ENERGY EXPENDITURE OF PROMPTED ACTIVE TELEVISION VIEWING

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PURPOSE: Incorporating stepping during television commercials has shown to be equally effective at increasing steps as traditional exercise. This study introduced the idea of prompted active television viewing (PATV). PATV uses common character mannerisms within the television program as the antecedent to promote physical activity while watching television. The aim of this study was to determine energy expenditure during sedentary television viewing (SED-TV), commercial stepping during a television program (COMM-TV) and physical activity prompted by common character phrases/mannerisms within a television program (PATV). **METHODS:** Subjects were 38 adults (age: 27.0 ± 8.0 years, BMI: 25.4 ± 4.2 kg/m^2). Who completed three experimental sessions SED-TV, COMM-TV, and PATV, in random order. Energy expenditure and heart rate were assessed during each session. Enjoyment was assessed after the initial experimental session and at completion of the study. **RESULTS:** There was significantly higher energy expenditure in the active versus sedentary session (COMM-TV vs SED-TV: difference = 32.7 ± 1.9 kcal, $p<0.001$; PATV vs SED-TV difference = 34.4 ± 1.9 kcal, $p<0.001$), and no difference among active sessions (COMM-TV vs PATV difference= 1.7 ± 1.5 kcal, $p = 0.827$). Males had higher energy expenditure ($p=0.016$), but not after adjustment for body weight ($p=0.776$). Significantly more minutes were spent in moderate activity in active versus sedentary sessions (METS ≥ 3.0: SED-TV = 0 mins, COMM-TV =4 .6 ± 3.6 mins, PATV = 4.3 ± 3.4 mins; HR ≥ 50% HRmax: SED-TV = 1.1 ± 4.9 mins, COMM-TV = 5.7 ± 4.8 mins, PATV = 7.2 ± 8.5 mins). No significant difference in frequency of moderate intensity minutes was found between COMM-TV and PATV. Assessing enjoyment of initial session found no significant difference in PATV compared to SED-TV ($p=0.150$) and COMM-TV compared to PATV ($p=1.000$). COMM-TV was significantly more enjoyable than SED-TV ($p=0.048$). **CONCLUSION:** PATV has the ability to offer higher energy expenditure and activity intensity

then SED-TV and equivalent energy expenditure and activity intensity as stepping during television commercials. Replacing of sedentary television viewing with prompted active television viewing may be sufficient to reduce sedentary behavior, prevent weight gain, and elicit additional health benefits.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

Dedicated to my Mother and Father who always encouraged me to do my best, and to Tommy for believing in me, always.

1.0 INTRODUCTION

Population studies have shown adults engage in moderate-to-vigorous physical activity for 1%-5% of their day[1,2]. There has been a decrease in occupational-related energy expenditure by approximately 100 calories per day in the past 50 years[3,4]. Moreover, there has been a large increase in the amount of time an individual has available to spend in leisure pursuits and recently a large portion of leisure time is now spent in sedentary activities[5]. It has been documented that approximately 40% of the population self-reports being entirely sedentary during their leisure time[6].

The benefits of regular, moderate-to-vigorous physical activity on health have been established and have been highlighted in the 2008 Physical Activity Guidelines for Americans[7]. Thus, regular physical activity has been recommended as one component of a healthy lifestyle to prevent or treat numerous health-related conditions. Unfortunately, only 48% of adults in the United States meet the recommended moderate-to-vigorous physical activity guidelines[8]. It has been shown that, on average, more than 90% of one's day has been spent engaged in light activity, sedentary behavior, or sleep[9].

This becomes a problem because there are negative health consequences of prolonged sedentary behavior. For example, prolonged sedentary behavior has been shown to be associated with increased mortality[10-12], cardiovascular disease[9,13,14], type 2 diabetes[15-18], metabolic syndrome risk factors[19-22] and obesity[20,23-27]. The Australian Diabetes, Obesity and Lifestyle study found that increased sedentary time is inversely associated with metabolic risk[28]. The association between sedentary behavior and health risk has been shown to be independent of engagement in

moderate-to-vigorous physical activity[23]. Therefore, strategies to reduce sedentary behavior may have public health benefits for both non-exercising as well as exercising individuals.

1.1 TELEVISION TIME; A TARGET FOR INTERVENTION

The most commonly reported leisure time activity is watching television, with an average viewing time per adult of 3 to 5 hours per day, and up to 35 hours per week[29-31]. Therefore, television viewing may be an important intervention target for reducing sedentary behavior. One possible intervention strategy may be to encourage engagement in physical activity while watching television. Wing and Greeno summarized a simplified theoretical approach to modifying lifestyle behaviors, such as reducing the time spent in sedentary behavior and increasing levels of physical activity[32]. One component of this theoretical approach is target antecedents of the desired behavior. "Antecedents" are defined as factors that precede and potentially prompt the desired behavior. When applied within the context of television viewing, antecedents could be prompts that occur during television viewing that promote reduced sedentary behavior and increase physical activity. One common occurrence that could serve as an antecedent to prompt engagement in physical activity during television viewing is commercials, and this strategy had previously been examined[33].

Steeves et al[33] examined previously sedentary, overweight/obese participants who were randomized to a group that stood up and stepped in place during the commercials of their normally viewed television programs, or to a group encouraged to engage in traditional forms of exercise. This six-month intervention was able to show that both interventions were effective in significantly increasing daily steps, with no significant difference between the two groups. These results appear

to indicate that a commercial stepping intervention was an effective approach to increase daily step counts and decrease sedentary time[33]. While these findings are encouraging, this study was limited to targeting commercials as the antecedent to prompt engagement in physical activity; however, technology such as DVR and remote control usage now allows individuals to skip commercials while watching television.

Steeves et al[34] also determined the energy cost of sitting during a television show versus stepping in place during television commercials. Sedentary television viewing induced a caloric requirement of 81 ± 19 kcal/hour, while one hour of television commercial stepping produced a statistically higher requirement of 148 ± 40 kcal/hour. The one hour of incorporating commercial stepping into television viewing resulted in an average of 21 ± 2 minutes of physical activity and 2111 ± 253 steps[34]. Commercial stepping provided an increase in approximately 61 kcal/hour of television watched. It was reported that the average adult watches three to five hours of television per day[29,35,36]. If commercial stepping can be incorporated into this behavior, an approximate 183-305 kcal/day increase in caloric expenditure would be achieved[34]. Hill et al reported that an increase in energy expenditure of 50-100 kcal per day may be sufficient to prevent weight gain, which may be important in the prevention of individuals becoming overweight or obese[37]. Thus, incorporating a simple behavior, like stepping during television commercials, can have a significant impact on daily caloric expenditure and potentially assist in the prevention of weight gain.

This proposed study introduced the idea of "prompted active television viewing" (PATV). PATV used common character phrases or mannerisms within the television program itself as the antecedent to promote physical activity rather than the use of commercials as antecedents. To our knowledge, PATV has not been examined to determine if it: 1) results in a significant increase in

energy expenditure during television viewing, 2) results in a significant increase in moderate-to-vigorous physical activity during television viewing. To our knowledge, PATV has not been compared to television commercial prompts for physical activity as studied by Steeves et al[33] to determine if it is equally or more effective for increasing energy expenditure, increasing moderate-to-vigorous physical activity, or as a method of improving enjoyment of physical activity.

Utilizing television commercials as a prompt for physical activity proved to be effective in increasing an individual's daily energy expenditure. With the advances in technology, the public now has the ability to skip commercials during recorded television, thus skipping the prompt to become physically active. The proposed PATV in this study provided a prompt for physical activity within a television program, eliminating the possibility for the prompt to be skipped over while the individual was watching the television program. There was a possibility that subjects would be more engaged in physical activity if prompted through interaction during the program rather than during commercials, potentially eliciting higher stepping intensity. Thus, before recommending PATV as an effective strategy for reducing sedentary behavior and increasing energy expenditure, or before examining PATV within an intervention study, the acute effects of PATV on these factors were examined.

1.2 SPECIFIC AIMS

This study compared PATV to both seated sedentary television viewing (SED-TV) and physical activity prompted by commercials during television viewing (COMM-TV) to examine the following specific aims.

1. To compare energy expenditure during a 30-minute television program between SED-TV, COMM-TV, and PATV.
2. To compare minutes of moderate-to-vigorous intensity physical activity during a 30-minute television program between SED-TV, COMM-TV, and PATV.

   NOTE: Moderate-to-vigorous intensity physical activity was defined as minutes $\geq$3.0 METS (metabolic equivalents) or $\geq$ 50% -70% of age-predicted maximal heart rate
3. To compare enjoyment of television viewing sessions between SED-TV, COMM-TV, and PATV.
4. To explore the effect of gender with the amount of energy expenditure in each television viewing session.

1.3 HYPOTHESIS

1. It was hypothesized that COMM-TV and PATV would result in significantly higher energy expenditure compared to SED-TV.
   a. An exploratory hypothesis was that there is no significant difference in energy expenditure between COMM-TV and PATV.
2. It was hypothesized that COMM-TV and PATV would produce more minutes identified as moderate-to-vigorous intensity physical activity than SED-TV.
   a. An exploratory hypothesis was that there is no significant difference in moderate-to-vigorous minutes between COMM-TV and PATV.
3. It was hypothesized that COMM-TV and PATV would result in greater enjoyment compared to SED-TV.

4. It was hypothesized that gender would not affect energy expenditure in each television viewing session.

2.0 REVIEW OF THE LITERATURE

2.1 PHYSICAL ACTIVITY AND HEALTH OUTCOMES

The primary focus of this project was sedentary behavior; however; it should be noted that the benefits of moderate-to-vigorous physical activity have been established in the literature. Evidence from the 2008 Physical Activity Guidelines Advisory Committee Report[38] continues to link greater moderate-to-vigorous physical activity, a metabolic equivalent (MET level) ≥ 3.0, with decreased risk of coronary heart disease, cardiovascular disease risk, hypertension, stroke, osteoporosis, colon and breast cancer, anxiety, depression, all-cause mortality, obesity and type 2 diabetes[39-50.] It has been recognized that physical activity confers a dose response relationship with improved health outcomes. However, health benefits may be achieved even with physical activity below the recommended levels. Specifically, engagement in light physical activity (MET level <3.0) has demonstrated an association with lower mortality[51], death rate[52], and prevention of weight gain[53,54].

2.2 PHYSICAL ACTIVITY PREVALENCE

Objective data measured from the 2003-2004 National Health and Nutritional Examination Survey (NHANES) found that 42% of children ages (6-11 years) and 8% of adolescence (12-19 years) obtained the recommended 60 minutes of physical activity per day. The adult (20 years and older) recommendation of 30 minutes per day was achieved in less than 5% of the population sample[1].

Similar findings were reported in the 2000-2001 Behavioral Risk Factor Surveillance System (BRFSS) data[55].

Hagströmer et al[56] observed that time spent at moderate-to-vigorous physical activity levels was lower in those at a higher age, and lower in those with a higher BMI. Based on accelerometer data, Troiano et al[1] determined that physical activity declined across age groups with 42% of children (ages 6-11) meeting the recommended physical activity level per day, 8% of adolescents (ages 12-19) meeting physical activity recommendations, and 5% of adults (over 20 years old) achieving physical activity recommendations.

2.3 PREVALENCE OF SEDENTARY BEHAVIOR

Sedentary behavior refers to activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down, watching television and other forms of screen-based entertainment[57]. A metabolic equivalent level of less than 1.5 designates sedentary behavior[58]. Sitting time has been used as a marker of sedentary behavior[19,59].

The International Prevalence Study (IPS)[60] measured various physical activity behaviors estimated across twenty countries. Data were collected between 2002 through 2004 utilizing the International Physical Activity Questionnaire-short form (IPAQ). The IPAQ contained the following question: *During the last 7 days, how much time did you usually spend sitting on a weekday?* Analysis of this question included data from 49,493 adults aged 18-65 years across the twenty surveyed countries. The median reported sitting time was 300 minutes (IRQ = 180-480 minutes). This equates to sitting 5 to 6 hours per day. For the pooled sample, there were no differences in sitting time by gender. Younger adults (aged 18-39 years) had significantly higher

total sitting time (p=0.008) than older adults (aged greater than 40 years) in 10 of the 18 comparable countries. Those respondents with more than 13 years of education reported sitting significantly more than those with 13 or fewer years of education (p=0.001) in 15 out of 19 comparable countries. Younger adults (aged 18-39 years) and those with more than 13 years of schooling had the highest sitting rates[60].

While subjective self-report measures provide investigators with the opportunity to assess a large amount of individuals, reporting bias is a concern[61]. Potential reasons for physical activity self-report bias include a combination of social desirability bias (over-reporting physical activity, as being physically active is a socially desirable characteristic) and challenges associated with estimating frequency and duration of physical activity, especially in children[61,62]. Use of pedometers and accelerometers, provide objective measurements of activity behaviors, and potentially reduce bias associated with subjective measurement[63,64].

Objective measures of physical activity within the U.S. population were collected from the National Health and Nutrition Examination Survey (NHANES) 2003-2004. NHANES methodology has been described elsewhere[1,5]. For the objective physical activity component, all ambulatory participants aged 6 years and older were asked to wear an accelerometer for seven days after their examination, during all waking hours except for bathing and swimming[1,5,65,66]. In children (aged 6-11 years), adolescents (aged 12-19 years) and adults (aged 20 and older) data were obtained from 6,329 participants who provided at least one usable day of accelerometer measurements[5]. Overall, the U.S. population spent 7.7 hours per day, or 54.9% of their waking time, engaged in sedentary behaviors. Similar objective measurements of sedentary behavior engagement were found among the Australian Diabetes, Obesity and Lifestyle Study (57% daily

time spent sedentary)[9], as well as among the Swedish population (47% daily time spent in sedentary behavior)[2].

A linear trend was observed among youth (aged 6-19 years old), with the age group 6-11 years olds being the least sedentary, followed by an increase in sedentary behavior among 12-15 year olds and 16-19 year olds; 16-19 year olds exhibited the highest amount of sedentary time among youth ($p < 0.001$). Similarly, a linear trend was observed among adults (aged 20-85 years old) with individuals within the 20-29 year old category being the least sedentary. Gradual increases in sedentary behavior were observed with each 10-year age group increase. Of the adult age groups, 70-85 year olds displayed the highest amounts of sedentary time ($p < 0.001$)[5].

When assessing the interaction between age and gender, females were more sedentary than males throughout youth (aged 6-15 years) and early adulthood (aged 20-39 years). This pattern was reversed after age 60 years, when the level of sedentary behavior in men surpassed that of women ($p_{\text{for interaction}} < 0.01$). In determining sedentary behavior differences by race and ethnicity, Black females aged 6-11 years were significantly less sedentary than either White or Mexican–American females aged 6-11 years ($p < 0.05$). No significant differences were found among males of any ethnicity. Mexican-American men and women (aged 20-85 years) were the least sedentary group of adults ($p < 0.05$), with Black adults having equivalent sedentary behavior time as White adults[5].

Prevalence of sedentary behavior across countries has been examined between the United States and Sweden[56]. Similar accelerometer protocols were performed from two cross-sectional samples: from Sweden, the Attitude Behavior and Change Study, 2001-2002[2]; from the United States, the NHANES 2003-2004[1]. Both studies objectively assessed physical activity with an accelerometer, with the only notable difference being the placement of the accelerometer, with this

being on the lower back in Sweden and on the right hip in the U.S., adult data were included in the analysis with four or more days of ten or more hours per day of accelerometer wear time. From Sweden, 1,172 respondents were included in the analysis, and from the U.S. 2,925 respondents were included in the analysis. The Swedish sample had 4%-7% fewer respondents aged 18-39 years than the U.S. sample. Prevalence of obesity was higher in the U.S. (30%) than in Sweden (9%). Swedish males had significantly more sedentary behavior than U.S. males for those 18-39 years of age [497 min/wk (CI: 484-510) vs. 444 min/wk (CI: 428-460)] and 40-59 years of age [505 min/wk (CI: 493-518) vs. 484 min/wk (CI: 476-492)]. In the 18-39 year old age group, Swedish females (486 min/wk CI: 475-497) had more minutes per week of sedentary behavior than U.S. females (462 min/wk CI: 449-474)[56].

