelerometer-measured sedentary time and sedentary time measured from the questionnaire.

CHAPTER 4

RESULTS

Results are presented in the following order: descriptive statistics, reliability (YRBS sedentary items and ASAQ), validity (YRBS sedentary items and ASAQ).

Descriptive Statistics

Descriptive statistics of the sample can be found in Table 1. The study sample included 98 participants (19% black, 67% female). As can be seen in the descriptive table, the sample size varied for the questionnaires and accelerometer data. The smaller number of participants for the accelerometer data is due to exclusion of participants who had invalid wear days.

Table 1
Descriptive Statistics

Variable	*N*	Mean	SD	Min	Max	Skewness	Kurtosis
Age (yrs)	98	16.1	1.9	12.2	19.4	-0.4	-0.7
Height (cm)	98	167.5	10.0	141.3	191.2	0.1	-0.3
Weight (kg)	98	66.5	18.3	31.2	132.8	1.3	2.2
Body Mass Index ($kg{\cdot}m^{-2}$)	98	23.5	5.3	15.6	40.5	1.2	1.0
YRBS Total Sedentary Time (min)	98	196.5	168.8	0.0	720.0	1.2	1.0
ASAQ Total Sedentary Time (min)	97	541.7	363.3	137.9	2110.0	2.4	7.0
Actigraph Sedentary Time (min)	79	620.6	75.3	423.3	824.2	0.2	0.3
Actigraph Sedentary Time (15-min bouts; min)	79	156.6	63.4	54.7	330.2	0.7	0.3
Actigraph Sedentary Time (30-min bouts; min)	79	75.3	30.0	0.0	182.6	0.6	1.5

Note. YRBS Total Sedentary Time is average sedentary time per day for an average school day from the Youth Risk Behavior Survey. ASAQ Total Sedentary Time is average sedentary time per day for a typical school week from the Adolescent Sedentary Activity Questionnaire. Actigraph Sedentary Time is average sedentary time measured from the accelerometer. Actigraph Sedentary Time (15-min bouts) is average sedentary time measured in 15-minute bouts from the accelerometer. Actigraph Sedentary Time (30-min bouts) is average sedentary time measured in 30-minute bouts from the accelerometer.

Reliability

YRBS. Data collected on visit 1 and 7 – 14 days later on visit 2 were used to assess test-retest reliability. Participants' responses from the YRBS were categorical, and analyzed in two ways. First, since the data were ordinal (i.e., 7 answer choices), a Spearman's rho was used to assess the correlation between visit 1 and visit 2 responses. Second, a Wilcoxon signed-rank test was used to compare medians in responses between administrations.

Test-retest reliability data for the YRBS sedentary items are presented in Table 2. Means and standard deviations are provided for descriptive purposes. The criterion value for minimal acceptable reliability has been defined at $R \geq .70$ by Nunnally and Bernstein [47]. The TV time item had above acceptable reliability (Spearman's rho of .82), while the computer/video game item was slightly below it (Spearman's rho of .68).

Table 2
Means (SD) and Spearman's rho for YRBS Time Spent Watching TV and Time Spent on Computer/Video Games on an Average School Day (*N* = 98)

Variable	Visit 1	Visit 2	Spearman's rho
TV Time (hrs/day)	3.0 (1.7)	3.1 (1.7)	.82
Computer/Video Game Time (hrs/day)	3.5 (1.8)	3.7 (1.8)	.68

Note. TV Time is time spent watching TV on an average school day; Computer/Video Game Time is time spent using computer/video games on an average school day; SD stands for standard deviation.

Table 3 shows the results for the Wilcoxon signed-rank test for time spent watching TV on an average school day ($p = .82$), and time spent on computer/video games on an average school day ($p = .19$). Results indicate that medians for visit 1 and visit 2 were not significantly different.

Table 3
Medians (IQR) and Wilcoxon signed-rank test for YRBS Time Spent Watching TV and Time Spent on Computer/Video Games on an Average School Day (*N* = 98)

Variable	Visit 1	Visit 2	*z*	*p*-value for Wilcoxon signed-rank test
TV Time (hrs/day)	3.0 (2.3)	3.0 (2.0)	-0.22	.82
Computer/Video Game Time (hrs/day)	3.0 (2.0)	3.0 (3.0)	-1.32	.19

Note. TV Time is time spent watching TV on an average school day; Computer/Video Game Time is time spent on computer/video games on an average school day; IQR stands for interquartile range.

The level of agreement for both sedentary behavior items for visit 1 and visit 2 is shown in Table 4. The majority of participants had responses that differed by 1 category or less between visit 1 and visit 2 (86% for the TV time item and 82% for the computer/video game item). Only 13% of participants had responses that differed by 2 categories or more for the TV time item between visit 1 and visit 2. Only 18% of participants had responses that differed by 2 categories or more for the computer/video game time items between visit1 and visit 2.

Table 4
Agreement of Self-Reported Scores for YRBS Time Spent Watching TV and Time Spent on Computer/Video Games on an Average School Day for Visit 1 and Visit 2 (*N* = 98)

Level of Agreement between Visit 1 and Visit 2	TV Time (hrs/day)		Computer/Video Game Time (hrs/day)	
	n	**%**	***n***	**%**
Perfect	58	59	40	41
Responses differ by 1 category	27	27	40	41
Responses differ by 2 categories	11	11	7	7
Responses differ by 3 categories	1	1	8	8
Responses differ by 4 categories	1	1	2	2
Responses differ by 5 categories	0	0	0	0
Responses differ by 6 categories	0	0	1	1

Note. TV Time is time spent watching TV on an average school day; Computer/Video Game Time is time spent on computer/video games on an average school day.

Additionally, the responses to the TV time item were categorized as watching ≤ 2 hours of TV per day, or watching > 2 hours of TV per day. The proportion of agreement and modified kappa statistic are shown in Table 5. The proportion of agreement for the TV time item across visit 1 and visit 2 was .90. The modified kappa statistic was .79, indicating a substantial agreement based on the recommendations of Landis and Koch [32].

Table 5
Agreement of Self-Reported Scores for YRBS Time Spent Watching TV on an Average School Day when Categorized as ≤ 2 hrs/day or > 2 hrs/day for Visit 1 and Visit 2 (*N* = 98)

TV Time	*n* for Visit 1	*n* for Visit 2	*Proportion of agreement*	*Modified kappa*
≤ 2 hrs/day	80 (82%)	78 (80%)	.90	.79
> 2 hrs/day	18 (18%)	20 (20%)		

Note. TV Time is time spent watching TV on an average school day.

ASAQ. Test-retest reliability data for the five categories of sedentary behavior and total time spent sedentary for weekdays, weekend days, and all days are presented in Table 6. These data show Spearman's rho ranging from .50 (Weekday Travel) to .78 (Week Small Screen Recreation). Small screen recreation time showed acceptable reliability for all days, weekdays, and weekend days, while cultural and total sedentary time showed acceptable reliability for all days and weekend days. Social time showed acceptable reliability just for all days. Education and travel time had unacceptable reliability for all days, weekdays, and weekend days. All days combined had the highest Spearman correlation coefficients for all categories of sedentary behavior and total time spent sedentary. Weekend days had higher Spearman correlation coefficients than weekdays for all categories of sedentary behavior and total time spent sedentary.

Table 6
Spearman's rho for ASAQ Sedentary Behavior for All Days, Weekdays, and Weekend Days by Category (*N* = 97)

Category	All Days	Weekdays	Weekend Days
SSR	.78	.72	.75
Education	.69	.67	.68
Travel	.57	.50	.54
Cultural	.74	.66	.71
Social	.72	.61	.64
Total	.74	.61	.71

Note. SSR stands for small screen recreation.

Median differences between questionnaire responses for each category of sedentary time and total time spent sedentary were examined with Wilcoxon signed-rank tests. For all days and weekdays, the only significant differences between questionnaire administrations were for education and travel time ($p < .05$), as shown in Table 7 and Table 8, respectively. For weekend days, the only significant difference between questionnaire administrations was for travel time ($p < .05$), as shown in Table 9.

Table 7
Medians (IQR) and Wilcoxon signed-rank test for each Category of Sedentary Behavior from the ASAQ for All Days (*N* = 97)

Category	Visit 1	Visit 2	*z*	*p*-value for Wilcoxon signed-rank test
SSR	1,020.0 (1280.0)	1,125.0 (1410.0)	-1.38	.17
Education	600.0 (938.0)	525.0 (775.0)	-3.08	< .001
Travel	225.0 (235.0)	270.0 (276.0)	-3.66	< .001
Cultural	210.0 (638.0)	225.0 (580.0)	-0.12	.91
Social	540.0 (660.0)	510.0 (708.0)	-1.02	.31
Total	3,275.0 (2063.0)	3,180.0 (2015.0)	-0.25	.81

Note. SSR stands for small screen recreation; IQR stands for interquartile range.

Table 8
Medians (IQR) and Wilcoxon signed-rank test for each Category of Sedentary Behavior from the ASAQ for Weekdays (*N* = 97)

Category	Visit 1	Visit 2	*z*	*p*-value for Wilcoxon signed-rank test
SSR	540.0 (870.0)	645.0 (988.0)	-1.63	.10
Education	480.0 (683.0)	450.0 (570.0)	-3.22	< .001
Travel	150.0 (235.0)	190.0 (155.0)	-3.47	< .001
Cultural	125.0 (448.0)	135.0 (435.0)	-0.25	.80
Social	300.0 (290.0)	210.0 (300.0)	-0.59	.55
Total	2,040.0 (1680.0)	1,995.0 (1515.0)	-0.18	.86

Note. SSR stands for small screen recreation, IQR stands for interquartile range.

Table 9
Medians (IQR) and Wilcoxon signed-rank test for each Category of Sedentary Behavior from the ASAQ for Weekend Days (*N* = 97)

Category	Visit 1	Visit 2	*z*	*p*-value for Wilcoxon signed-rank test
SSR	420.0 (428.0)	480.0 (420.0)	-1.48	.14
Education	60.0 (225.0)	90.0 (210.0)	-1.02	.31
Travel	60.0 (115.0)	120.0 (68.0)	-2.65	.01
Cultural	60.0 (212.0)	60.0 (223.0)	-0.47	.64
Social	240.0 (330.0)	270.0 (353.0)	-0.25	.80
Total	1,110.0 (800.0)	1,170.0 (763.0)	-1.10	.27

Note. SSR stands for small screen recreation; IQR stands for interquartile range.

Validity

YRBS. Presented in Table 10, results of the regression of accelerometer-measured weekday average sedentary time on the TV time item, computer/video game item, and total screen time from the YRBS were similar for the three variables [average sedentary time from accelerometer (SED), average sedentary time measured in 15-min bouts from accelerometer (SED-15), and average sedentary time measured in 30-min bouts (SED-30) from accelerometer]. Regression analysis demonstrated a low proportion of explained variance in accelerometer-measured sedentary behavior (between 0% and 1% variance) by the three variables (TV time item, computer/video game item, and total screen time from the YRBS) for all three dependent variables (weekday SED, weekday SED-15, and weekday SED-30). Standard errors of estimate (SEE) for all regression equations were high and were nearly equal to the standard deviations of the dependent variables.

Table 10
Multiple Regression Models to Estimate Weekday Average Sedentary Time from Accelerometer (*N* = 79)

Independent Variable	Intercept	*b*-weight	*R*	R^2	*SEE*
Weekday Average Sedentary Time					
YRBS TV Time	642.073	-5.807	.12	.01	87.49
YRBS Computer/Video Game Time	613.714	3.308	.07	.01	87.84
YRBS Total Screen Time	630.063	-0.025	.05	.00	87.97
Weekday Average Sedentary Time (15-min bouts)					
YRBS TV Time	163.596	-2.019	.05	.00	75.59
YRBS Computer/Video Game Time	139.556	5.194	.12	.02	75.10
YRBS Total Screen Time	154.005	0.020	.05	.00	75.59
Weekday Average Sedentary Time (30-min bouts)					
YRBS TV Time	72.423	1.610	.08	.01	36.84
YRBS Computer/Video Game Time	68.775	2.366	.12	.01	36.71
YRBS Total Screen Time	71.825	0.028	.13	.02	36.66

Note. Weekday Average Sedentary Time is average sedentary time per day for weekdays. Weekday Average Sedentary Time (15-min bouts) is average sedentary time measured in bouts of 15 minutes or longer per day for weekdays. Weekday Average Sedentary Time (30-min bouts) is average sedentary time measured in bouts of 30 minutes or longer per day for weekdays. TV Time is time spent watching TV on an average school day; Computer/Video Game Time is time spent on computer/video games on an average school day. Total Screen Time is TV time plus computer/video game time.

Spearman correlations between the YRBS sedentary items and accelerometer average weekday sedentary time are shown in Table 11. Spearman correlation coefficients ranged from -.03 (TV time) to .12 (computer/video game time). TV time, computer/video game time, and total sedentary time had low correlation coefficients with accelerometer-measured sedentary time, suggesting poor evidence of validity [46].

Table 11
Associations (Spearman's rho) between the YRBS Sedentary Items and Actigraph GT3X+ Counts per Minute (*N* = 79)

	Actigraph GT3X+ Sedentary Time		
YRBS Sedentary Items	Weekday Average Sedentary Time	Weekday Average Sedentary Time (15-min)	Weekday Average Sedentary Time (30-min)
TV Time	-.03	-.04	.06
Computer/Video Game Time	.12	.12	.04
Total Screen Time	.03	.02	.03

Note. TV Time is time spent watching TV on an average school day; Computer/Video Game Time is time spent on computer/video games on an average school day; Total Screen Time is the TV Time items plus Computer/Video Game Time.