2.4 FACTORS CONTRIBUTING TO SEDENTARY BEHAVIOR

Utilizing data from the American Time Use Survey conducted annually by the Bureau of Labor Statistics in conjunction with NHANES data, investigators have sought to determine trends in daily American time use[3,4,6,67]. Data from 2009 suggest approximately 32% of the 24-hour day was spent sleeping and approximately 31% was spent at work. The remaining 37% of the day included activities of travel and leisure time engagement[67]. Adults reported engaging in activities that were predominately sedentary or of light intensity during total daily waking hours[68]. The prevalence of sedentary behaviors in the U.S has increased, as well as an overall decline in total physical activity, over the past 50 years[67].

In relation to travel activity, daily vehicle miles traveled per person has increased by 0.4 miles per year over the last 50 years[3]. Automobile use to drive to work has increased from 67%

of people who commute to 88% of people who commute[3]. There has been a decrease in public transportation from 16.5% to 5%, and walking from 16.5% to 7% to get to work[3]. Presently, when compared to Whites, walking for non-work related travel is twice as likely in Blacks, Asians and Hispanics[38]. Commute times are also higher for these minority groups compared to Whites[69]. An average individual spends approximately 55 minutes per day driving, with men accruing more mileage and longer car drive durations than women[3].

Employment in moderate-to-high intensity physical activity occupations, such as goods production and agricultural occupations, has been replaced by low or sedentary intensity service occupations. Since the 1950's, highly active occupations decreased from 30% to 23%, moderately active occupations have decreased from 47% to 36%, and low active or sedentary jobs increased from 23% to 41%[3,4]. Thus, availability for leisure time has increased from 4 hours per day in the 1950's to 8 hours per day more recently[3].

The prevalence of sedentary leisure-time behavior is disproportionate between race and ethnicity. Cumulative literature has identified Hispanic and non-Hispanic Blacks as being more sedentary than other racial and ethnic minority groups, with Hispanic and non-Hispanic Black women being the most sedentary during leisure time[43,55,70,71].

Over the past five decades, there has been a decline in work-related and transportation activity and an increase in sedentary behavior[3,4]. Thus, it is possible that activity has been engineered out of the American's current lifestyle. To examine how the impact of decreasing occupational and lifestyle expenditures has affected the current population, Bassett et al conducted a study on an Old Order Amish Community[72]. The Old Order Amish do not employ modern convenience or electricity, and are typically farmers. Ninety-eight Amish men and women participated in this study. Pedometers were worn to measure steps for a period of one week. The

International Physical Activity Questionnaire was used to determine activity intensity. The findings indicated that the Amish had high levels of physical activity (18,425 steps/day for men and 14,196 steps/day for women), achieved 10 hours/week of vigorous intensity and 42.8 hours/week of moderate intensity physical activity in men, with lower amounts of 3.4 hours/week of vigorous and 39.2 hours/week of moderate intensity physical activity for women[72]. While this study suggested that the Amish have relatively high levels of physical activity, the findings of this study should be interpreted with caution due to the lack of a control or comparison group.

2.5 SEDENTARY BEHAVIOR AND ITS RELATION TO HEALTH OUTCOMES

2.5.1 Association between Mortality and Sedentary Behavior

2.5.1.1 All-Cause Mortality and Sedentary Behavior

One of the largest studies to determine an association between sedentary behavior and mortality was the American Cancer Society's Cancer Prevention Study II (CPS-II)[52]. Participants in this analysis were drawn from the CPS-II Nutrition Cohort, a prospective study of cancer incidence and mortality covariates by the American Cancer Society in 1992[73]. Subjects were between the ages of 50-74 years old when they were invited to participate in 1992, and completed a questionnaire on various demographic, behavioral, medical and lifestyle factors. Mortality endpoints were identified through the National Death Index[74]. Analysis was conducted on 123,216 individuals (53,400 men and 69,776 women) with a mean age of 63.6 years (SD = 6.0) in men and 61.9 years (SD = 6.5) in women. After multivariate adjustment, total time spent sitting was positively associated with all-cause mortality in both men and women. The relative risk of all-

cause mortality was significantly higher for men (RR= 1.18) and women (RR= 1.37) who sat for more than 6 hours per day compared to those who sat less than 3 hours per day (p=0.003). This association remained significant after adjustment for body mass index[52].

The association between sitting time and mortality has been assessed in a representative sample of 17,013 Canadians through the Canada Fitness Survey[75]. The sample included 7,278 Canadian men and 9,735 Canadian women aged 18-90 years old with average follow-up time of 12 years (SD = ± 2.1). The Canada Fitness Survey collected data through a lifestyle questionnaire as well as a physical fitness battery and anthropometric measurements[76]. In this population, the amount of daily sitting time was positively associated with mortality rates from all-causes in the combined sample of men and women ($p < 0.0001$)[75]. Denoting sitting 'almost none of the time' as the reference group, hazard ratios increased across sitting groups (sitting ½ of the time, 1.11; sitting ¾ of the time, 1.36; sitting almost all of the time, 1.54) ($p<0.0001$) for all-cause mortality. Similar trends were observed in the sex-specific analyses. All-cause mortality rate was highest among men who sat 'almost all of the time' ($p = 0.005$) and women who sat 'almost all of the time' ($p<0.0001$)[75], independent of body mass index.

The Multiethnic Cohort Study provides an unique ability to measure the association between sedentary behaviors and mortality across various racial and ethnic groups[77]. Two U.S. locations, Hawaii and California, recruited 215,000 men and women aged 45-75 for this cohort study. Five racial and ethnic groups were represented (African American, Latino, Japanese American, Native Hawaiian and White) and followed for 13 years. Included in this analysis were 134,596 men and women who completed a questionnaire of lifestyle factors. Amount of time spent in sedentary behavior was associated with a higher risk for mortality in women who sat 10 hours or more per day compared to a reference group of women sitting less than 5 hours per day

(HR 1.11, 95% CI: 1.04-1.19). No association was present with total daily sitting time and mortality in men[77].

2.5.1.2 Cardiovascular Disease Mortality and Sedentary Behavior

Four studies[52,75,77,78] have examined the relationship between cardiovascular disease mortality and sedentary behavior. The Multiethnic Cohort Study[77] showed a 19% increase in cardiovascular mortality among women who sat for 10 hours or more per day than women who sat less than 5 hours per day. Total daily sitting time was not associated with cardiovascular mortality in men[77]. The other three studies reported an increase in cardiovascular disease mortality with increased sedentary time in both men and women. Among the American Cancer Society's Cancer Prevention Study[52], time spent sitting was associated with an increased risk for cardiovascular disease mortality in both men (HR: Sitting 0-<3 hours/day: 1.00, sitting 3-5 hours/day: 1.06, sitting ≥6 hours/day: 1.18) and in women (RR: Sitting 0-<3 hours/day: 1.00, sitting 3-5 hours/day: 1.20, sitting ≥6 hours/day: 1.33)[52]. Within the Canadian Fitness Survey population[75], compared to self-reported siting 'almost none of the time', risk of cardiovascular mortality was higher for sitting ¼ of the time (HR = 1.01), sitting ½ of the time (HR = 1.22), sitting ¾ of the time (HR =1.47), sitting almost all of the time (HR = 1.54)($p < 0.0001$)[75]. Similar trends were observed in the sex-specific analyses, with cardiovascular disease mortality increasing as amount of time spent in sedentary behavior increased among both genders, men ($p=0.03$) and women ($p=0.002$)[75]. Within the Aerobics Center Longitudinal Study[78], participants who self-reported greater than 23 hours per week of sedentary behavior had a 37% greater risk of cardiovascular mortality, compared to participants who reported less than 11 hours per week of sedentary behavior[78].

2.5.1.3 Cancer Mortality and Sedentary Behavior

Within the Multiethnic Cohort Trial[77] and the Canadian Fitness Survey[75], no association with cancer and sedentary behavior was found. In the Canadian CFS population, the amount of daily sitting time was not significantly associated with mortality rates from cancer in the combined sample of men and women. Additionally, there was no relationship between sitting and cancer mortality when stratified by gender[75].

The American Cancer Society's Cancer Prevention Study reported time spent sitting was associated with an increased risk of cancer mortality among women ($p < 0.0001$), but not men[52]. Further investigation into this association determined a prolonged duration of sedentary behavior was associated with an increased risk for ovarian cancer (for ≥6 vs. <3 hours per day: HR = 1.55)($p = 0.01$)[79].

2.5.2 Association between Morbidity and Sedentary Behavior

2.5.2.1 Cardio-metabolic Consequences Associated with Sedentary Behaviors

Elevated levels of cardio-metabolic and inflammatory biomarkers have been associated with increased risk of cardiovascular disease[80,81]. Increased amounts of sedentary behavior have been consistently associated with increased risk of poor metabolic health and cardiovascular disease risk[13,15,82-84]. Additionally, increased time spent in sedentary activity has been consistently linked to increased risk of diabetes[16,17,85,86]. Multiple studies have objectively examined the association of cardio-metabolic biomarkers with sedentary time[9,15,28,83,87,88].

Objectively measured sedentary time was assessed in a subsample of adults in the Australian Diabetes, Obesity and Lifestyle Study (AusDiab)[15,89,90]. Participants underwent anthropometric and behavior assessments, and wore an accelerometer for seven consecutive days.

Included in this analysis were 67 men and 102 women (total n=169). Mean age of subjects was 53.4 years, 54% attended college or higher education, 38% were in the highest income bracket and 30% had metabolic syndrome. An increase in sedentary time was positively associated with a higher 2-hour plasma glucose ($p = 0.002$)[15].

The National Health and Nutrition Examination Survey (NHANES), compared objectively measured sedentary time and the association with cardio-metabolic risk in a diverse sample of U.S. adults[83]. Subjects participated in the NHANES survey from the 2003-2004 and 2005-2006 cycles, which included demographic and anthropometric assessment, as well as a seven day accelerometer data collection period[91]. The study sample included 4,757 subjects of whom 50% were male; the average age of the full sample was 46.5 years (SD = ±14.2 years), with the average hours of sedentary time of 8.44 (SD= ±1.45) hours per day. A significant, linear association was observed between total sedentary time and waist circumference ($p= 0.0495$), HDL-cholesterol ($p=0.014$), insulin levels ($p<0.001$), beta cell function [HOMA-%B ($p<0.001$)] and insulin sensitivity [HOMA-%S ($p<0.001$)][83]. Subjects who were the most sedentary sat for 2 hours more per day than subjects who were the least sedentary. Amount of time spent in sedentary behaviors had significant associations with insulin levels, HOMA-%B, and HOMA-%S within all racial/ethnic groups. There was no association between time spent in sedentary behavior and systolic blood pressure within any racial/ethnic group[83]. There was an observed interaction between higher amounts of sedentary time with each additional year of age for waist circumference ($p=0.002$), HDL-cholesterol ($p=0.037$) and C-reactive protein ($p=0.005$)[83].

The AFINOS study[92] examined the objective association of sedentary behavior to cardiovascular risk factors in adolescents[92]. A sample of 201 adolescents from Madrid participated in a physical examination, blood profiling and seven-day accelerometer data collection.

Adolescents with the most amount of time spent in sedentary behavior had less favorable systolic blood pressure, triglyceride levels, glucose levels and cardiovascular risk scores (p=0.037), compared to those that spent the least amount of time in sedentary behaviors. The combined effects of high levels of overall adiposity and high levels of abdominal adiposity in conjunction with high levels of sedentary behavior elicited the least favorable cardiovascular risk score ($p<0.001$)[92].

Only a marginally significant association was found in time spent in sedentary behavior with fasting insulin (p=0.05) in a cross-sectional objective study of individuals with a family history of type 2 diabetes[88]. The Medical Research Council Ely Study[93] provided objective longitudinal data on the association between the amounts of time spent in objectively measured sedentary time and insulin resistance in overall healthy, middle aged Caucasian adults. This study found a significant association (R^2= 0.441, p=0.009) between time spent being sedentary at baseline and fasting insulin levels at follow up (mean 5.6 years), independent of time spent at moderate-to-vigorous physical activity[93].

2.6 TELEVISION VIEWING AND ITS RELATION TO HEALTH OUTCOMES

Time spent engaged in sedentary behaviors confers negative health consequences as described above. When objectively measured, U.S. adults engaged in an average of 7.7 hours of sedentary behavior per day, with amount of sedentary behavior increasing with increasing age, and no significant differences among White, Black or Mexican-Americans[5,94]. Time spent engaged in watching television (through television set or on a computer/device) is the most commonly

reported sedentary leisure-time behavior, with the average American viewing an average of 35 hours of television per week[31,95,96].

2.6.1 Cardio-metabolic Consequences of Television Viewing

Increased amounts of sedentary behavior have been consistently associated with increased risk of all-cause, CVD-related and all-other cause mortality[52,75,78,84,96-101] in both men and women, independent of BMI and physical activity. Six studies subjectively assessed television-viewing time in relation to CVD mortality[78,97,101-104]. In a meta-analysis of these six studies, a hazard ratio of 1.17 (95% CI: 1.13-1.20) was determined per 2 hours a day of screen time[94]. This association did not differ based on gender, age, education level or BMI.

The effects of television viewing on blood pressure/hypertension were examined in seven studies with mixed results[105-111]. Five studies noted a positive relationship on amount of self-reported television viewing behaviors and objective blood pressure measurements[106-110]. A positive relationship with the amount of television viewing and increased blood pressure was found in two studies[106,107]; the National Heart Lung and Blood Institute- Family Heart Study showed a positive relationship in the amount of television viewing and increased blood pressure in women only[110] and the Cardiovascular Risk Development in Young Adults study found a positive relationship in the amount of television viewing and increased blood pressure in white males only[109]. The Bogalusa Heart Study found a positive relationship between the amount of television viewed and diastolic blood pressure[108]. Two studies found no relationship between objectively measured blood pressure and self-reported amount of television viewing[105,111].

Three studies[16,17,105] that looked at the relationship between self-reported television time and diabetes status were reviewed and showed mixed results. The Nurses' Health Study analyzed self-reported television viewing time and diabetes status in 50,277 non-obese women and 68,497 non-diabetic women[17]. During the six years of follow up 1,515 new cases of diabetes were reported. Television time was positively associated with the risk of type 2 diabetes. When adjusting for age, smoking, exercise levels and other covariates, each 2 hour per day increment in television watching was associated with a 14% increased risk of diabetes[17]. Hu et al[16], investigated the 10 year follow up of 37,918 men aged 40-75 years on self-reported measures of television time and diabetes status[16]. Investigators found that time spent watching television was associated with a higher risk of diabetes. In the AusDiab study[105], television time was assessed with subjective measures, and diabetes was assessed using an oral glucose tolerance test. This study showed higher television viewing time was associated with diabetes in women only.

2.6.2 Obesity Risk and Television Viewing

Twenty-five cross-sectional studies examined the relationship between television viewing and indicators of overweight/obesity[18,26,53,105-110,112-127]. Overall, there was a positive relationship reported between television viewing time and overweight/obesity indicators. From the Nurses' Health Study[17], 7.5% of the originally non-obese women became obese with television time being positively associated with the risk of obesity (BMI $\geq$30 kg/m^2). When adjusting for age, smoking, exercise levels and other covariates, each 2 hour per day increment in television watching was associated with a 23% increase in obesity[17]. A study conducted by Raynor et al[128] sought to determine common behaviors of individuals who were successful in achieving weight maintenance following weight loss. In this study of 1,422 subjects it was found that successful weight

maintenance following weight loss was associated with the avoidance of watching television, and was independent of self-reported moderate-to-vigorous physical activity[128].

Four longitudinal studies determined that television-viewing behaviors during childhood/adolescent was a strong predictor of obesity in adulthood, particularly among females[111,129-131]. A study conducted in New Zealand assessed 1,037 children from a birth cohort and followed them until age 32. Height, weight and fitness were objectively assessed, while television viewing was subjectively assessed. This study found that childhood television viewing predicted having a higher BMI at age 32 (OR = 1.30)[129]. In 26-year olds, population-attributable fractions indicate that 17% of the overweight characteristic can be attributed to watching television for more than 2 hours per day during childhood and adolescence (aged 5-15 years)[111]. A 1958 British birth cohort assessed 11,301 subjects' height, weight, circumference measures and television viewing patterns for 45 years. Females with more frequent television viewing at 11 years old (watching television 'often') had a higher BMI at 33 years old and experienced faster gain in BMI between 23-45 years of age. Television viewing behaviors at 11 years old had no effect on BMI or an increase in BMI in adult males[130]. Weekday and weekend television viewing behaviors were assessed in a 1970 British birth cohort over 30 years[131]. Subjects (n=11,261) were assessed for television viewing behavior, height and weight at ages 5-years, 10-years and 30-years. Watching television for at least 4 hours per weekend day at age 5 was associated with higher BMI scores at 10-years old and 30-years old. Each additional hour of television watched on weekends at 5 years old increased the risk of adult obesity (BMI $\geq$ 30 kg/m^2) by 7%[131].

2.7 SEDENTARY RISK INDEPENDENT OF PHYSICAL ACTIVITY

The health benefits achieved by participating in physical activity may not necessarily mediate the risk from engagement in sedentary behavior. Hamilton et al, suggested that even when an individual met the physical activity recommendations, prolonged periods of sitting may have deleterious biological consequences[59]. The joint effect of physical activity and sedentary behaviors on health outcomes were examined in seventeen studies[16,17,52,53,75,78,79,86,96,97,101,102,128,132-135]. Physical activity did not significantly modify the association of sedentary behavior in relation to mortality risk[75,96,97], risk of being overweight[53], or changes in BMI[136]. Stratifying for physical activity level, there was no attenuation of the association of sedentary behavior and risk of mortality[52,75,96], overweight/obesity[17,53,133], BMI/weight gain[128,136], diabetes[16,17,86], hypertension[132] or ovarian cancer[79].

In the Australian Diabetes, Obesity and Lifestyle study (AusDiab), among healthy individuals who reported at least 150 minutes a week of moderate-to-vigorous intensity physical activity, a significant dose-response association of television time was observed with waist circumference, systolic blood pressure, and 2 hour plasma glucose in both men and women[9,15]. Additionally, women had a dose-response relationship between television time and fasting plasma glucose, triglycerides and HDL-cholesterol[9]. Three studies showed protective effects of physical activity from sedentary behavior in relation to mental disorders[135] and CVD events/mortality[78,101]. Thus, engagement in sedentary behavior, specifically television time, conferred negative health consequences, independent of physical activity level.

Data from the American Cancer Society Prevention Study II[52] showed that time spent sitting was associated with an increased risk of all-cause mortality, independent of level of physical activity ($p<0.05$)[52]. In a review of eight cross-sectional studies[26,106,109,123,137-140], six

studies[26,106,123,137,138,140] showed a significant negative relationship between television viewing and moderate-to-vigorous intensity physical activity. The other two studies[109,139] showed this significant negative relationship in women and non-black men only.

Matthews[103] tested the independent and combined effects of television viewing and moderate to-vigorous physical activity on mortality through the NIH-AARP Diet and Health Study. This study examined 240,819 adults aged 50-71 years old who self reported television viewing time and physical activity. Mortality was determined with the National Death Index. In this study, compared to the reference group of watching less than one hour of television per day and exercising at moderate to vigorous intensity more than seven hours per week (HR =1.0); there was not much difference in those that were most active (>7 hours/week MVPA) and watching the most television (7+ hours/day) (HR =1.5), and those that were least active (never/rarely exercise) and watched the least television (<1 hour/day) (HR =1.16). This shows the independent effect of moderate-to-vigorous activity and television watching.

2.8 MECHANISMS OF HOW SEDENTARY TIME CAN INFLUENCE HEALTH

Common hypotheses for the mechanisms of how sedentary time influences health risks include; increase in energy intake, decrease in energy expenditure and suppression of lipoprotein lipase (LPL) in skeletal muscle. Five studies[126,141-144] have examined the relationship of increased energy intake and television viewing behaviors. Halford et al[142] conducted a study to assess food versus non-food television advertisements on child food intake. This study was conducted in 93 children aged 5-7 years old. The children were exposed to 10 non-food advertisements and 10 food advertisements in a repeated measures study design. A variety of snack foods were offered during

the study session and consumption of snack amount and preference was measured. This study found that food advertisement exposure produced a significant increase in total food intake in young children. Van de Bluck[143] surveyed the average weekly eating behaviors and television viewing behaviors of secondary school children. Surveys of the children found that only 3.5% of adolescents did not eat snacks or drink soft drinks when they watched television. Investigators were able to calculate that 1-hour of television watching equated to the consumption of 156-calories. A questionnaire delivered to mothers of children aged 3-8 years old sought to examine child television viewing habits and food items requested[144]. Taras et al, found that foods children requested because they had seen it on television paralleled with the frequency of these foods being advertised. Number of weekly television viewing hours positively correlated with the child's request for the advertised food and increased caloric intake[144]. Stroebele et al[141], recruited 76 undergraduate college students to record their dietary intake and television viewing behaviors over 7 days. Participants in this study ate at least one meal per day with the television on. On the days participants ate at least one meal with the television on, they watched more television in general. A study by Jeffery et al[126], focused on one year prevention of weight gain, television viewing was not related to energy intake in men, but television viewing was positively related to energy intake in women.

Two studies were reviewed that examined the hypothesis that television viewing is related to a decrease in energy expenditure. In the previous mentioned Stroebele et al study[141], of undergraduate college students who recorded their dietary intake and television viewing behaviors over 7 days; participants, who usually exercised, exercised less during days when they ate with the television on ($p<0.05$). Data from the 1999 Youth Risk Behavior Survey[145] found that high school students who watched more television per week engaged in less physical activity.

Prolonged sedentary behaviors suppresses lipoprotein lipase (LPL) activity in skeletal muscle, resulting in metabolic consequences such as dyslipidemia, insulin resistance, hypertension and obesity[21,146]. LPL serves to regulate lipid concentrations and maintain cardio-metabolic homeostasis. In human subjects, four studies determined that a reduction in time spent sitting improved metabolic consequences including triglycerides, HDL-cholesterol, fasting plasma glucose and resting blood pressure[52,83,147,148]. Prolonged time spent sitting had metabolic consequences that influenced specific biomarkers (TG, HDL-C, fasting plasma glucose, resting blood pressure, leptin). Short-term detrimental changes in insulin sensitivity and post-prandial lipid metabolism was shown in individuals who markedly reduced their daily steps to very low levels (about 1500 steps per day during a two week period)[149].

2.9 CORRELATES OF SEDENTARY BEHAVIOR

Several constructs have been investigated to determine engagement in sedentary behavior or physical activity. Neighborhoods have been associated with participation in physical activity and may influence time spent in sedentary behaviors. Neighborhood-level variables (walkability and socio-economic status) were calculated in 154 Australian census collection districts[150]. Individual-level variables were collected from adults living within the census district using a mail-survey (n= 2,224). Neighborhood walkability was negatively associated with television viewing time in women, but not in men. After controlling for neighborhood SES, BMI, physical activity and SES, women living in medium- and high walkable neighborhoods reported significantly less television

viewing time per day (14 minutes less and 17 minutes less, respectively) compared to those residing in low walkable neighborhoods[150].

A population-based subjective survey of 1,332 Australian adults sought to explore the association of physical activity and sedentary behavior with barriers, enjoyment, and preference[151]. Respondents reporting high enjoyment and preference for physical activity were more likely to report high levels of physical activity. Those indicating more than two barriers to physical activity were less likely to be physically active. Preference for sedentary behavior was associated with the decreased likelihood of being physically active. Weather as a barrier to physical activity was associated with the increased likelihood of sedentary behavior[151].

Children and adolescences engage in television viewing approximately 21 hours per week, a 10-hour decrease from adults, mostly impacted by a child's structured environment (school and homework)[152]. Positive relationships between television viewing times in children included: being non-Caucasian across all age groups, BMI, between-meal snacking, weekend television viewing behavior, being an adolescent male and having adolescent depression[153-156]. Physical activity was inversely associated with screen-time among preschoolers, but non-significant associations were present between physical activity and older children/adolescents[153-155]. Positive television viewing time was also shown to be associated with having a single-parent family, lower parent income, lower parent education and lower SES[154,155,157,158]. Increased screen time was consistently associated with overweight/obesity in children[159-162]. Additionally, greater amounts of television time resulted in poorer cognitive development, short-term memory, attention span, academic achievement and language skills and fewer words in the child's vocabulary[160,163-165].

2.10 INTERVENTIONS TO DECREASE SEDENTARY BEHAVIOR

In a laboratory setting, Raynor et al[166] explored the role of environmental access in replacing physically active behaviors for sedentary behaviors. Non-obese sedentary male college students were randomly assigned to 1 of 4 experimental sessions of a physically active behavior or sedentary behavior located far (5-minute walk away) or near (located in the same room). The four experimental sessions were as follows; exercise far/sedentary far, exercise far/sedentary near, exercise near/sedentary far, exercise near/sedentary near. Participants were free to move between the two activities during the 20-minute experimental session. Participants spent most of their time engaged in sedentary activities when these activities were easily accessible (exercise near/sedentary near and exercise far/sedentary near). Participants chose to spend all of their time exercising when sedentary behavior was not easily available and physical activity was easily available (exercise near/sedentary far)[166].

The Raynor et al study[166] demonstrated that proximity and convenience of behavior dictated engagement in behavior. Various strategies have been utilized to reduce sedentary behavior, in particular television viewing including active video gaming[167], television budgeting[99,168,169], home consultation[170,171], curriculum based interventions[172-174], goal setting and feedback[100] and commercial stepping/antecedents[33].

One study conducted by Ni Mhurchu et al[167], examined the effect of active video games on children's physical activity levels. Twenty children aged 12 years were assigned to an active video gaming group or a non-intervention control group for 12-weeks. The children who received the active video game package had less screen time (a difference of 44 minutes) compared to the control group.

Three studies[99,168,169] have been conducted utilizing television budgeting, a method of shutting a television set off after a designated amount of use. A study by Todd et al,[168] assigned 22 boys aged 8-11 years old into two groups for a 20 week intervention. The intervention group received an interactive session on breaking free of TV and recommendations of how to achieve this, newsletters and a TV limiting device; the control group received no intervention. At 10 weeks into the study, the intervention group reduced their television use by 47% and the control group reduced their television use by 24%. By 20 weeks however both groups increased their television use from 10 weeks, the intervention group still had lower television time than the control group[168]. Ni Mhurchu et al,[169] conducted a 6 week intervention in 29 children aged 9-12 years old. The experimental group received electronic television monitors, participants were told to restrict their television time to less than 1 hour per day and discussed ways to reduce their television time. The control group received verbal advice on strategies to decrease television watching. Results from this study showed the experimental group decreased their television time by 4.2 hours per week, with no change in television time in the control group[169]. Otten et al[99], observed the effect of television budgeting in adults by assigning 36 overweight and obese adults to an intervention or control group. The intervention group was to reduce their television viewing to 50% less than their weeklong run-in television time; no further instructions were given. This study found that the intervention group reduced their television viewing time by 61%, but objective armband data found that total sedentary time was reduced by only 3.8%, indicating reducing television time resulted in a shift to other sedentary behaviors[99].

Two studies[170,171] utilized home consultation to reduce sedentary time and increase physical activity. Anand et al[170], conducted a study among 57 Canadian households to determine if a household-based lifestyle intervention was effective at reducing energy intake and increasing

physical activity after 6 months. A counselor regularly visited homes to set dietary goals, physical activity goals, provided education about healthy lifestyles and engaged the household in physical activity. No statistically significant effects on decreasing sedentary time or increasing physical activity were seen. Trends were seen with increased knowledge about healthy diet practices, increased leisure time physical activity, and decreased sedentary behavior. A study in children conducted by Reilly et al[171], utilized a combination nursery and home intervention to target an increase in physical activity and a decrease in sedentary time. A sample of 545 children aged 4 years old were randomized to an intervention or control group. Children in the intervention group received a nursery school element consisting of 3, 30 minute physical activity sessions each week for 24 weeks as well as a take-home educational pack on decreasing sedentary time and increasing physical activity. The control group received no intervention. This study found no effect on measures of physical activity or sedentary time[171].

Intervention approaches to increase physical activity and decrease sedentary time through school-based curriculum has been employed in three studies[172-174]. The Get Moving! Intervention conducted by Spruijt-Metz[172] focused on encouraging Latina girls to develop public service announcements aimed at increasing physical activity and decreasing physical inactivity. Facilitated discussion about the importance of physical activity was incorporated through the student-based public service announcement development. This intervention achieved significant reductions in sedentary time among the minority girls[172]. In the Switch Play Intervention conducted by Salmon et al[173], school-aged children were randomly assigned to one of three interventions or a control group which received no intervention. The three interventions included a behavioral modification group which aimed to reduce television time by 20% through educational lessons, a functional motor skill group which focused on motor skills mastery through

games, and a combined behavioral modification and functional motor skill group that received both interventions. In this study the behavior modification group saw in increase an television watching[173]. Salmon et al conducted another intervention entitled Switch-2-Activity[174]. This study incorporated a control school that did not receive the intervention, as well as a behavioral modification school that received 6 lessons focused on self-monitoring, behavioral contracting and budgeting television time. This intervention was able to elicit a reduction of screen time in boys on the weekend[174].

Gardiner et al, attempted to reduce sedentary time through setting goals and providing feedback in the Stand Up for your Health study[100]. In this study, 59 older adults aged 60 and over participated in an accelerometer-based intervention. Participants received a one-time in-person goal setting session, as well as one objectively tailored feedback mailing on their sedentary behavior seven days later. This intervention was able to reduce sedentary time, as well as increase the number of breaks taken throughout the day. Results found that a higher percentage of the participants' day was spent in light and moderate-to-vigorous physical activity[100].

Steeves et al, piloted a study to decrease sedentary time by instructing participants to walk during the commercials of their television shows[33]. This experiment incorporated the attempt to decrease prolonged sedentary time by channeling a common sedentary behavior and prompting the participants to become active during the commercials. Fifty-eight sedentary overweight adults were enrolled to one of two six-month behavioral physical activity programs; one group was encouraged to walk 30 minutes each day, the second group was encouraged to stand and step or walk during each commercial break of a 90 minute television program at least 5 days per week. Over the six months, both groups significantly increased their daily steps (4,611 ± 1,553 steps/day vs. 7,605 ± 2,471 steps/day). The commercial stepping group increased their steps to 4,909 ±

1,335 steps/day and the walking groups increased their steps to 7,865 ± 1,939 steps/day, with no significant difference between the two groups. Investigators were able to show that stepping during commercial breaks provides a feasible alternative to traditional physical activity approaches to increase physical activity determined by number of steps per day[33].

3.0 METHODS

3.1 SUBJECTS

A total of thirty-eight (n= 38) apparently healthy men (n=19) and women (n=19) between the ages of 18-55 years, with a BMI of 18.5 to <40.0 kg/m^2 were recruited to participate in this study. Disease risk, care and engagement in physical activity are often sensitive and complicated for individuals with BMI classification as underweight (<18.5 kg/m^2) or those classified as extremely obese (≥40.0 kg/m^2) and are beyond the scope of this study[175]. Subjects meeting the American College of Sports Medicine (ACSM) criteria for classification of low to moderate risk were eligible to participate in this study[7]. Additional exclusionary criteria for this study included:

1. Reported being treated for a current medical condition that could affect metabolism. These included the following; cancer, heart disease, type 1 or type 2 diabetes, hyperthyroidism, hypothyroidism or polycystic ovarian syndrome.
    a. Rationale: Individuals with these conditions require medical clearance that was beyond the scope of this study[7].
2. Currently taking prescription or over the counter medication that could affect metabolic rate.
    a. Rationale: These conditions and their medications may have affected metabolic response to exercise. It was imperative to the study to ensure that any changes in caloric expenditure was elicited from the intervention and as many possible extraneous interactions were eliminated.

3. Currently taking prescription or over the counter medication that could affect heart rate.
    a. Rationale: These conditions and their medications may have affected heart rate response to exercise. It was imperative to the study to ensure any changes in heart rate was elicited from the intervention and as many possible extraneous interactions were eliminated.
4. Presence of any condition that may limit one's ability to walk for exercise.
    a. Rationale: Subjects were required to walk for exercise in order to complete the experimental sessions; any orthopedic limitations would limit the ability of these individuals to complete the study protocol.
5. Currently pregnant, pregnant in the last 6 months, breast feeding in the past 3 months or currently lactating.
    a. Pregnancy and lactation could affect metabolic rate, which would confound the primary aim of this study.