Results from the Wilcoxon signed-rank tests, shown in Table 12, demonstrated that median weekday sedentary time measured with the YRBS was significantly lower than median sedentary time from the accelerometer. The median weekday sedentary time from the YRBS was significantly higher than the median sedentary time from the accelerometer measured in 30-min bouts. No significant difference was found between the median weekday sedentary time measured with the YRBS and accelerometer for SED-15.

Table 12
Wilcoxon signed-rank test between the YRBS Sedentary Items and Actigraph Measures (*N* = 79)

	YRBS Total Sedentary Time	Weekday Average Sedentary Time	Weekday Average Sedentary Time (15-min bouts)	Weekday Average Sedentary Time (30-min bouts)
Significance Level	--	< .001	.46	< .001
Negative Ranks	--	3	38	57
Positive Ranks	--	76	41	22
Tied Ranks	--	0	0	0
z Statistic	--	-7.64	-0.74	-4.90
Median	120.0	618.3	148.8	72.0
IQR	240.0	102.3	102.7	38.3

Note. YRBS Total Sedentary Time is the TV Time items plus Computer/Video Game Time. IQR stands for interquartile range. A negative rank in this instance indicates that accelerometer-measured sedentary time was less than sedentary time from the YRBS items. A positive rank indicates that accelerometer-measured sedentary time was greater than sedentary time from the YRBS items. Tied ranks indicate that accelerometer-measured sedentary time was equal to sedentary time from the YRBS items.

ASAQ***.*** Results of the regression of accelerometer-measured sedentary time (SED, SED-15, and SED-30) on weekday, weekend, and total sedentary time measured by the ASAQ are presented in Table 13. Regression results demonstrated a low proportion of variance in accelerometer-measured sedentary time explained (between 0% and 2% variance) by the predictor variables. SEE for all regression equations were high and were nearly equal to the standard deviations of the dependent variables.

Table 13
Multiple Regression Models to Estimate Accelerometer-determined Sedentary Time (*N* = 79)

Independent Variable	Intercept	*b*-weight	*R*	R^2	*SEE*
Average Sedentary Time					
ASAQ Weekday Average	614.112	0.024	.09	.01	87.70
ASAQ Weekend Average	600.255	0.013	.08	.01	79.15
ASAQ Total Sedentary Time	614.376	0.012	.06	.00	75.64
Average Sedentary Time (15-min bouts)					
ASAQ Weekday Average	144.463	0.028	.13	.02	75.06
ASAQ Weekend Average	160.312	-0.010	.08	.01	59.01
ASAQ Total Sedentary Time	148.472	0.015	.09	.01	63.14
Sedentary Time (30-min bouts)					
ASAQ Weekday Average	68.982	0.017	.16	.02	36.51
ASAQ Weekend Average	77.189	-0.009	.10	.01	44.01
ASAQ Total Sedentary Time	70.612	0.009	.11	.01	29.95

Note. Average Sedentary Time is average sedentary time per day. Average Sedentary Time (15-min bouts) is average sedentary time measured in bouts of 15 minutes or longer per day. Average Sedentary Time (30-min bouts) is average sedentary time measured in bouts of 30 minutes or longer per day. ASAQ Weekday Average is the average of five weekdays. ASAQ Weekend Average is the average of two weekend days. ASAQ Total Sedentary Time is the weighted average of all days.

Spearman correlations for average sedentary time from the ASAQ and the accelerometer are presented in Table 14. Spearman correlation coefficients ranged from -.06 (ASAQ Weekend Average) to .15 (ASAQ Weekday Average). The low correlation coefficients suggest poor evidence of validity for the ASAQ.

Table 14
Spearman's rho for Criterion-Related Validity Comparing the ASAQ Sedentary Items with the Actigraph GT3X+ Sedentary Time (*N* = 79)

ASAQ Sedentary Items	Actigraph GT3X+ Sedentary Time		
	Average Sedentary Time	Average Sedentary Time (15-min bouts)	Average Sedentary Time (30-min bouts)
ASAQ Weekday Average	.15	.03	.03
ASAQ Weekend Average	.11	.02	-.06
ASAQ Total Sedentary Time	.15	.04	.09

Note. ASAQ Weekday Average is the average of five weekdays. ASAQ Weekend Average is the average of two weekend days. ASAQ Total Sedentary Time is the weighted average of all days. Average sedentary time is average sedentary time measured from the accelerometer. Average sedentary 15-minute bouts is average sedentary time measured in 15-minute bouts by the accelerometer. Average sedentary time 30-minute is average sedentary time measured in 30-minute bouts by the accelerometer.

Wilcoxon signed-rank tests between the ASAQ and Actigraph measures are shown in Table 15. The median ASAQ weekday sedentary time and the median ASAQ total sedentary time were significantly lower than the median accelerometer-measured SED. The median ASAQ weekday sedentary time, the median weekend sedentary time, and the median ASAQ total sedentary time were significantly higher than the median accelerometer-measured SED-15 and SED-30.

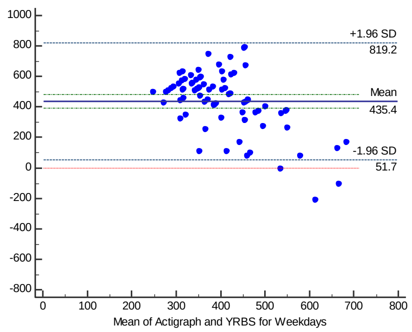
Table 15
Wilcoxon signed-rank tests between the ASAQ and Actigraph Measures (*N* = 79)

ASAQ Sedentary Items	ASAQ Sedentary Items	Average Sedentary Time	Average Sedentary Time (15-min bouts)	Average Sedentary Time (30-min bouts)
ASAQ Weekday Average	--	$p < .001$	$p < .001$	$p < .001$
Negative Ranks	--	17	73	79
Positive Ranks	--	62	6	0
Tied Ranks	--	0	0	0
z Statistic	--	-4.83	-7.36	-7.72
Median	393.0	618.3	148.8	72.0
IQR	330.0	102.3	102.7	38.3
ASAQ Weekend Average	--	$p = .37$	$p < .001$	$p < .001$
Negative Ranks	--	32	74	78
Positive Ranks	--	47	5	1
Tied Ranks	--	0	0	0
z Statistic	--	-0.89	-7.51	-7.68
Median	565.0	610.8	158.0	67.5
IQR	420.0	107.0	76.6	40.5
ASAQ Total Sedentary Time	--	$p < .001$	$p < .001$	$p < .001$
Negative Ranks	--	19	74	79
Positive Ranks	--	60	5	0
Tied Ranks	--	0	0	0
z Statistic	--	-4.16	-7.62	-7.72
Median	467.9	611.2	153.4	73.5
IQR	290.7	93.8	88.3	32.5