3.2 RECRUITMENT AND SCREENING PROCEDURES

Subjects were recruited through flyer postings and online media advertisement (e.g., Craigslist). The University of Pittsburgh's Institutional Review Board (IRB) approved all recruitment methods and materials.

Potential participants were instructed to contact the study by telephone. Potential subjects underwent a brief (<5 minute) pre-screening phone interview conducted by the principle investigator to determine eligibility based on age, height, weight, body mass index, ability to step

in place, and medication that affected metabolism, metabolic rate or heart rate. Verbal consent was obtained at the onset of the interview and a waiver for written consent was included for this pre-screening. To ensure confidentially, those expressing interest were assigned an identification number.

Those individuals that were deemed eligible based on the telephone screen were then invited to attend an orientation session. During this visit at the University of Pittsburgh Physical Activity and Weight Management Research Center, subjects read the informed consent document and had the opportunity to ask questions about all the components of the study. Subjects who remained interested in participating were then asked to read and sign the approved informed consent document. Following receipt of written informed consent, subject eligibility was confirmed with the following methods:

1. Subjects completed a Physical Activity Readiness Questionnaire (PAR-Q)[176] to assess cardiovascular, metabolic, and orthopedic conditions that might place them in the "high risk" stratification for non-physician supervised exercise testing. A response of 'yes' on this questionnaire excluded the individual from participating as a subject.
2. Subjects had their height and weight measured to confirm that they were within the eligible BMI range (18.5 to <40.0 kg/m^2) using the following procedures:
    a. Height was measured using a wall-mounted stadiometer (Perspective Enterprises; Portage MI). The subject was asked to remove their shoes and stand erect on the floor with his/her back parallel to the vertical mounted measure scale, looking straight ahead. The subject was instructed to stand as straight as possible, with feel flat on the floor. The horizontal measuring block was brought down level to sit on the top of the head. Height was

recorded to the nearest 0.1 cm. Duplicate measurements were taken and a third measurement was taken if the two measures differed by ≥ 1.0 cm. If the criterion was not met after a third measure was taken, the average of all three measures was used.

b. Body weight was measured using a Tanita WB-110A digital scale (Tanita Corporation; Arlington Heights, IL). Measurements were made with the subjects wearing street clothing, pockets emptied and heavy clothing and shoes removed when possible. Weight was recorded to the nearest 0.1 kg. Duplicate measurements were taken and a third measurement was taken if the two measures differed by ≥ 1.0 kg. If the criterion was not met after a third measure was taken, the average of all three measures was used.

c. Body Mass Index (BMI) was calculated using the standard Quetelet formula of body weight in kilograms divided by square height in meters (kg/m^2).

Subjects were shown and given the opportunity to familiarize themselves with the face mask they would wear during the experimental sessions. Those unable to tolerate the face mask or unable to stand and step in place were not eligible to participate in the study. These screening procedures were conducted by the principle investigator and took approximately 5-10 minutes.

3.3 EXPERIMENTAL DESIGN

Eligible subjects participated in three experimental sessions, with each session held on a separate day with a minimum of 24 hours between experimental visits. The experimental sessions included sedentary television viewing (SED-TV), stepping during television commercials (COMM-TV), or

stepping during a prompted active television viewing (PATV) session, with the order of these sessions being randomly determined. The details of each of these visits are described below.

Subjects were compensated $60 for completion of all three of the experimental sessions. If a subject voluntarily elected to terminate their participation or failed to follow the approved study protocol, no compensation was provided. However, if the subject was unable to complete all experimental sessions as a result of the investigator determining that further participation was not safe due to a change in medical condition or not possible due to no fault of their own (e.g., equipment failure, etc.), the subject was compensated $20 for each of the experimental procedures that was completed.

3.4 EXPERIMENTAL SESSIONS

Prior to each experimental session the subject was instructed to fast, other than water, for a period of 4 hours, and to abstain from moderate-to-vigorous exercise for a period of 24 hours. Adherence to these guidelines was confirmed by self-report at each of the experimental sessions. Each experimental session was scheduled for 60 minutes to allow for the following: 15 minutes to be fitted with metabolic and heart rate equipment, 5 minutes of seated rest, 30 minutes of television viewing, and 10 minutes to remove equipment at completion of the session. The subject completed the SED-TV, COMM-TV, and PATV sessions across the three experimental visits, with the order of these sessions being randomly selected so that only one of the experimental sessions was performed at each of the experimental visits.

3.4.1 Common Television Show and Episode for the Experimental Sessions

This study used an episode of "The Big Bang Theory" as the common television show used across experimental sessions. "The Big Bang Theory" was chosen because it was the highest rated 30-minute sitcom aired on prime time network television at the time of this study. Moreover, it contained common character phrases and mannerisms within the program that served as antecedents to promote physical activity within the PATV protocol. Specifically, Season 1, Episode 6 entitled, "The Middle Earth Paradigm" of "The Big Bang Theory" was used for the experimental sessions. The rationale for episode selection is found in Section 3.4.2.3 PATV Session. The participant watched the episode in its entirety at each of the experimental visits.

3.4.2 Description of the Three Experimental Sessions

3.4.2.1 SED-TV Session:

The subject arrived at the laboratory where fasting and abstention from moderate-to-vigorous exercise was confirmed. The subject was fitted with the metabolic testing equipment and heart rate monitor (see description below). The subject was required to sit quietly with their feet flat on the floor for a period of 5 minutes. Following this 5 minute rest period, the subject watched the episode of "The Big Bang Theory" in its entirety, including commercials, for a period of 30 minutes of television viewing. During this experimental session the subject was instructed not to talk to or engage with the investigators or study staff. Throughout the 5 minute rest period and 30 minute television viewing period both energy expenditure and heart rate was assessed. At the

completion of the television show the metabolic and heart rate monitoring equipment was removed from the subject.

3.4.2.2 COMM-TV Session:

The subject arrived at the laboratory where fasting and abstention from moderate-to-vigorous exercise was confirmed. The subject was fitted with the metabolic testing equipment and heart rate monitor (see description below). The subject was required to sit quietly with their feet flat on the floor for a period of 5 minutes. Following this 5 minute rest period, the subject watched the episode of "The Big Bang Theory" in its entirety. During this experimental session the subject was instructed not to talk to or engage with the investigators or study staff. During each of the commercial breaks of the program the subject was instructed to stand up and step in place continuously at a self-selected "moderate pace" (e.g. 100-120 steps per minute), with each foot stepping up off the ground about 15-20 cm as demonstrated by the investigator. This study protocol was used by Steeves et al[34]. To ensure the subject was stepping at or below a safe moderate intensity, if the subjects' heart rate exceeded 80% of their age-predicted maximal heart rate during these stepping sessions, the study staff instructed the subject to reduce the cadence of his/her stepping until the heart rate was below this value. The subject returned to a seated position once the commercial break finished. Throughout the 5 minute rest period and 30 minute television viewing period both energy expenditure and heart rate was assessed. At the completion of the television show the metabolic and heart rate monitoring equipment was removed from the subject.

The Season 1, Episode 6 entitled, "The Middle Earth Paradigm" of "The Big Bang Theory" included approximately 21 minutes of the television show and 9 minutes of commercial time, for a total of 30 minutes of television program time.

3.4.2.3 PATV Session:

The subject arrived at the laboratory where fasting and abstention from moderate-to-vigorous exercise was confirmed. The subject was fitted with the metabolic testing equipment and heart rate monitor (see description below). The subject was required to sit quietly with their feet flat on the floor for a period of 5 minutes. Following this 5 minute rest period, the subject watched the episode of "The Big Bang Theory" in its entirety. During this experimental session the subject was instructed not to talk to or engage with the investigators or study staff. During each of the predetermined prompts within the television show, the subject was instructed to stand up and step in place continuously for a period of 1 minute at a self-selected "moderate pace" (e.g. 100-120 steps per minute), with each foot stepping up off the ground about 15-20 cm as demonstrated by the investigator. A timer was available to ensure accurate timing of these 1 minute activity periods. If an activity prompt occurred while the subject was already standing and stepping, they were instructed to add an additional 1 minute of stepping to the end of their current stepping bout for each prompt that occurred. To ensure the subject was stepping at or below a safe moderate intensity, if the subject's heart rate exceeded 80% of their age-predicted maximal heart rate during these stepping sessions, the study staff instructed the subject to reduce the cadence of his/her stepping until the heart rate was below this value. The subject returned to a seated position once the 1 minute prompted stepping bout finished. Throughout the 5 minute rest period and 30 minute television viewing period both energy expenditure and heart rate were assessed. At the completion of the television show the metabolic and heart rate monitoring equipment was removed from the subject.

PATV Session Rationale

In order to determine activity prompts, number of activity prompts and duration of activity prompts during "The Big Bang Theory", the investigator conducted pilot research. A list of the most common story line catch-phrases and mannerisms was determined from watching Season One. Each episode was watched to determine the frequency of each prompt. Nine total activity prompts were recognized to be common throughout the show's first season. The median time prompts appeared during an episode was 9.0 times; the mean time prompts appeared during an episode was 8.7 times. Two episodes from the seventeen-episode season had exactly nine active prompts. Episode 6 "The Middle Earth Paradigm" was chosen as the experimental episode based on this criterion. Table 1 displays the active prompts and the frequency of prompts per episode of Season One. The amount of commercials and the duration of commercial breaks was also recorded. An average of nine minutes was spent in commercial breaks across the episodes. Activity prompts were then set for one minute of stepping to equate to the amount of time that would be spent in commercial breaks.

Table 1. Active Prompts and Frequency per Episode of 'The Big Bang Theory'; Season One

Active Prompt	Episode																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Any Character knocks on a Door		1			1	5				1						1	
Penny Says 'Sweetie'					1			1	2		2	1	1			1	
Raj can't talk to women	2	3		1	2		2	5	2	1			1	4	3	3	
Howard yells "Ma!"											3	1					
Leonard says 'Here we go'	1	1									2						
A character walks upstairs	2	3	1	3	3	1	1		2	3	2			1	1	1	1
Reference to take-out food		1					1			1		1	1	2	1		1
Leonard says "Sheldon"	6	4	3	3	2	3	3	1	4	4	6	3	4	3	5		2
Leonard says " I don't know"	1								1	1							
Total	**12**	**13**	**4**	**7**	**9**	**9**	**7**	**7**	**11**	**11**	**15**	**7**	**10**	**6**	**10**	**6**	**4**

Values reported as n.

3.4.3 Measurement of Energy Expenditure and Heart Rate

3.4.3.1 Energy Expenditure

Energy expenditure was measured during the 5 minute seated rest period and the 30 minute television session for each of the experimental sessions using a CareFusion Encore Metabolic Cart (Vorba Linda, CA). This system was calibrated for air volume and gas concentrations prior to each test according to the manufacturers' specifications. Subjects were fitted with a facemask to allow for the measurement of all inspired and expired air during the data collection period. Minute-by-minute energy expenditure was computed as the product of liters of oxygen consumed and the non-protein caloric equivalent based on the respiratory quotient. These data were used to provide total energy expenditure during the experimental session.

3.4.3.2 Heart Rate

Heart rate was measured at 30 second intervals continuously throughout the experimental session using a Polar heart rate monitor (Port Washington, NY). The subject was fitted with a heart rate monitor placed at the level of the xiphoid process and attached to the subject using an elastic strap according the manufacturer's specifications. Investigators monitored heart rate from the watch display. The subject was not be able to see his/her heart rate.

3.4.3.3 Laugh Frequency

Laugh frequency was recorded by the principle investigator during each experimental sessions. Any auditory or physical event that was perceived to be laughter was tallied. Overall laugh frequency score was calculated as a sum of tallied events of laughter for each experimental session.

3.4.3.4 Enjoyment

Enjoyment was assessed with a revised version of the Physical Activity Enjoyment Scale (PACES)[177] and modified into three versions. After the first visit, participants received mPACES-1st visit, which included 16 statements, scored on a 5-point Likert scale ranging from 1 (disagree a lot) to 5 (agree a lot). After the final experimental session, participants were given mPACES-COMM-TV, which instructed the participant to choose which session, they enjoyed more: the COMM-TV session, SED-TV session or neither (neutral) for 16 statements. The mPACES-PATV was also delivered after the final experimental session, and instructed the participant to choose which session they enjoyed more: the PATV session, SED-TV session or neither (neutral) for 16 statements.

3.5 STATISTICAL ANALYSIS

SPSS version 22.0.0 for Mac (SPSS INC., Chicago, Illinois) was used for statistical analysis. Subject characteristics, including, age, gender, height, body weight and body mass index, were calculated. One-way analysis of variance (ANOVA) tested whether there were differences in subject characteristics based upon gender. To compare the differences in energy expenditure and heart rate across experimental sessions, repeated measures ANOVA were used, non-normally distributed variables were transformed or analyzed using nonparametric tests. If the assumption of sphericity was not met, the Greenhouse-Geisser correction was used. When necessary, post-hoc analysis with the p-value adjusted for multiple comparisons using the Bonferroni adjustment was performed to determine differences between experimental sessions. To determine if gender

had an effect on energy expenditure or heart rate, the 2-factor (gender x condition) repeated measures ANOVA was performed.

An ANOVA was used to determine if there was a difference in laughing frequency between the experimental sessions. Repeated measures ANOVA were used to examine differences in energy expenditure and heart rate across the experimental sessions with mean laughing frequency across the three experimental sessions included as a covariate.

Frequency statistics were used to determine the intensity of stepping behavior by heart rate and MET level. The Shapiro-Wilk test was used to determine non-normal distribution of data and a Wilcoxon Signed Ranks test was performed to compare intensity of the COMM-TV and PATV sessions.

Mean scores for enjoyment of the initial session were calculated and an ANOVA was performed to determine if there was a difference between experimental conditions. Post-hoc analysis with the p-value adjusted for multiple comparisons using the Bonferroni procedure was used to determine differences between experimental sessions. The Wilcoxon Signed Ranks test was performed on the mPACES-final visit to determine deviation from neutral. For all statistical analyses, an alpha level of 0.05 was used to define statistical significance.

3.6 POWER ANALYSIS

The aim of this study was to determine the energy expenditure during sedentary television viewing, commercial stepping during a television program as well as energy expenditure during physical activity prompted by common character phrases/mannerisms within a television program. Previous research examining energy expenditure during commercial stepping during a

television program reported an increase in 61 ± 21 kcal/hour compared to sedentary television viewing[34]. It was projected that the study would also be able to elicit a measurable increase in energy expenditure between the two active viewing trials (COMM-TV and PATV) compared with the sedentary viewing trial, SED-TV. The Steeves et al, study used a longer television program of 60 minutes, where the current study used a shorter duration program of 30 minutes. It was reasonable to anticipate half the difference of the previous study, so the anticipated effect size for this study was an increase in 30 ±10.5 kcal/hour for the two active viewing trials (COMM-TV and PATV) over the sedentary trial, SED-TV. Using a power of 80% and an alpha of 0.05 (with a Bonferroni adjustment for 3 comparisons), 38 subjects were needed to detect a 30kcal/hour difference.

4.0 RESULTS

The purpose of this study was to determine the energy expenditure during sedentary television viewing, commercial stepping during a television program as well as energy expenditure during physical activity prompted by common character phrases/mannerisms within a television program. This was a cross-over study design of three randomly ordered conditions, where each subject acted as their own control. The results of this study are presented below.

4.1 SUBJECT CHARACTERISTICS

Thirty-eight healthy adults (19 males and 19 females) between the ages of 21 to 55 years old participated in this investigation at the Physical Activity and Weight Management Research Center at the University of Pittsburgh. The subjects had a body mass index (BMI) of 25.4 ± 4.2 kg/m^2 with values ranging from 18.7 to 36.0 kg/m^2. Males were taller ($p<0.001$), weighed more ($p<0.001$) and had a higher BMI ($p=0.005$). Subjects' characteristics are shown in Table 2.

Table 2. Subject Characteristics

	Variable	All Subjects (n=38)	Male (n=19)	Female (n=19)	p-value for Gender Differences
Gender	Male	19 (50%)			
	Female	19 (50%)			
Age (years)		27.0 ± 8.0	27.0 ± 8.0	29.0 ± 7.0	0.527
Height (m)		1.7 ± 0.1	1.8 ± 0.1	1.6 ± 0.1	0.000
Body Weight (kg)		74.2 ± 16.3	84.3 ± 15.6	64.1 ± 9.2	0.000
BMI (kg/m^2)		25.4 ± 4.2	27.3 ± 4.3	23.6 ± 3.2	0.005

Values are n (%) or mean ± SD. Abbreviations: BMI=body mass index

Figure 1 illustrates subject recruitment, randomization and retention. One hundred and seventeen participants initially underwent a telephone screening and 64 (54.7%) participants consented to be screened after receiving information about the study. Of those screened, 53 (82.8%) were eligible to participate and 11 (17.1%) were not. Reasons for ineligibility are shown in Figure 1. Thirty-eight participants attended an orientation session and consented to be a part of the study. Following the completion of baseline assessments, 38 subjects were randomized into one of six experimental protocols based on the order that they completed the experimental conditions. The experimental protocols are as follows: 1) SED-TV, COMM-TV, PATV; 2) SED-TV, PATV, COMM-TV; 3) COMM-TV, SED-TV, PATV; 4) COMM-TV, PATV, SED-TV; 5) PATV, SED-TV, COMM-TV; 6) PATV, COMM-TV, SED-TV. All randomized subjects completed the three experimental sessions.

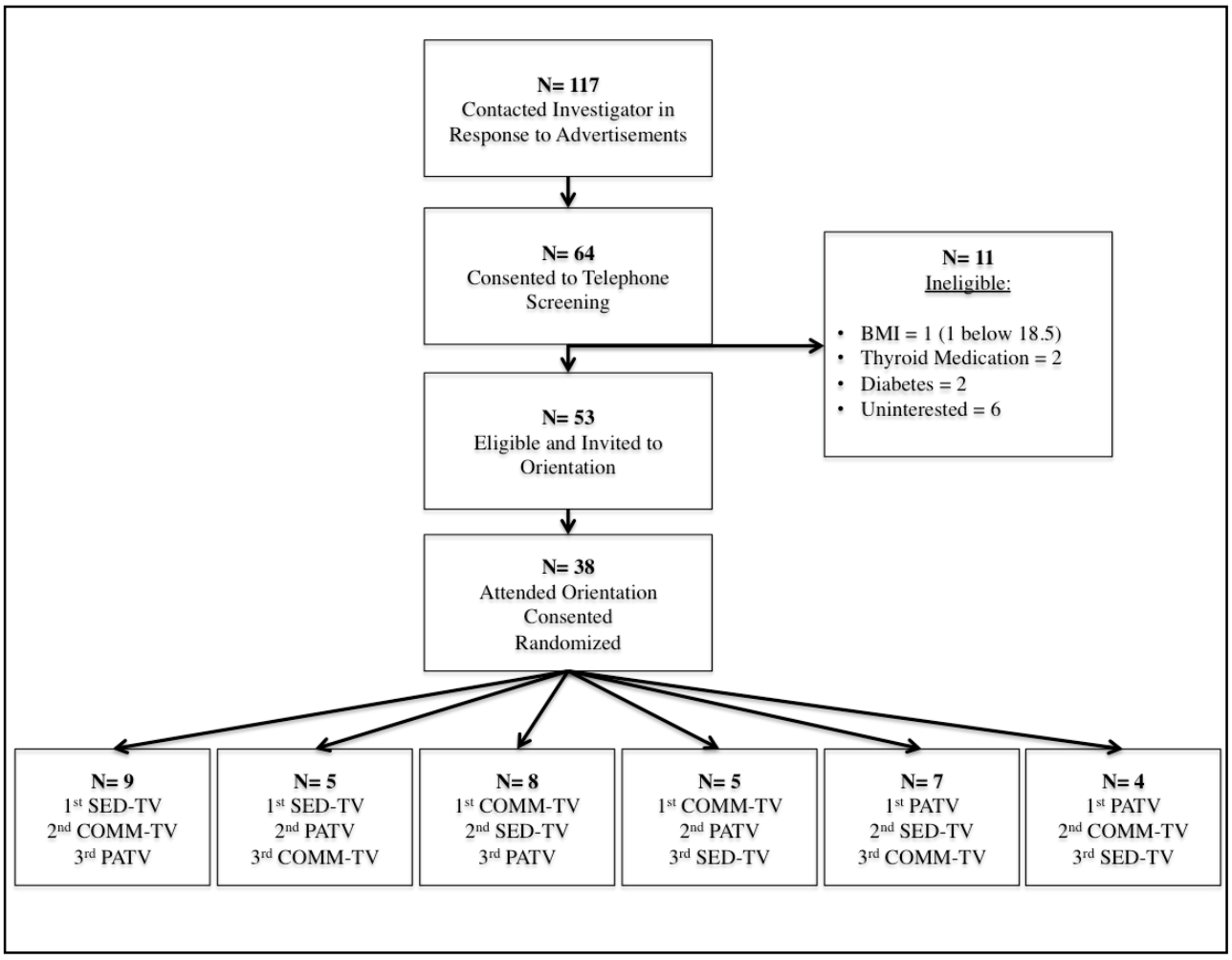

Figure 1. Study Recruitment, Randomization and Retention

4.2 ENERGY EXPENDITURE

4.2.1 Energy Expenditure, By Condition; and the Influence of Body Weight and Laugh Frequency

A one-way repeated measures analysis of variance (ANOVA) was performed on energy expenditure across experimental sessions. Based on the Mauchly's test, the assumption of sphericity was met. Results of the analysis are reported in Table 3. SED-TV elicited a caloric

expenditure of 37.3 ± 9.9 kcal, COMM-TV elicited a caloric expenditure of 69.9 ± 16.4 kcal and PATV elicited a caloric expenditure of 71.6 ± 17.9 kcal. A significant difference in energy expenditure across the experimental sessions was reported (p=0.000). Post-hoc analyses with Bonferroni adjustment showed that there was significantly higher energy expenditure in COMM-TV compared to SED-TV (difference = 32.7 ± 1.9 kcal) (p=0.000), and significantly higher energy expenditure in PATV compared to SED-TV (difference = 34.4 ± 1.9 kcal) (p=0.000). No difference was found in energy expenditure between COMM-TV and PATV (difference = 1.7 ± 1.5 kcal) (p = 0.827). Figure 2 also displays the mean energy expenditure per minute by experimental session.

Energy expenditure was adjusted for body weight. There was a significant difference in energy expenditure per kilogram of body weight across the experimental sessions (p=0.000). SED-TV elicited energy expenditure per kilogram of body weight of 0.50 ± 0.07 kcal/kg, COMM-TV yielded energy expenditure of 0.96 ± 0.18 kcal/kg, and PATV yielded energy expenditure of 0.97 ± 0.17 kcal/kg. Post-hoc analyses with Bonferroni adjustment showed that there was significantly higher energy expenditure per kilogram of body weight in COMM-TV compared to SED-TV (difference = 0.45 ± 0.03 kcal/kg) (p=0.000), and significantly higher energy expenditure per kilogram of body weight in PATV compared to SED-TV (difference = 0.47 ± 0.03 kcal/kg) (p=0.000). No difference was found in energy expenditure per kilogram of body weight between COMM-TV and PATV (difference = 0.02 ± 0.02 kcal/kg) (p = 1.000).

Table 3. Analysis of Energy Expenditure by Experimental Session

	Experimental Session			
	SED-TV	COMM-TV	PATV	p-value
Energy Expenditure (kcal)	37.3 ± 9.9	69.9 ± 16.4	71.6 ± 17.9	0.000
Difference with SED-TV	--	-32.7 ± 1.9 (p= 0.000)	-34.4 ± 1.9 (p= 0.000)	
Difference with COMM-TV	32.7 ± 1.9 (p= 0.000)	--	-1.7 ± 1.5 (p= 0.827)	
Difference with PATV	34.4 ± 1.9 (p= 0.000)	1.7 ± 1.5 (p= 0.827)	--	
Energy Expenditure per kg by Body Weight (kcal/kg)	0.50 ± 0.07	0.96 ± 0.18	0.97 ± 0.17	0.000
Difference with SED-TV	--	-0.45 ± 0.03 (p= 0.000)	-0.47 ± 0.03 (p= 0.000)	
Difference with COMM-TV	0.45 ± 0.03 (p= 0.000)	--	-0.02 ± 0.02 (p= 1.000)	
Difference with PATV	0.47 ± 0.03 (p= 0.000)	0.02 ± 0.02 (p= 1.000)	--	
Energy Expenditure adjusted by Laughing frequency (kcal)	37.2 ± 9.9	71.5 ± 17.2	72.9 ± 18.2	0.000
Difference with SED-TV	--	-34.3 ± 2.3 (p= 0.000)	-35.7 ± 2.5 (p= 0.000)	
Difference with COMM-TV	34.3 ± 2.3 (p= 0.000)	--	-1.3 ± 1.8 (p= 0.460)	
Difference with PATV	35.7 ± 2.5 (p= 0.000)	1.3 ± 1.8 (p= 0.460)	--	
Values are presented as mean ± SD. SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session.				

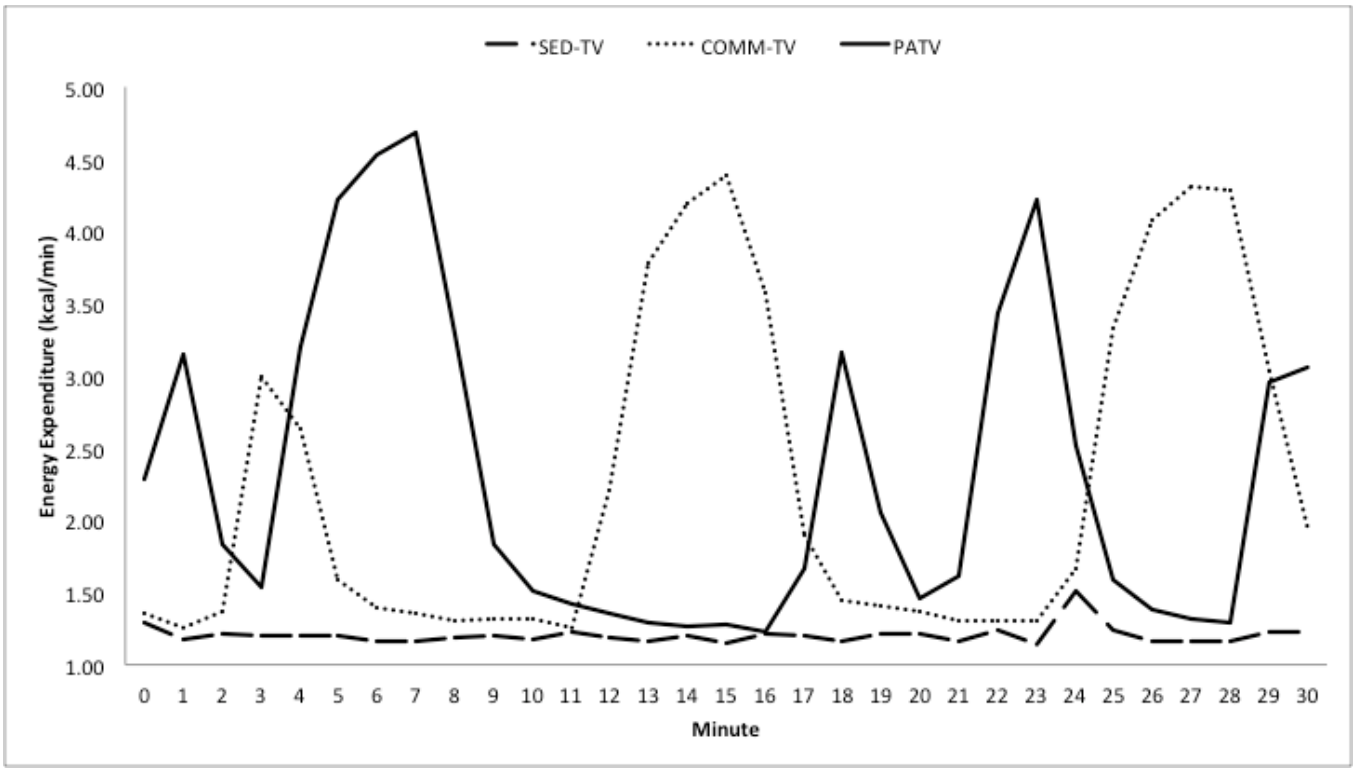

Figure 2. Energy Expenditure by Minute of Experimental Sessions

Laughing during the television show may have an influence on expired gas volumes and concentrations, which might influence the measure of energy expenditure. A one way repeated measures ANOVA determined there was no difference in laugh frequency between the three experimental sessions (p=0.460). The mean laughing score was computed and a one way repeated measures ANOVA was performed for energy expenditure using mean laughing score as a covariate. Results of the analysis are reported in Table 3. The pattern of the results was similar to the results observed when the data were not adjusted for laughing frequency.

4.2.2 Gender Effects on Energy Expenditure

An exploratory analysis of energy expenditure was conducted stratified by gender (Table 4), which showed a significant Measure X Gender interaction (p= 0.016). Males expended 14.8 ± 3.0

calories more than females (males: 44.7 ± 7.9 kcal, females: 29.9 ± 4.9 kcal) during SED-TV, 21.9 ± 5.1 calories more than females (males: 80.9 ± 14.5 kcal, females: 59.0 ± 9.4 kcal) during COMM-TV, and 24.7 ± 8.6 calories more than females (males: 84.0 ± 16.6 kcal, female: 59.3 ± 8.0 kcal) during PATV.

Analysis performed separately for males showed a significant difference in energy expenditure across the experimental sessions (p=0.000). Post-hoc analysis with Bonferroni adjustment was performed and showed a significantly higher energy expenditure in COMM-TV compared to SED-TV (difference = 36.3 ± 2.9 kcal) (p=0.000) and a significantly higher energy expenditure in PATV compared to SED-TV (difference = 39.3 ± 3.2 kcal) (p=0.000). There was no difference in energy expenditure between COMM-TV and PATV (difference = 3.0 ± 2.7 kcal) (p = 0.845). A similar pattern of findings was observed when energy expenditure was adjusted for frequency of laughing and when expressed as kcal/kg of body weight (see Table 5).

Analysis performed separately for females showed a significant difference in energy expenditure across the experimental session (p=0.000). Post-hoc analysis with Bonferroni adjustment was performed and showed a significantly higher energy expenditure in COMM-TV compared to SED-TV (difference = 29.1 ± 2.1 kcal) (p=0.000) and significantly higher energy expenditure in PATV compared to SED-TV (difference = 29.4 ± 1.6 kcal) (p=0.000). There was no significant difference in energy expenditure between COMM-TV and PATV (difference = 0.3 ± 1.5 kcal) (p = 1.000). A similar pattern of findings was observed when energy expenditure was adjusted for frequency of laughing and when expressed as kcal/kg of body weight (see Table 6).

Table 4. Analysis of the Effect of Gender on Energy Expenditure by Experimental Session

Variable		Experimental Session			p-values		
		SED-TV	COMM-TV	PATV	Measure	Gender	Measure x Gender
Total kcal	Male	44.7 ± 7.9	80.9 ± 14.5	84.0 ± 16.6	0.000	0.007	0.016
	Female	29.9 ± 4.9	59.0 ± 9.4	59.3 ± 8.0			
Total kcal adjusted for laughing frequency	Male	44.3 ± 8.0	82.5 ± 15.9	84.7 ± 17.8	0.000	0.060	0.102
	Female	30.1 ± 5.6	60.6 ± 10.2	61.1 ± 8.4			
kcal/kg	Male	0.53 ± 0.06	0.98 ± 0.19	1.01 ± 0.20	0.000	0.056	0.776
	Female	0.47 ± 0.07	0.93 ± 0.18	0.93 ± 0.12			

Values are presented as mean ± SD, $p < 0.05$. Abbreviations: SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session.