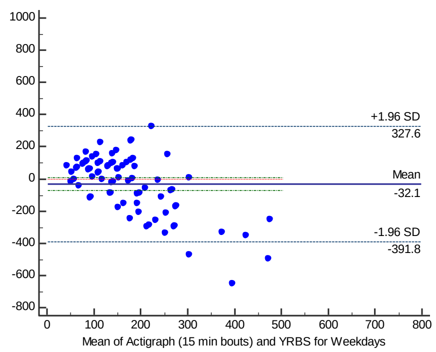
Note. ASAQ Weekday Average is the average of five weekdays. ASAQ Weekend Average is the average of two weekdays. ASAQ Total Sedentary Time is the weighted average of all days. Average sedentary time is average sedentary time measured from the accelerometer. Average sedentary 15-minute bouts is average sedentary time measured in 15-minute bouts by the accelerometer. Average sedentary time 30-minute is average sedentary time measured in 30-minute bouts by the accelerometer. Negative Ranks means accelerometer rank less than ASAQ ranks. Positive Ranks means accelerometer rank greater than ASAQ rank. Tied Ranks means accelerometer rank same rank as ASAQ rank. IQR stands for interquartile range. A negative rank in this instance indicates that accelerometer-measured sedentary time was less than sedentary time from the ASAQ. A positive rank indicates that accelerometer-measured sedentary time was greater than sedentary time from the ASAQ. Tied ranks indicate that accelerometer-measured sedentary time was equal to sedentary time from the ASAQ.

Bland-Altman Plots**.** Figure 1 presents the Bland-Altman plots of the difference versus the mean for the YRBS weekday estimates of sedentary time. Figure 1A depicts that sedentary time was higher by 435 minutes for the accelerometer than for the YRBS, indicating that systematic bias was found. Figure 1B shows that the difference between the YRBS and the accelerometer-measured sedentary time did not differ significantly because zero fell within the 95% confidence limits of the difference scores. Figure 1C demonstrates that sedentary time was higher by an average of 113 minutes for the YRBS than for the accelerometer, indicating the presence of systematic bias. For all three criterion measures from the accelerometer (SED, SED-15, and SED-30), proportional bias was found as evidenced by the downward left-to-right slope of the data points, indicating that the size of the difference between sedentary time from the accelerometer and sedentary time from the YRBS changed as the mean of the methods increased. The differences in estimates of sedentary time between the accelerometer and YRBS were significantly (all $p < .001$) correlated with the means of the methods (r = -.58 to -.91).

1A



1B



1C

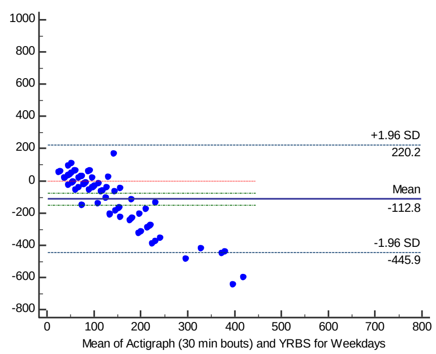
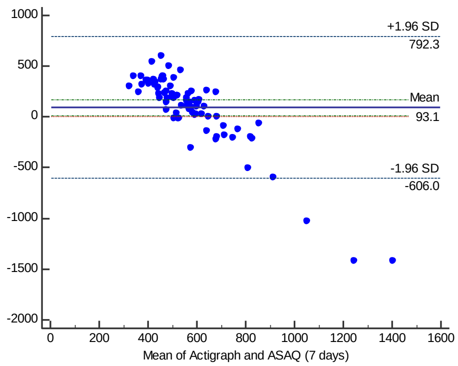


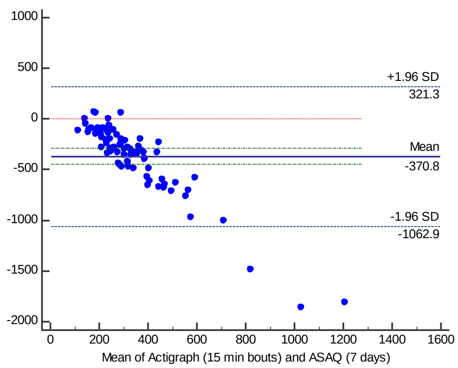
Figure 1
(1A) Bland-Altman plot of paired differences between Actigraph and YRBS for weekdays versus YRBS for weekdays. (1B) Bland-Altman plot of paired differences between Actigraph (15-min bouts) and YRBS for weekdays versus YRBS for weekdays. (1C) Bland-Altman plot of paired differences between Actigraph (30-min bouts) and YRBS for weekdays versus YRBS for weekdays. The x-axis is the mean of the methods. The y-axis is the difference between methods. The red dotted line represents a difference of zero between methods. The solid blue line represents the mean difference between methods. The large dashed lines represent the 95% limits of agreement. The green dashed lines represent the 95% confidence intervals around the mean difference.

Figure 2 presents the Bland-Altman plots of the difference versus the mean for the ASAQ 7 day estimates of sedentary time. Figure 2A shows that systematic bias was evident in the ASAQ estimates of sedentary time. Sedentary time was 93 minutes higher for the accelerometer than for the ASAQ. In Figure 2B, sedentary time was higher by an average of 371 minutes for the ASAQ than for the accelerometer with 15-min bouts. In Figure 2C, sedentary time was higher by an average of 452 minutes for the ASAQ than for the accelerometer with 30-min bouts. For all three criterion measures from the accelerometer (SED, SED-15, and SED-30), proportional bias was found as evidenced by the downward left-to-right slope of the data points, indicating that the size of the difference between sedentary time from the accelerometer and sedentary time from the ASAQ changed as the means of the methods increased. The differences in estimates of sedentary time between accelerometer and ASAQ were highly correlated with the means of the methods (r = -.91 to -.99, all $p < .001$).

2A



2B



2C

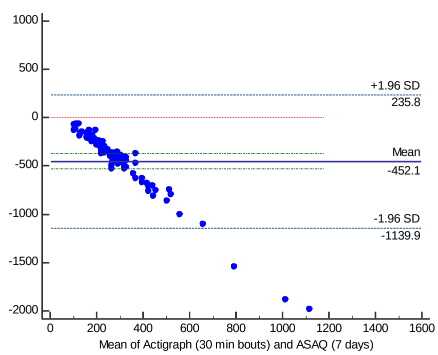
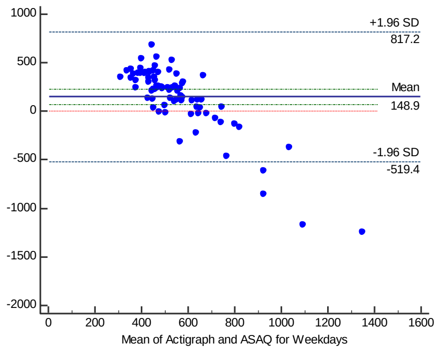


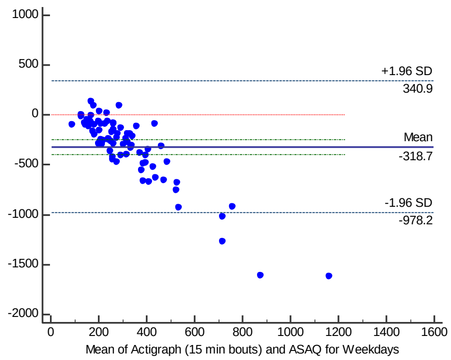
Figure 2
(2A) Bland-Altman plot of paired differences between Actigraph and ASAQ (7 days) versus ASAQ (7 days). (2B) Bland-Altman plot of paired differences between Actigraph (15-min bouts) and ASAQ (7 days) versus ASAQ (7 days). (2C) Bland-Altman plot of paired differences between Actigraph (30-min bouts) and ASAQ (7 days) versus ASAQ (7 days). The x-axis is the mean of the methods. The y-axis is the difference between methods. The red dotted line represents a difference of zero between methods. The solid blue line represents the mean difference between methods. The large dashed lines represent the 95% limits of agreement. The green dashed lines represent the 95% confidence intervals around the mean difference.

Figure 3 presents the Bland-Altman plots of the difference versus the mean for the ASAQ weekday estimates of sedentary time. Figure 3A demonstrates that sedentary time was higher by an average of 149 minutes for the accelerometer than for the ASAQ for weekdays, suggesting systematic bias. In Figure 3B, sedentary time was higher by an average of 319 minutes for the ASAQ than for the accelerometer. In Figure 3C, sedentary time was higher by an average of 399 minutes for the ASAQ than for the accelerometer. For all three criterion measures from the accelerometer (SED, SED-15, and SED-30), proportional bias was found as evidenced by the downward left-to-right slope of the data points, indicating that the size of the difference between sedentary time from the accelerometer and sedentary time from the ASAQ changed as the means of the methods increased. The differences in estimates of sedentary time between accelerometer and ASAQ were highly correlated with means of the methods (r = -.87 to -.98, all $p < .001$).

3A



3B



3C

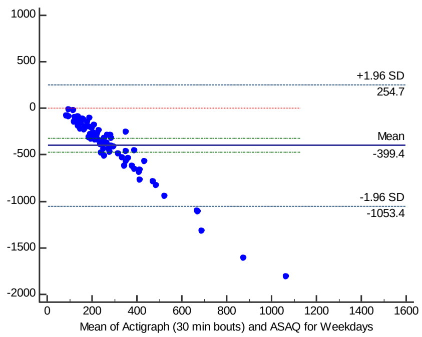
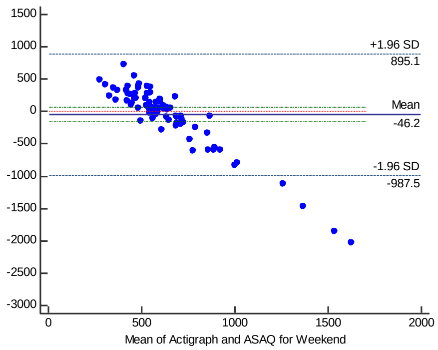


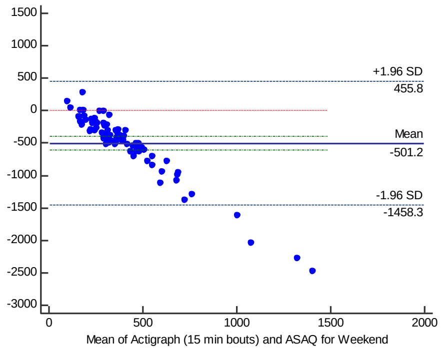
Figure 3
(3A) Bland-Altman plot of paired differences between Actigraph and ASAQ for weekdays versus ASAQ for weekdays. (3B) Bland-Altman plot of paired differences between Actigraph (15-min bouts) and ASAQ for weekdays versus ASAQ for weekdays. (3C) Bland-Altman plot of paired differences between Actigraph (30-min bouts) and ASAQ for weekdays versus ASAQ for weekdays. The x-axis is the mean of the methods. The y-axis is the difference between methods. The red dotted line represents a difference of zero between methods. The solid blue line represents the mean difference between methods. The large dashed lines represent the 95% limits of agreement. The green dashed lines represent the 95% confidence intervals around the mean difference.

Figure 4 presents the Bland-Altman plots of the difference versus the mean for the ASAQ weekend day estimates of sedentary time. Figure 4A demonstrates that compared to the accelerometer, the ASAQ did not differ in estimates of sedentary time over the weekend, meaning no systematic bias was found. Figure 4B demonstrates that sedentary time was higher by an average of 501 minutes for the ASAQ than for the accelerometer. Figure 4C shows that sedentary time was higher by an average of 584 minutes for the ASAQ than for the accelerometer. For all three criterion measures from the accelerometer (SED, SED-15, and SED-30), proportional bias was found as evidenced by the downward left-to-right slope of the data points, indicating that the size of the difference between sedentary time from the accelerometer and sedentary time from the ASAQ changed as the means of the methods increased. The differences in estimates of sedentary time between accelerometer and ASAQ were highly correlated with the means of the methods (r = -.95 to -.98, all $p < .001$).

4A



4B



4C

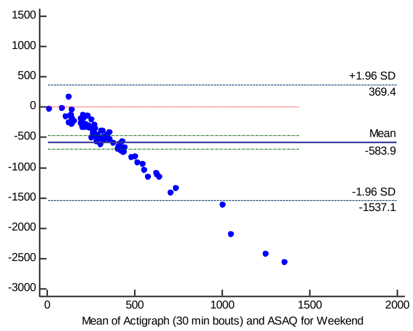


Figure 4

(4A) Bland-Altman plot of paired differences between Actigraph and ASAQ for weekend days versus ASAQ for weekend days. (4B) Bland-Altman plot of paired differences between Actigraph (15-min bouts) and ASAQ for weekend days versus ASAQ for weekend days. (4C) Bland-Altman plot of paired differences between Actigraph (30-min bouts) and ASAQ for weekend days versus ASAQ for weekend days. The x-axis is the mean of the methods. The y-axis is the difference between methods. The red dotted line represents a difference of zero between methods. The solid blue line represents the mean difference between methods. The large dashed lines represent the 95% limits of agreement. The green dashed lines represent the 95% confidence intervals around the mean difference.

Extended Results: Extreme Scores Removed for the ASAQ***.*** Several participants self-reported implausible values on the ASAQ (n = 5); thus validity analyses were performed with the extreme scores removed. Extreme scores were identified as more than 16 hours of sedentary behavior in one day. The cut off of 16 hours was chosen to represent the approximate time spent awake in a day (assuming 8 hours of sleep). Tables with the analyses with extreme scores removed can be found in Appendix A.

Regarding the regression results, two of the nine analyses had a slightly greater variance. For example, the r^2 was 8% higher for the ASAQ weekday average when extreme scores were removed. However, the variance accounted for in weekday average sedentary time from the accelerometer by the ASAQ was still only 9% in the analysis with extreme scores removed; therefore, the results were similar to the initial analysis indicating a lack of evidence for validity of the ASAQ.

Spearman correlations between the accelerometer and the ASAQ were generally unchanged when extreme scores were removed from the analysis. The greatest increase in correlations between the accelerometer and ASAQ occurred for the ASAQ weekday average and weekday average sedentary time from the accelerometer. The correlation on the original sample was .15 and the correlation from the sample with extreme scores removed was .25. However, this correlation value still represents poor evidence of validity.