Table 5. Analysis of Energy Expenditure by Experimental Session for Males

	Experimental Session			
	SED-TV	COMM-TV	PATV	p-value
Energy Expenditure (kcal)	44.7 ± 7.9	80.9 ± 14.5	84.0 ± 16.6	0.000
Difference with SED-TV	--	-36.3 ± 2.9 (p= 0.000)	-39.3 ± 3.2 (p= 0.000)	
Difference with COMM-TV	36.3 ± 2.9 (p= 0.000)	--	-3.0 ± 2.7 (p= 0.845)	
Difference with PATV	39.3 ± 3.2 (p= 0.000)	3.0 ± 2.7 (p= 0.845)	--	
Energy Expenditure per kg by Body Weight (kcal/kg)	0.53 ± 0.06	0.98 ± 0.19	1.01 ± 0.20	0.000
Difference with SED-TV	--	-0.44 ± 0.04 (p= 0.000)	-0.48 ± 0.04 (p= 0.000)	
Difference with COMM-TV	0.44 ± 0.04 (p= 0.000)	--	-0.04 ± 0.03 (p= 0.904)	
Difference with PATV	0.48 ± 0.04 (p= 0.000)	0.04 ± 0.03 (p= 0.904)	--	
Energy Expenditure adjusted by Laughing frequency (kcal)	44.3 ± 8.0	82.5 ± 15.9	84.7 ± 17.8	0.000
Difference with SED-TV	--	-38.2 ± 3.4 (p= 0.000)	-40.3 ± 4.4 (p= 0.000)	
Difference with COMM-TV	38.2 ± 2.2 (p= 0.000)	--	-2.2 ± 3.2 (p= 1.000)	
Difference with PATV	40.3 ± 4.4 (p= 0.000)	2.2 ± 3.2 (p= 1.000)	--	

Values are presented as mean ± SD. SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session.

Table 6. Analysis of Energy Expenditure by Experimental Session for Females

	Experimental Session			
	SED-TV	COMM-TV	PATV	p-value
Energy Expenditure (kcal)	29.9 ± 4.9	59.0 ± 9.4	59.3 ± 8.0	0.000
Difference with SED-TV	--	-29.1 ± 2.1 (p= 0.000)	-29.4 ± 1.6 (p= 0.000)	
Difference with COMM-TV	29.1 ± 2.1 (p= 0.000)	--	-0.3 ± 1.5 (p= 1.000)	
Difference with PATV	29.4 ± 1.6 (p= 0.000)	0.3 ± 1.5 (p= 1.000)	--	
Energy Expenditure per kg by Body Weight (kcal/kg)	0.47 ± 0.07	0.93 ± 0.18	0.93 ± 0.12	0.000
Difference with SED-TV	--	-0.46 ± 0.04 (p= 0.000)	-0.46 ± 0.03 (p= 0.000)	
Difference with COMM-TV	0.46 ± 0.04 (p= 0.000)	--	-0.00 ± 0.02 (p= 1.000)	
Difference with PATV	0.46 ± 0.03 (p= 0.000)	0.00 ± 0.02 (p= 1.000)	--	
Energy Expenditure adjusted by Laughing frequency (kcal)	30.1 ± 5.6	60.6 ± 10.2	61.1 ± 8.4	0.000
Difference with SED-TV	--	-30.5 ± 1.4 (p= 0.000)	-30.9 ± 1.8 (p= 0.000)	
Difference with COMM-TV	30.5 ± 1.4 (p= 0.000)	--	-0.5 ± 0.9 (p= 1.000)	
Difference with PATV	30.9 ± 1.8 (p= 0.000)	0.5 ± 0.9 (p= 1.000)	--	

Values are presented as mean ± SD. SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session.

4.3 HEART RATE

4.3.1 Heart Rate

A one-way repeated measures analysis of variance (ANOVA) was performed on average heart rate across experimental sessions. Based on the Mauchly's test the assumption of sphericity was met. Results of the analysis are reported in Table 7 and Figure 3 displays the mean average heart rate per minute by experimental session. SED-TV elicited an average heart rate of 70.5 ± 12.0 bpm, COMM-TV elicited an average heart rate of 80.4 ± 10.8 bpm and PATV elicited an average heart rate of 83.6 ± 11.4 bpm. There was a significant difference in average heart rate across the experimental sessions (p=0.000). Post-hoc analysis with Bonferroni adjustments showed a significantly higher average heart rate in COMM-TV compared to SED-TV (difference = 9.9 ± 1.7 bpm) (p=0.000) and a significantly higher average heart rate in PATV compared to SED-TV (difference = 13.1 ± 1.6 bpm) (p=0.000). There was no significant difference in average heart rate between COMM-TV and PATV (difference = 3.2 ± 1.8 bpm) (p = 0.250). A similar pattern of results was observed for heart rate when adjusted for laughing frequency during each of the experimental sessions.

Table 7. Analysis of Average Heart Rate by Experimental Session

	Experimental Session			
	SED-TV	COMM-TV	PATV	p-value
Heart Rate (bpm)	70.5 ± 12.0	80.4 ± 10.8	83.6 ± 11.4	0.000
Difference with SED-TV	--	-9.9 ± 1.7 (p=0.000)	-13.1 ± 1.6 (p=0.000)	
Difference with COMM-TV	9.9 ± 1.7 (p=0.000)	--	-3.2 ± 1.8 (p=0.250)	
Difference with PATV	13.1 ± 1.6 (0.000)	3.2 ± 1.8 (p=0.250)	--	
Heart Rate adjusted by Laughing frequency (bpm)	70.5 ± 11.5	82.2 ± 9.9	84.6 ± 11.2	0.000
Difference with SED-TV	--	-11.6 ± 2.0 (p= 0.000)	-14.1 ± 1.8 (p= 0.000)	
Difference with COMM-TV	11.6 ± 2.0 (p= 0.000)	--	-2.5 ± 2.0 (p= 0.723)	
Difference with PATV	14.1 ± 1.8 (p= 0.000)	2.5 ± 2.0 (p= 0.723)	--	

Values are presented as mean ± SD (for Heart Rate) and mean ± SE (for Heart Rate adjusted by Laughing Frequency). SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session, bpm= beats per minute.

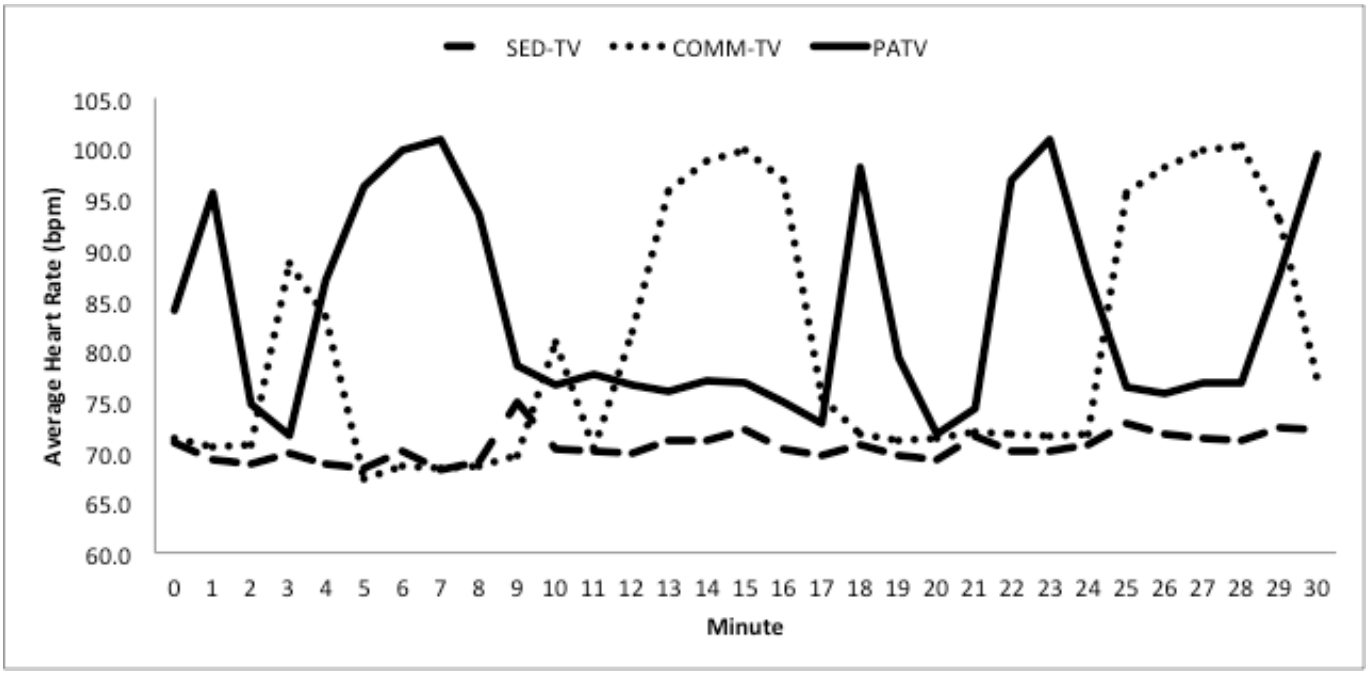

Figure 3. Mean Average Heart Rate by Minute of Experimental Sessions

4.3.2 Gender Effects on Average Heart Rate

An exploratory analysis of average heart rate was conducted stratified by gender (Table 8), which showed that there was no significant difference in average heart rate by gender (p=0.888). Males had a lower average heart rate than females during SED-TV (males: 69.8 ± 11.8 bpm, females: 71.2 ± 12.5 bpm), COMM-TV (males: 79.3 ± 11.3 bpm, females: 81.5 ± 10.6 bpm), and PATV (males: 83.1 ± 12.1 bpm, females: 84.0 ± 10.9 bpm). A similar pattern of results was observed for heart rate when stratified by gender and adjusted for laughing frequency during each of the experimental sessions.

Table 8. Analysis of the Effect of Gender on Average Heart Rate by Experimental Session

Variable		Experimental Session			p-values		
		SED-TV	COMM-TV	PATV	Measure	Gender	Measure x Gender
Total bpm	Male	69.8 ± 11.8	79.3 ± 11.3	83.1 ± 12.1	0.000	0.92	0.888
	Female	71.2 ± 12.5	81.5 ± 10.6	84.0 ± 10.9			
Total bpm adjusted for laughing frequency	Male	68.7 ± 10.2	82.2 ± 8.7	82.7 ± 11.3	0.000	0.339	0.651
	Female	72.3 ± 12.8	82.2 ± 11.4	86.5 ± 11.2			

Values are presented as mean ± SD, Abbreviations: SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session, bpm= beats per minute.

4.4 INTENSITY OF STEPPING

4.4.1 Metabolic Equivalent

Frequency statistics were used to characterize the number of minutes spent at ≥3.0 METS during the 30-minute television show per session. SED-TV resulted in zero minutes engaged at an intensity ≥ 3.0 METS. COMM-TV resulted in a 4.6 ± 3.6 minutes (range: 0-11 minutes) [Median: 4.0 (Inter-Quartile Range: 0.8, 7.3)] at an intensity ≥ 3.0 METS. PATV resulted in a 4.3 ± 3.4 minutes (range: 0-12 minutes) [Median: 4.0 (Inter-Quartile Range: 2.0, 6.3)] at an intensity of ≥3.0 METS. Based on the Shapiro-Wilk test the data were not normally distributed. Using a Wilcoxon Signed Ranks test, there was significant difference in the frequency of minutes spent at ≥3.0 METS in SED-TV compared to COMM-TV (p=0.000) and SED-TV compared to PATV (p=0.000). No significant difference was found between COMM-TV and PATV (p=0.569) (Figure 4) (Figure 5).

4.4.2 Heart Rate

Frequency statistics were used to determine how many minutes were spent ≥ 50% of a person's age-predicted maximal heart rate. SED-TV resulted in 1.1 ± 4.9 minutes (range: 0-28 minutes) [Median: 0.0 (Inter-Quartile Range: 0.0, 0.0)] engaged at an intensity ≥ 50% of age-predicted maximal heart rate. COMM-TV resulted in a 5.7 ± 4.8 minutes (range: 0-15 minutes) [Median: 6.0 (Inter-Quartile Range: 0.0, 10.0)] at an intensity ≥ 50% of age-predicted maximal heart rate. PATV resulted in a 7.2 ± 8.5 minutes (range: 0-30 minutes) [Median: 7.0 (Inter-Quartile Range:

0.0, 11.0)] at an intensity $\geq$ 50% of age-predicted maximal heart rate. Based on the Shapiro-Wilk test the data were not normally distributed. Using a Wilcoxon Signed Ranks test, there was a significant difference in the frequency of minutes spent at or above 50% of age-predicted maximal heart rate in SED-TV compared to COMM-TV (p=0.000) and SED-TV compared to PATV (p=0.000). No significant difference was found between COMM-TV and PATV (p=0.423) (Figure 4) (Figure 5).

Frequency statistics were used to determine how many minutes were spent $\geq$ 70% of age-predicted maximal heart rate. SED-TV resulted in 0.0 ± 0.16 minutes (range: 0-1 minutes) [Median: 0.0 (Inter-Quartile Range: 0.0, 0.0)] engaged in an intensity $\geq$ 70% of age-predicted maximal heart rate. COMM-TV resulted in a 0.2 ± 0.8 minutes (range: 0-5 minutes) [Median: 0.0 (Inter-Quartile Range: 0.0, 0.0)] at an intensity $\geq$ 70% of age-predicted maximal heart rate. PATV resulted in zero minutes at an intensity $\geq$ 70% of age-predicted maximal heart rate. Based on the Shapiro-Wilk test the data were not normally distributed. Using a Wilcoxon Signed Ranks test there was no significant difference in the frequency of minutes spent at or above 70% of age-predicted maximal heart rate in SED-TV compared to COMM-TV (p=0.257), SED-TV compared to PATV (p=0.317), or COMM-TV compared to PATV (p=0.102) (Figure 4) (Figure 5).