For the Wilcoxon signed-rank test of the nine comparisons, only one was different when extreme scores were removed. The median ASAQ weekend average sedentary time was significantly different from the median accelerometer-measured weekend sedentary time when extreme scores were removed. These medians were not significantly different in the original sample. Overall, regarding evidence of validity of the ASAQ for estimating accelerometer-measured sedentary time, similar conclusions could be made from the original sample and from the sample with extreme scores removed.

CHAPTER 5

DISCUSSION

The overarching goal of this study was to evaluate the reliability and validity of questionnaire measures of sedentary time in adolescents. Specifically, this study investigated the sedentary items on the YRBS and the ASAQ, namely (a) the test-retest reliability of each questionnaire, and (b) the criterion-related validity of these questionnaires. Sedentary time from the accelerometer was operationally defined in three ways: (a) average sedentary time in minutes, (b) average sedentary time measured in 15-minute bouts, and (c) average sedentary time measured in 30-minute bouts.

Estimates of sedentary time in this cohort differed substantially depending on the assessment method. Accelerometer-measured sedentary time averaged 621 minutes per day (equivalent to 75% of total wear time). Sedentary time in 15-minute bouts averaged 157 minutes per day (equivalent to 38% of total wear time). Sedentary time in 30-minute bouts averaged 75 minutes per day (equivalent to 9% of total wear time). Based upon the Evenson et al. [48] paper that examined the 2003 – 2006 NHANES data, the average accelerometer-measured sedentary time for 12 – 17 year olds was 449 minutes per day (equivalent to 55.9% of total wear time) and less than the current study. Evenson et al. suggested that sedentary time increases with age. A potential reason the sample in the current study had more sedentary time than the NHANES sample is that 18% of participants were between 18 and 19 years of age in the current study and these participants were older than the oldest participants in the NHANES sample.

Reliability of the YRBS Sedentary Behavior Items

The sedentary items on the YRBS demonstrated moderate to good evidence of test-retest reliability. To date, no other study has used Spearman's rho to examine test-retest reliability of the YRBS sedentary items. Based on evidence of high reliability and stability of the data across time, our findings suggest that TV time item on the YRBS can be used to measure changes in sedentary behavior over time in the same group of participants. The computer/video game item was just below the minimally accepted level of reliability, so it is questionable whether this item could be used to track sedentary behavior over time. Findings that demonstrate the data were stable from visit 1 to visit 2 suggest that the YRBS TV time item can be used to measure changes in sedentary time over a period of time in adolescents.

In a previous study that examined the reliability of the TV time item from the YRBS, responses were categorized as watching ≤ 2 hours of TV on an average school day vs. watching more than 2 hours [34]. The kappa statistic in this previous study was .47, which demonstrated moderate strength of agreement [32]. When the TV time item was categorized as ≤ 2 hours per day and > 2 hours per day in the current study, substantial agreement was found (modified kappa = .79). The TV time item was categorized this way for two reasons. First, research evidence suggests an association between viewing > 2 hours of TV per day and numerous adverse health effects [2]. Second, this categorization is consistent with YRBS categorization of "at risk" and "not at risk," in order to determine the prevalence of at risk behaviors. Although both studies provided some evidence of reliability, it is unclear why consistency of responses was better in the current study than in the 1999 YRBS study. Both samples were large, and the length of time between questionnaire administrations, and the age of participants were similar for the two studies. In the current study, the questionnaires were administered individually in a laboratory setting, while the 1999 YRBS study administered the questionnaires in groups in school-based settings. It is possible that participants were more attentive to the items in the laboratory setting of the current study than in the field setting of the

1999 YRBS study, which resulted in more consistent responses in the current study. Differences in education level could be a reason the consistency of responses was better in the current study than in the 1999 YRBS study. In the current study, the oldest participants were 19 years old and had graduated from high school, whereas in the 1999 YRBS study, the oldest participants were 18 years old and still in high school. No item measuring computer/video game time was included in the 1999 YRBS study.

Reliability of the ASAQ

Reliability estimates for the sedentary time categories of the ASAQ were presented for three time points: weekday, weekend, and all days. Results of the current study showed that some, but not all, of the sedentary time categories had acceptable reliability.

Compared to weekdays and weekend days, all days had higher reliability coefficients for each category of sedentary behavior. Interestingly, weekend days had higher reliability coefficients than weekdays for all categories of sedentary behavior. This latter finding is surprising because behavior on weekend days may be more variable than behavior on weekdays during the school year due to the large amount of time required for students to sit during the school day. A potential reason weekdays had lower correlations than weekends could be because in the present study a little less than half of the participants completed the questionnaire in the summer months, and that may have made it difficult for them to recall their sedentary behaviors during an average school week.

Findings from the current study are somewhat different than those found by Hardy et al. [35], who reported intraclass correlation coefficients (ICCs) ranging from .58 for education time to .80 for Small Screen Recreation time. Hardy et al. reported that the data were unable to be normalized by transforming the primary outcomes of interest, but ICCs, which are parametric tests typically used with normally distributed data, were used. The use of ICCs by Hardy et al. is noteworthy because Spearman’s rho were used with the non-normally distributed data in the current study. Hardy et al. found higher correlations for sedentary categories on weekdays than on weekend days. Conversely, findings from the current study demonstrated higher correlations for all sedentary categories on weekend days compared to weekdays. In another study, Hardy et al. [20] examined the test-retest reliability of the ASAQ in a broader age range of adolescents. The results of this study demonstrated, on average, ICCs of .72 for all categories of sedentary behavior combined, while for individual categories of sedentary behavior, ICCs were quite variable. The model of ICCs used was not reported. It was unclear whether the data were normally or non-normally distributed in this study.

Current results examining stability of mean ranks over time suggest that several categories of sedentary behavior from the ASAQ can be measured consistently over a one-week to two-week period. The categories of sedentary behavior from the ASAQ that did not differ from visit 1 to visit 2 were, small screen recreation, cultural, social, and total sedentary time. The categories of sedentary behavior that were not as consistent from visit 1 to visit 2 were education and travel. The ASAQ refers to sedentary behaviors occurring before and after school during a typical school week. It appears that adolescents are less able to consistently recall the amount of sedentary time spent in education and travel activities compared to the other sedentary categories.

Hardy et al. [20, 35] did not report Wilcoxon signed-rank tests, or t-tests, so comparison of the differences in distributions for the categories of sedentary behavior between visit one and visit two was not possible. Hardy et al. [20, 35] did not report median values at both time points, so comparison of the medians from the previous studies to the current study was not possible.

Validity

Concurrent validity evidence was examined to determine if the YRBS sedentary items and the ASAQ could accurately estimate sedentary time as measured by the criterion measure of Actigraph GT3X+ accelerometers. Validity of the YRBS sedentary items and ASAQ was examined with four statistical approaches: regression analyses, Spearman’s rho, Wilcoxon signed-rank tests, and modified Bland-Altman plots.

Validity of the YRBS Sedentary Behavior Items

The ability of the YRBS sedentary items to estimate sedentary time from the criterion accelerometer measure of sedentary time (absolute validity) was poor. Standard errors from the regression analysis, significant differences from the Wilcoxon signed-rank test, and the bias from the modified Bland-Altman plots all suggested YRBS sedentary items cannot be used to estimate objectively measured sedentary behavior in adolescents.

In addition, evidence of relative validity between the YRBS sedentary items and accelerometer-measured sedentary time (Spearman’s rho) was also poor. Regardless of how accelerometer-measured sedentary time was expressed, Spearman correlations between YRBS sedentary items and accelerometer-measured sedentary time were ≤ .12.

It is worth noting that the YRBS sedentary items assess screen time behaviors on weekdays and not total time spent sedentary. In order to examine evidence of validity, the YRBS sedentary items were compared to average weekday sedentary time from the accelerometer.

Validity of the ASAQ

Similar to the YRBS sedentary items, the ASAQ sedentary items did not accurately estimate sedentary time as measured by the accelerometer. Results from the regression, Wilcoxon signed-rank test, and modified Bland-Altman plots consistently suggested poor evidence of absolute validity. Researchers should be cautious about inferring the absolute amount of sedentary behavior in which adolescents engage based on the questionnaires used in the current study. Evidence of relative validity between the ASAQ and accelerometer-measured sedentary time (Spearman’s rho) was also poor. Regardless of how accelerometer-measured sedentary time was expressed, Spearman correlations between YRBS sedentary items and accelerometer-measured sedentary time were ≤ .15. When the five subjects with implausible values were excluded from analyses, the results were generally similar to the original analyses. The few values that differed when the implausible values were excluded from the analyses were not large enough to change the overall conclusions of the study (i.e., validity evidence for the ASAQ was low).

When total sedentary time from the ASAQ was compared to accelerometer-measured sedentary time, comparisons were made between the ASAQ and average sedentary time from the accelerometer, and average sedentary time measured in bouts of 15 minutes and 30 minutes from the accelerometer. The rationale for comparing average sedentary time from the accelerometer to average sedentary time measured in bouts from the accelerometer was to determine if the ASAQ estimates were closer to actigraph estimates restricted to continuous bouts and to see if there was a stronger correlation between the ASAQ estimates and the Actigraph SED estimates performed in bouts. During weekday, weekend, and all days, ASAQ sedentary time was lower than accelerometer-measured average sedentary time, but higher than accelerometer-measured sedentary time in 15-minute and 30-minute.

Overall, results of the current study demonstrate moderate to good evidence of reliability and poor evidence of validity for the YRBS sedentary items and the ASAQ. Despite showing poor evidence of validity, these questionnaires may be useful in certain situations. Results suggest these questionnaires would not be appropriate to use for quantifying the absolute amount of sedentary time. Although it might be difficult to determine the estimated magnitude of the change in sedentary time, the use of these questionnaires may allow researchers to determine whether or not sedentary time has changed when participants are responding to the same condition (e.g., school year).

Strengths and Limitations

While the data presented here is of interest, this study is not without limitations. The YRBS sedentary items and ASAQ ask participants to think about how much time they spend in sedentary behaviors during a typical school week. A limitation of the current study is that close to half of the participants were tested during the summer months, which may add to the difficulty in adolescents recalling how much time they spent sedentary during a typical school day. The ASAQ assesses time spent sedentary before and after school, but when examining evidence of validity, the ASAQ was compared to total sedentary time measured by the accelerometer, thus presenting a possible limitation. An additional limitation of the study is that no objective measures of the specific variables assessed by the YRBS (TV time, computer/video game time) were available. An overall objective measure of sedentary time from the accelerometer was used, but because this measure is not a specific measure of the variables assessed by the YRBS, the relationship between self-reported screen time and objectively measured screen time may be underestimated. Future researchers may consider using objective measures of screen time to examine validity evidence of the YRBS.

Importantly, the criterion measure of sedentary time in the current study is not without limitations. The use of ≤ 100 counts per minute to categorize sedentary behavior may have resulted in some activities being falsely classified as sedentary. For example, if a participant was standing and not moving, the accelerometer might classify this as sedentary behavior. The inclinometer function of the accelerometers was not used to measure changes in body position; however, the use of an inclinometer could correct for some false classifications of sedentary behavior. Future studies may consider using the activPAL™ accelerometer to track changes in body position. Relatedly, our data suggest the use of a bout length of 15 or 30 minutes to measure sedentary time may have limitations. The use of these bout lengths resulted in less sedentary time than when bouts were not used to assess sedentary time. Perhaps the reason for the lower amount of sedentary time using bouts lengths from the accelerometers is that adolescents accumulate sedentary time in shorter bouts. Future studies could examine the impact of varying bout lengths with accelerometer-measured sedentary time to determine if bout length influences classification of sedentary time. Another potential limitation of this study is that a minimum of 10 hours of wear time was required for the accelerometer. If an average waking day of about 16 hours is assumed, it can be seen that the use of 10 hours of wear time leaves 6 hours, during which additional sedentary behavior can occur. Kang et al., suggest using a correction for total waking time [49]. Future research measuring sedentary behavior in adolescents could potentially improve the measurement of sedentary behavior by using this proposed wear time correction.

These identified study limitations are countered with numerous strengths. A strength of the current study is the relatively large sample size. When examining the reliability of a questionnaire, it is important for the length of time between two questionnaire administrations to be sufficient amount of time apart so subjects do not remember their responses from the first administration, but also do not change their behavior before the second administration. Often, two weeks between testing visits is considered sufficient amount of time. The length of time between visit 1 and visit 2 in the current study was 12.5 days on average, which is another strength of this study. Finally, the YRBS provides a measure of screen time, which is not a full measure of sedentary time, but may be clinically meaningful as excessive TV time has been associated with numerous health risks.

Future studies in this research area may consider strategies to enhance data quality. For example, in the current study, participants were administered several questionnaires. Future work might be more cognizant of “questionnaire fatigue” by limiting out comes or administering the questionnaires in a one-on-one setting. Adolescents may also overestimate how much time they spend sedentary. In the current study, participants estimated 541.7 minute of sedentary time on average per day from the ASAQ, while the accelerometer estimated 620.6 minutes of sedentary time per day on average. Since the ASAQ assesses time spent sedentary before and after school, it could be speculated that ASAQ responses overestimate sedentary time. Future research needs to develop methodology to better capture the engagement in the range of sedentary behaviors, regardless of bout length, in environments specific to adolescent children including those influenced by seasons (i.e. during the school year or in the summer), structure of a given week (i.e. weekday vs. weekend).

In conclusion, this study demonstrates moderate to good evidence of reliability and poor evidence of validity for estimating sedentary time for the YRBS and ASAQ in adolescents. The YRBS sedentary items and ASAQ may be useful in certain research situations, even though the evidence of validity was poor. Due to the adverse health effects of excessive sedentary time, the availability of tools that can track changes in sedentary time may be useful to researchers and in public health interventions [2].