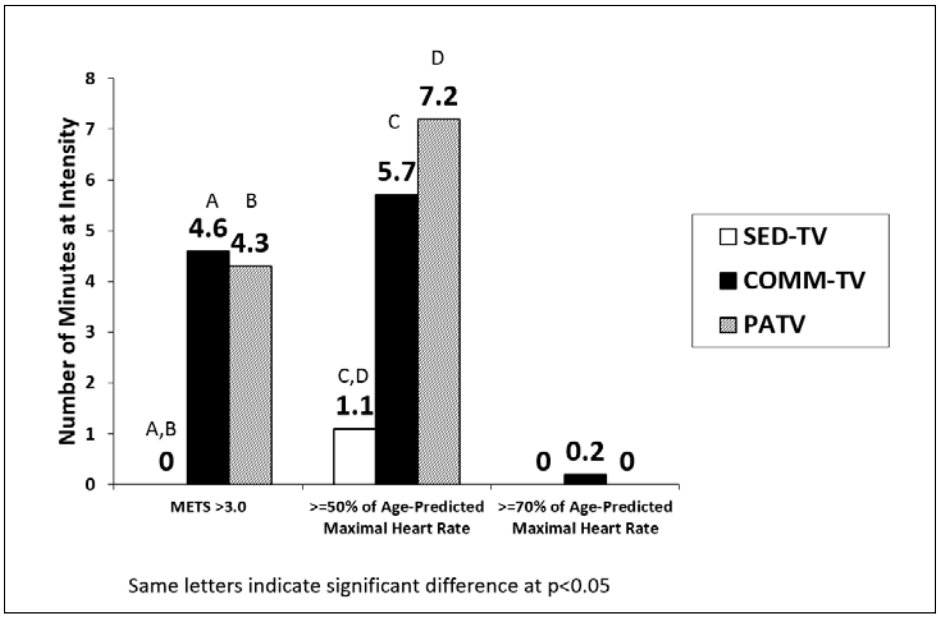

Figure 4. Mean Minutes Engaged At Stepping Intensity

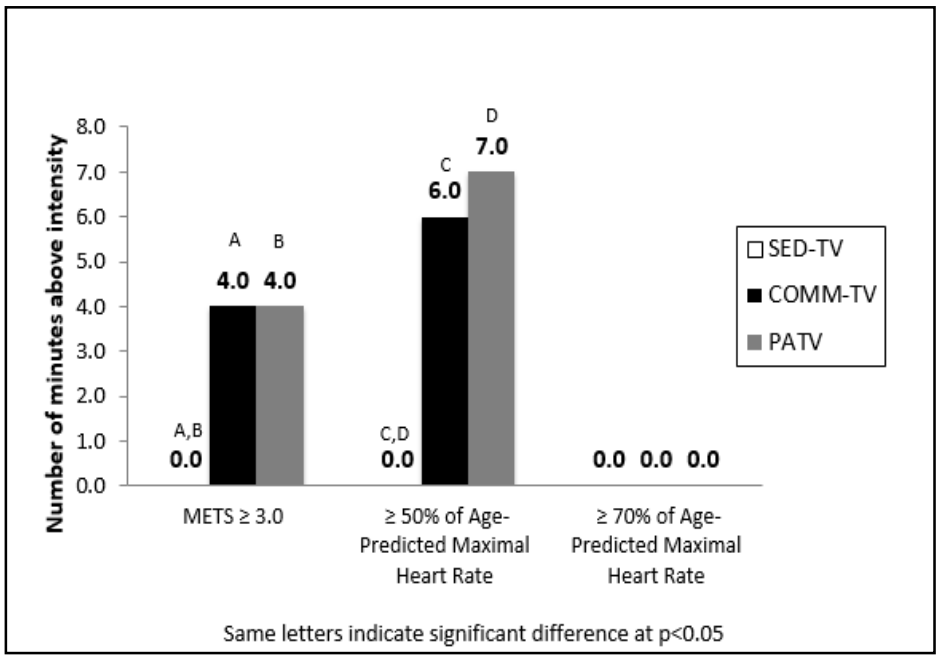

Figure 5. Median Minutes Engaged at Stepping Intensity

4.5 ENJOYMENT

4.5.1 Enjoyment of Initial Experimental Session

Enjoyment of the initial experimental session was assessed using a modified version of the Physical Activity Enjoyment Scale. Scores for the scale range from 16 – 80 with a score of 16 indicating the least amount of enjoyment, and a score of 80 indicating the maximal amount of enjoyment. Data based on the initial experimental session are presented in Table 9. Initial enjoyment scores were 53.9 ± 11.9 (range: 34-71) for SED-TV, 62.9 ± 7.5 (range: 48-75) for COMM-TV, and 61.4 ± 7.1 (range: 47-74) for PATV, with one-way ANOVA showing significant differences across conditions (p=0.035). Post-hoc analysis with Bonferroni adjustments showed a significantly higher initial enjoyment in COMM-TV compared to SED-TV (difference = 9.1 ± 3.6) (p=0.048). No difference was found in initial enjoyment in PATV compared to SED-TV (difference = 7.6 ± 3.7) (p=0.150) and initial enjoyment in COMM-TV and PATV (difference = 1.5 ± 3.8) (p = 1.000).

Table 9. Enjoyment of Initial Experimental Session

	Experimental Session			
	SED-TV	COMM-TV	PATV	p-value
Enjoyment of Initial Session	53.9 ± 11.9	62.9 ± 7.5	61.4 ± 7.1	0.035
Difference with SED-TV	--	-9.1 ± 3.6 (p=0.048)	-7.6 ± 3.7 (p=0.150)	
Difference with COMM-TV	9.1 ± 3.6 (p=0.048)	--	1.5 ± 3.8 (p=1.000)	
Difference with PATV	7.6 ± 3.7 (p=0.150)	-1.5 ± 3.8 (p=1.000)	--	

Mean score presented as mean ± SD. mPACES scales ranges from 16 indicating least enjoyment to 80 indicating most enjoyment. SED-TV= Sedentary television viewing session, COMM-TV= Commercial stepping television session, PATV= Prompted active television stepping session, mPACES= modified physical activity enjoyment scale.

4.5.2 Enjoyment of Sedentary and Active Sessions

Upon completion of the final experimental session, subjects completed two mPACES questionnaires (mPACES-COMM-TV, mPACES-PATV) comparing either active session to the sedentary television viewing session. Figure 6 shows the comparison of scores for SED-TV versus COMM-TV, with scores of -1 representing SED-TV, 0 representing neutral and scores of +1 representing COMM-TV. Figure 7 shows the comparison of scores for SED-TV versus PATV, with scores of -1 representing SED-TV, 0 representing neutral and scores of +1 representing PATV. A Wilcoxon Signed Ranks test was performed to compare scores per question on mPACES-COMM-TV to neutral (score = 0), and scores per question on mPACES-PATV to neutral (score = 0). All questions were determined to be statistically significant from neutral

(score = 0) for both mPACES-COMM-TV and mPACES-PATV. In both cases, enjoyment scores favored performing activity during television viewing (COMM-TV, PATV) compared to SED-TV.

The final mPACES questionnaires were analyzed stratified by gender. Figure 8 shows the comparison of scores for SED-TV versus COMM-TV for males, Figure 9 shows the comparison of scores for SED-TV versus PATV for males. The comparison of scores for SED-TV versus COMM-TV for females is shown in Figure 10, and the comparison of scores for SED-TV versus PATV for females in shown in Figure 11. For each gender, a Wilcoxon Signed Ranks test was performed to compare scores per question on mPACES-COMM-TV to neutral (score = 0), and scores per question on mPACES-PATV to neutral (score = 0). All questions were determined to be statistically significant from neutral (score = 0) for both mPACES-COMM-TV and mPACES-PATV for both genders. In all cases, enjoyment scores favored performing activity during television viewing (COMM-TV, PATV) compared to SED-TV.