CHAPTER 6

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APPENDIX A

Extended results with extreme scores removed for the ASAQ

Table 13
Multiple Regression Models to Estimate Accelerometer-determined Sedentary Time (*N* = 74)

Independent Variable	Intercept	*b*-weight	*R*	R^2	*SEE*
Average Sedentary Time					
ASAQ Weekday Average	579.920	0.104	.29	.09	72.94
ASAQ Weekend Average	621.150	0.003	.01	.00	76.25
ASAQ Total Sedentary Time	584.252	0.084	.22	.05	74.31
Average Sedentary Time (15-min bouts)					
ASAQ Weekday Average	137.685	0.046	.16	.03	60.96
ASAQ Weekend Average	163.398	-0.012	.06	.00	61.63
ASAQ Total Sedentary Time	143.922	0.028	.09	.01	61.49
Sedentary Time (30-min bouts)					
ASAQ Weekday Average	67.534	0.019	.14	.02	29.42
ASAQ Weekend Average	72.523	0.005	.05	.00	29.65
ASAQ Total Sedentary Time	66.894	0.018	.13	.02	29.45

Note. Average Sedentary Time is average sedentary time per day. Average Sedentary Time (15-min bouts) is average sedentary time measured in bouts of 15 minutes or longer per day. Average Sedentary Time (30-min bouts) is average sedentary time measured in bouts of 30 minutes or longer per day. ASAQ Weekday Average is the average of five weekdays. ASAQ Weekend Average is the average of two weekend days. ASAQ Total Sedentary Time is the weighted average of all days.

Table 14
Spearman's rho for Criterion-Related Validity Comparing the ASAQ Sedentary Items with the Actigraph GT3X+ Sedentary Time (*N* = 74)

	Actigraph GT3X+ Sedentary Time		
ASAQ Sedentary Items	**Average Sedentary Time**	**Average Sedentary Time (15-min bouts)**	**Average Sedentary Time (30-min bouts)**
ASAQ Weekday Average	.25	.07	.02
ASAQ Weekend Average	.09	.02	-.02
ASAQ Total Sedentary Time	.23	.07	.09

Note. ASAQ Weekday Average is the average of five weekdays. ASAQ Weekend Average is the average of two weekend days. ASAQ Total Sedentary Time is the weighted average of all days. Average sedentary time is average sedentary time measured from the accelerometer. Average sedentary 15-minute bouts is average sedentary time measured in 15-minute bouts by the accelerometer. Average sedentary time 30-minute is average sedentary time measured in 30-minute bouts by the accelerometer.

Table 15
Wilcoxon signed-rank tests between the ASAQ and Actigraph Measures (N = 74)

ASAQ Sedentary Items	ASAQ Sedentary Items	Average Sedentary Time	Average Sedentary Time (15-min bouts)	Average Sedentary Time (30-min bouts)
ASAQ Weekday Average	--	$p < .001$	$p < .001$	$p < .001$
Negative Ranks	--	12	68	74
Positive Ranks	--	62	6	0
Tied Ranks	--	0	0	0
z Statistic	--	-6.33	-7.07	-7.48
Median	369.0	624.7	151.8	71.7
IQR	265.0	96.4	92.8	38.1
ASAQ Weekend Average	--	$p = .04$	$p < .001$	$p < .001$
Negative Ranks	--	27	69	73
Positive Ranks	--	47	5	1
Tied Ranks	--	0	0	0
z Statistic	--	-2.01	-7.24	-7.43
Median	530.0	601.5	157.1	68.1
IQR	370.0	108.8	78.4	41.2
ASAQ Total Sedentary Time	--	$p < .001$	$p < .001$	$p < .001$
Negative Ranks	--	14	69	74
Positive Ranks	--	60	5	0
Tied Ranks	--	0	0	0
z Statistic	--	-5.61	-7.37	-7.48
Median	446.1	613.4	153.7	73.1
IQR	280.0	91.2	85.1	32.0

Note. ASAQ Weekday Average is the average of five weekdays. ASAQ Weekend Average is the average of two weekdays. ASAQ Total Sedentary Time is the weighted average of all days. Average sedentary time is average sedentary time measured from the accelerometer. Average sedentary 15-minute bouts is average sedentary time measured in 15-minute bouts by the accelerometer. Average sedentary time 30-minute is average sedentary time measured in 30-minute bouts by the accelerometer. Negative Ranks means accelerometer rank less than ASAQ ranks. Positive Ranks means accelerometer rank greater than ASAQ rank. Tied Ranks means accelerometer rank same rank as ASAQ rank. IQR stands for interquartile range. A negative rank in this instance indicates that accelerometer-measured sedentary time was less than sedentary time from the ASAQ. A positive rank indicates that accelerometer-measured sedentary time was greater than sedentary time from the ASAQ. Tied ranks indicate that accelerometer-measured sedentary time was equal to sedentary time from the ASAQ.

APPENDIX B

Questionnaires

Youth Risk Behavior Survey Sedentary Behavior Items

On an average school day, how many hours do you watch TV?

A. I do not watch TV on an average school day

B. Less than 1 hour per day

C. 1 hour per day

D. 2 hours per day

E. 3 hours per day

F. 4 hours per day

G. 5 or more hours per day

On an average school day, how many hours do you play video or computer games or use a computer for something that is not school work? (Count time spent on things such as Xbox, PlayStation, an iPod, an iPad or other tablet, a smartphone, YouTube, Facebook or other social networking tools, and the Internet.)

A. I do not play video or computer games or use a computer for something that is not school work

B. Less than 1 hour per day

C. 1 hour per day

D. 2 hours per day

E. 3 hours per day

F. 4 hours per day

G. 5 or more hours per day

Adolescent Sedentary Activity Questionnaire

14. Think about a normal *school week*, and write down how long you spend doing the following activities before and after school each day

Activity	Monday		Tuesday		Wednesday		Thursday		Friday	
	Hours	Minutes	Hours	Minutes	Hours	Minutes	Hours	Minutes	Hours	Minutes
Watching TV?										
Watching videos /DVDs?										
Using the computer for fun?										
Using the computer for doing homework?										
Doing homework not on the computer?										
Reading for fun?										
Being tutored?										
Travel (car/bus/train)?										
Doing crafts or hobbies?										
Sitting around (chatting with friends/ on the phone/chilling)?										
Playing/practicing a musical instrument?										

15. **Think about a *normal weekend*, and write down how long you spend doing the following activities on the *weekend***

Activity	Saturday		Sunday	
	Hours	Minutes	Hours	Minutes
Watching TV?				
Watching videos/DVDs?				
Using the computer for fun?				
Using the computer for doing homework?				
Doing homework not on the computer?				
Reading for fun?				
Being tutored?				
Travel (car/bus/train)?				
Doing crafts or hobbies?				
Sitting around (chatting with friends/on the phone/chilling)?				
Playing/practicing a musical instrument?				
Going to church or Saturday school?				