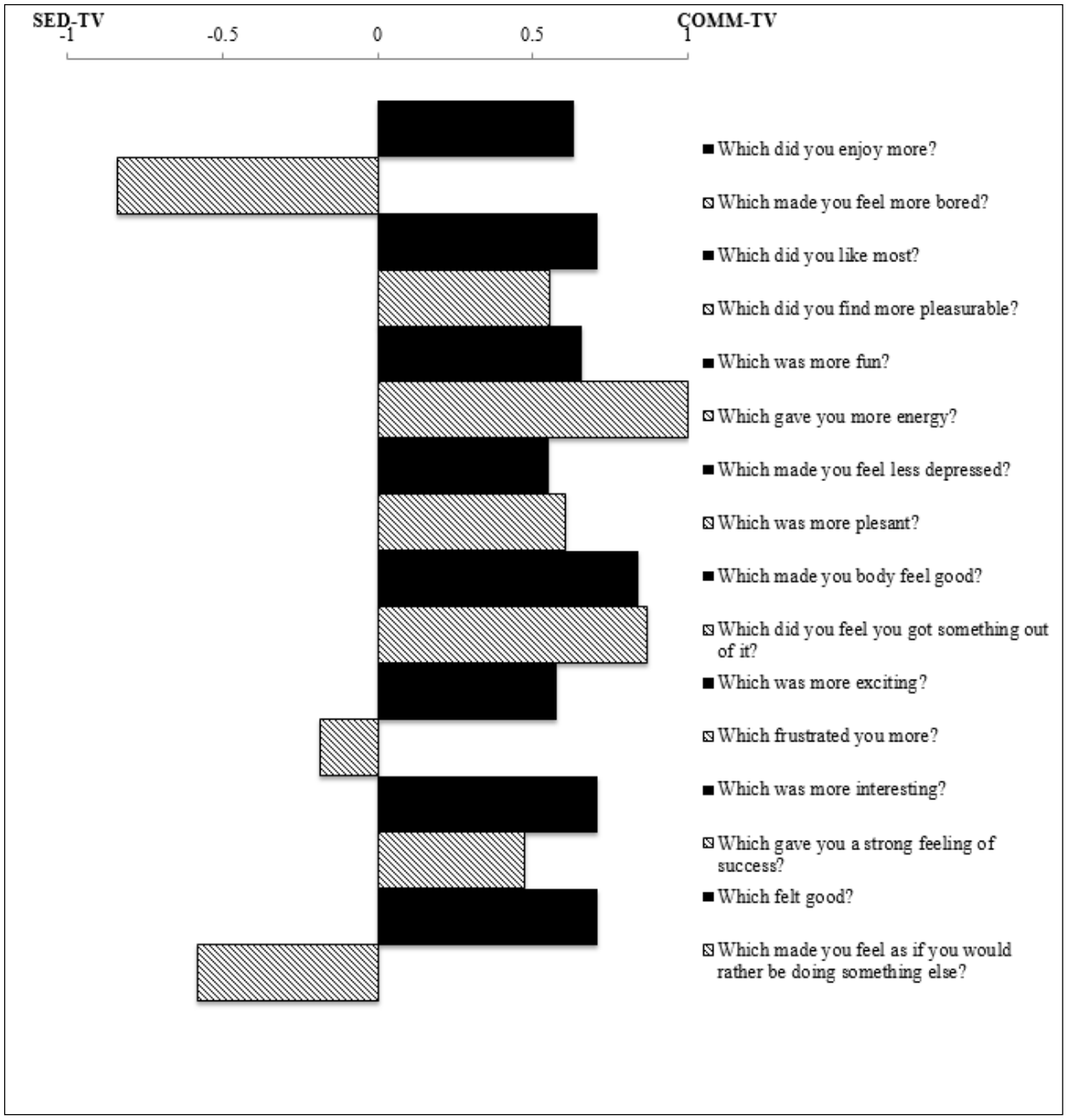

Figure 6. Enjoyment of SED-TV versus COMM-TV

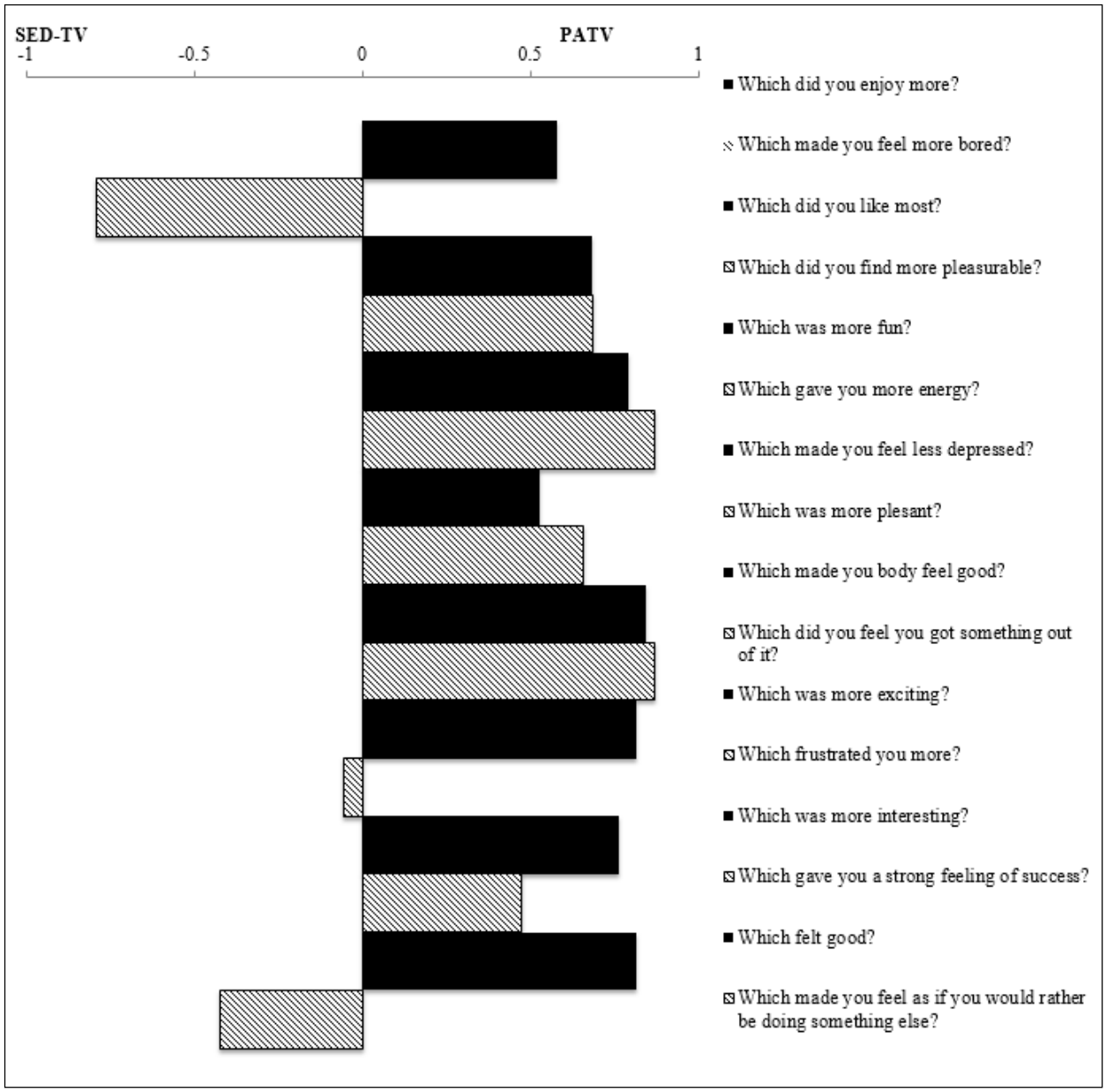

Figure 7 . Enjoyment of SED-TV versus PATV

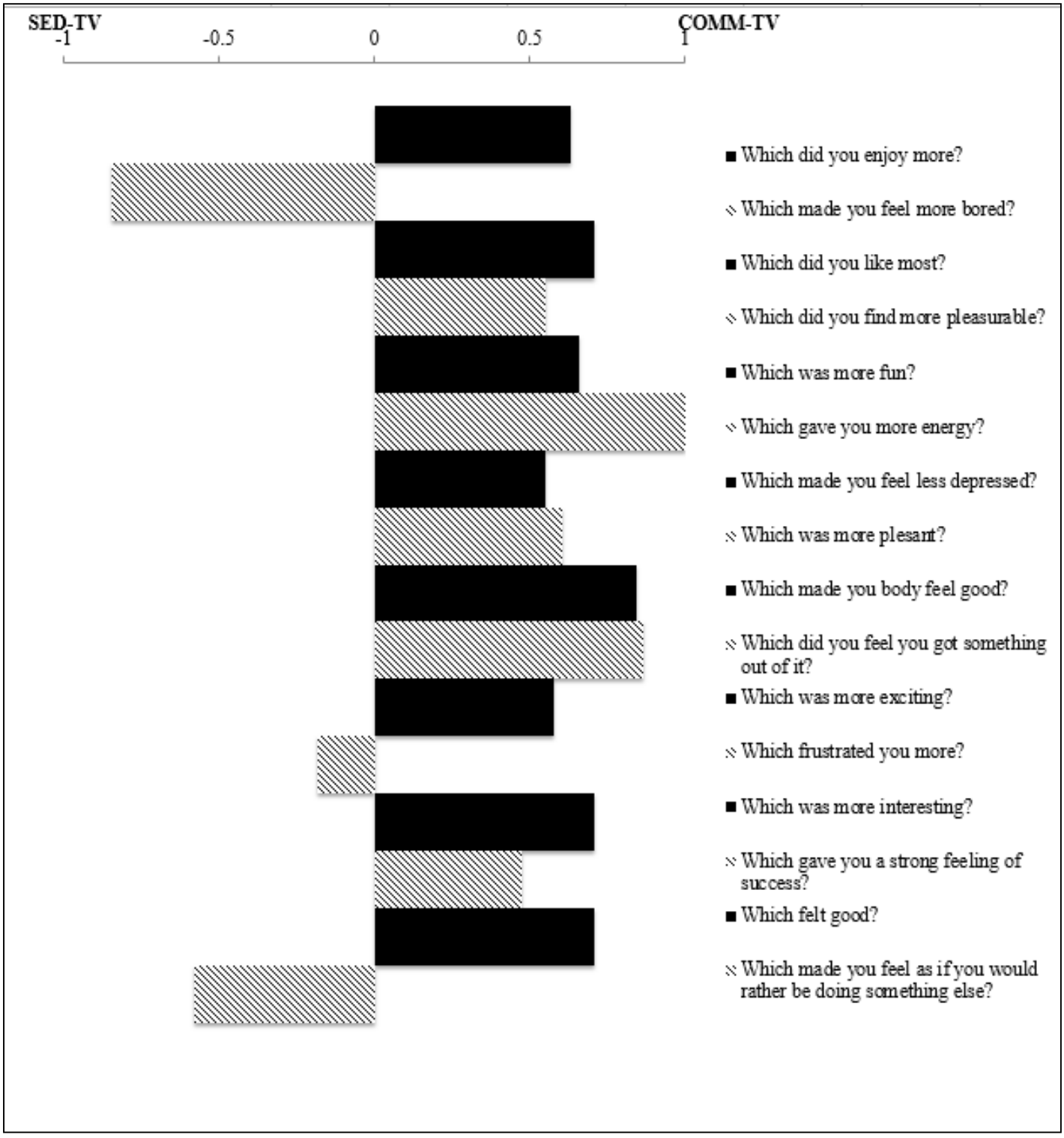

Figure 8. Enjoyment of SED-TV versus COMM-TV for Males

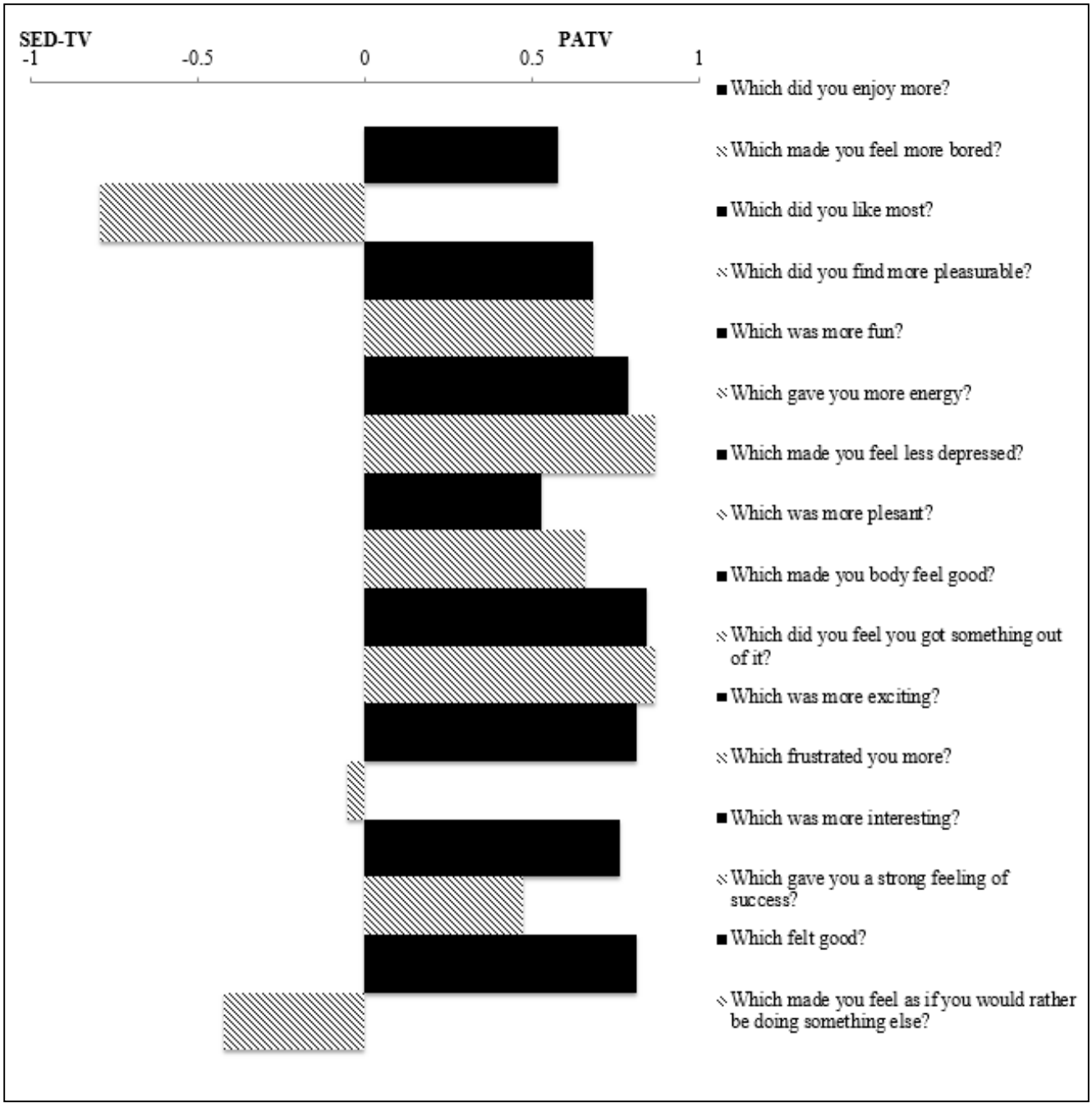

Figure 9. Enjoyment of SED-TV versus PATV for Males

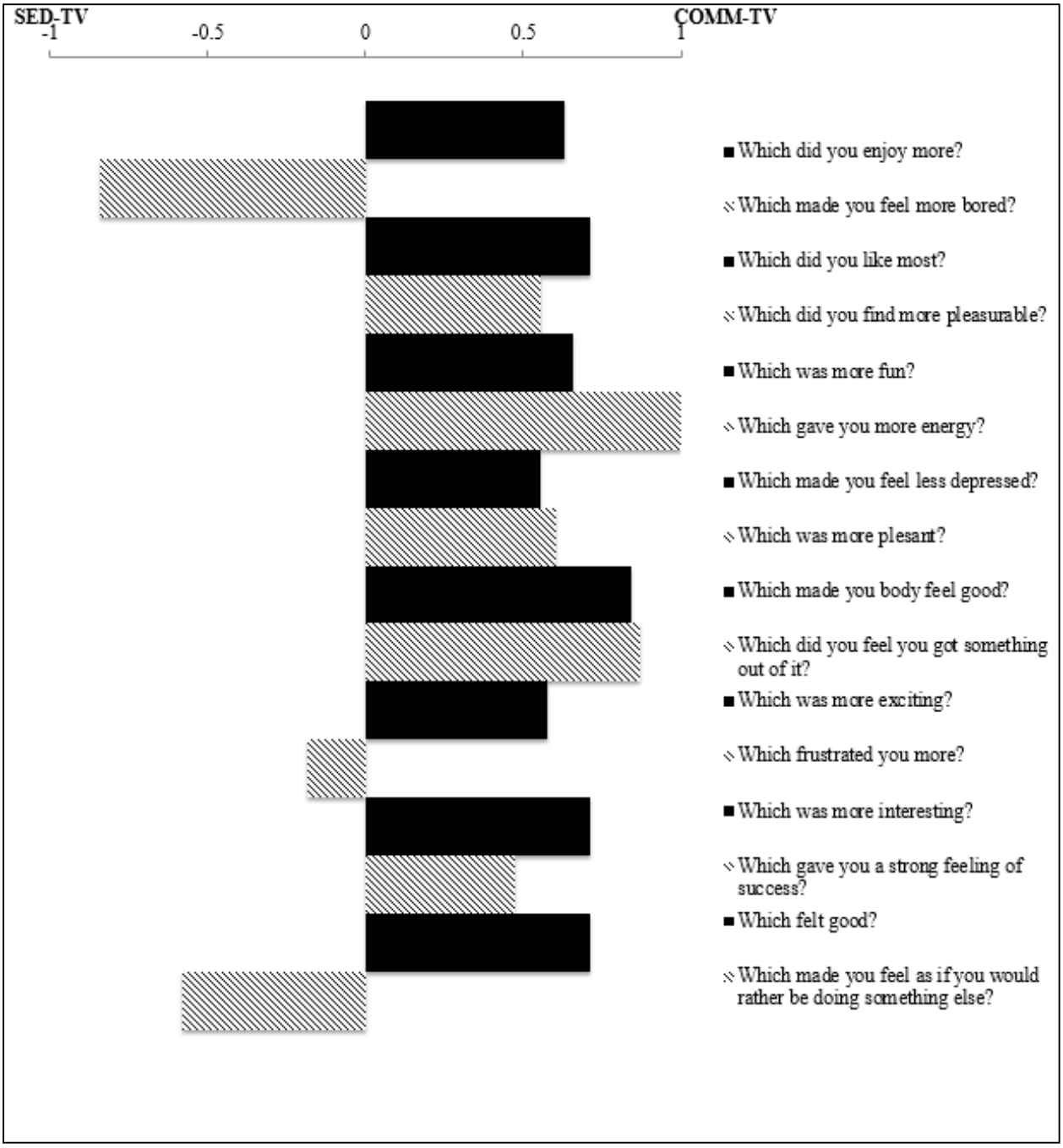

Figure 10. Enjoyment of SED-TV versus COMM-TV for Females

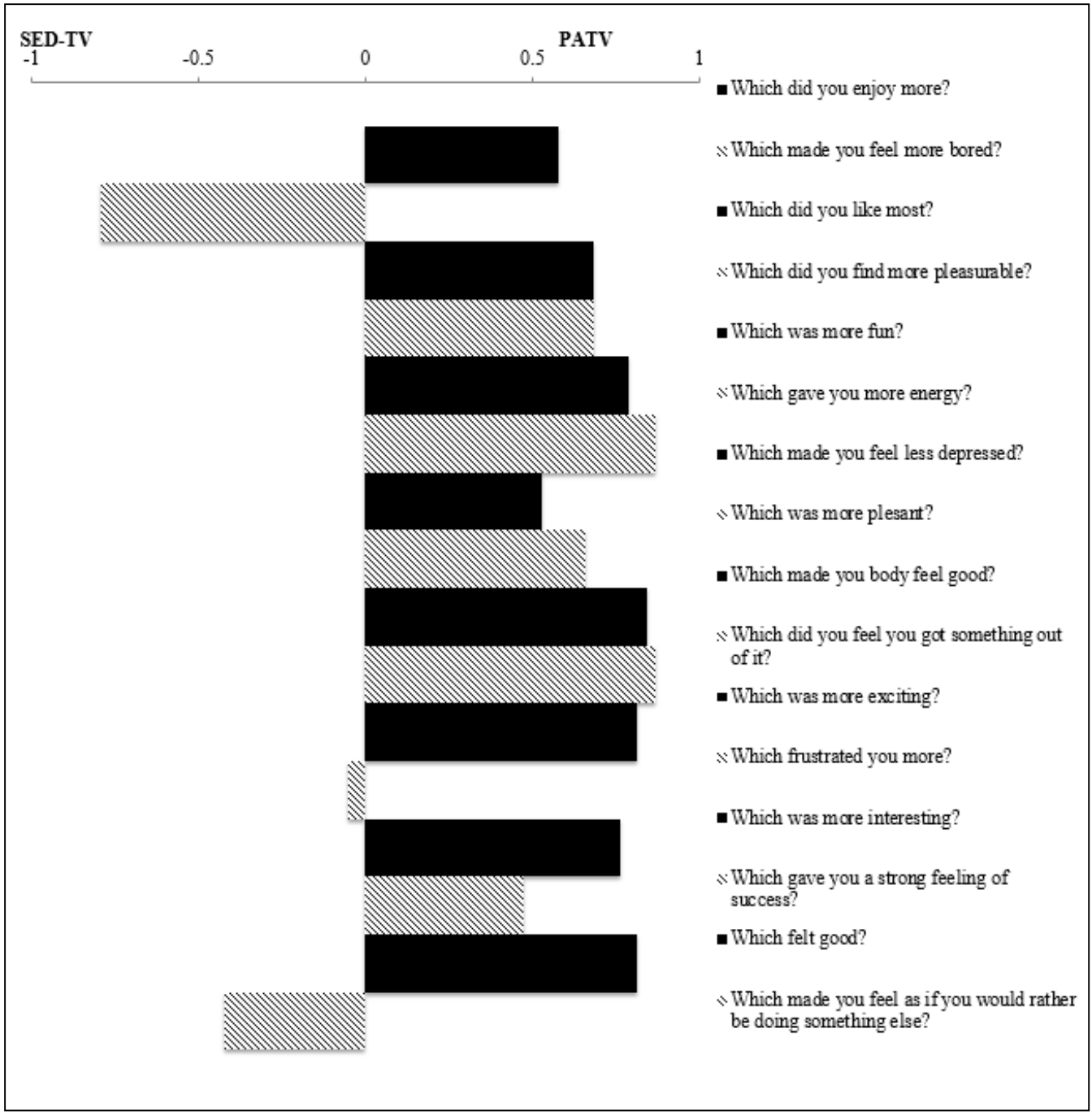

Figure 11. Enjoyment of SED-TV versus PATV for Females

4.6 SUMMARY OF RESULTS

The purpose of this study was to compare PATV to SED-TV and COMM-TV in relation to energy expenditure, intensity of stepping, enjoyment and to examine the effects of gender. Results of the specific aims of this study are as follows:

1. It was hypothesized that COMM-TV and PATV would result in significantly higher energy expenditure compared to SED-TV. An exploratory hypothesis was that there is no significant difference in energy expenditure between COMM-TV and PATV.
    a. Significantly higher energy expenditure was elicited in COMM-TV and PATV compared to the SED-TV. There was no significant difference in energy expenditure between COMM-TV and PATV.
2. It was hypothesized that COMM-TV and PATV would result in more minutes identified as moderate-to-vigorous intensity physical activity than SED-TV. An exploratory hypothesis was that there is no significant difference in minutes of moderate-to-vigorous activity between COMM-TV and PATV.
    a. When activity was quantified as minutes spent at ≥3.0 METS or ≥50% age predicted maximal heart rate, both COMM-TV and PATV elicited more minutes than SED-TV. There was no significant difference in the minutes spent ≥3.0 METS or ≥50% age predicted maximal heart rate between COMM-TV and PATV. When activity was quantified as minutes spent at ≥70% age predicted maximal heart rate, there was no significant difference between SED-TV, COMM-TV, and PATV.
3. To compare enjoyment of television viewing sessions between SED-TV, COMM-TV, and PATV.

a. Analysis of the data based on the first experimental session completed for each study participant showed that COMM-TV was enjoyed significantly more that SED-TV, with PATV enjoyed more that SED-TV but this difference not being statistically significant. There was no significant difference between COMM-TV and PATV.

b. After completion of all three experimental session, enjoyment favored COMM-TV versus SED-TV and PATV versus SED-TV.

4. It was hypothesized that gender would not affect energy expenditure in each television viewing session.

    a. Analysis of data based on absolute energy expenditure (kcal) showed that males expended more energy in each of the experimental sessions compared to females. However, when corrected for body weight (kcal/kg), gender differences in energy expenditure were no longer observed.

5.0 DISCUSSION

5.1 ENERGY EXPENDITURE

5.1.1 Energy Expenditure by Condition

The purpose of this study was to determine the energy expenditure during sedentary television viewing (SED-TV), commercial stepping during a television program (COMM-TV), and stepping prompted by common character phrases/mannerisms within a television program (PATV). The current investigation produced higher energy expenditure in COMM-TV (69.9 ± 16.4 kcal) and PATV (71.6 ± 17.9 kcal) compared to SED-TV (37.3 ± 9.9 kcal) ($p=0.000$). No difference was found in energy expenditure between COMM-TV and PATV ($p = 0.827$).

Steeves et al[34] conducted a study that focused on stepping during television commercials, and showed that this achieved an energy expenditure of 148 ± 40 kcal during a 60-minute television show. By comparison, the approximately 70 kcal energy expenditure observed in both COMM-TV and PATV in this current study was achieved in 30 minutes. If extrapolated to 60 minutes, the energy expenditure achieved with COMM-TV and PATV would be comparable to the 148 kcal reported by Steeves et al[34].

The current study was able to achieve the reported energy expenditure in COMM-TV with 9 minutes of commercial time, and in PATV with prompts that resulted in 9 minutes of activity time. Unfortunately, the amount of commercial time was not reported by Steeves et al[34], and therefore a direct comparison with the current study is unable to be made. However, Steeves et

al[34] did report 21 minutes of time spent stepping, which most likely indicates that there was 21 minutes of commercials during their 60 minute protocol.

5.1.2 Energy Expenditure and the Influence of Laughter

The "Big Bang Theory" is marketed as a sitcom television program, thus laughter was an extraneous variable within the experimental sessions. Laughing may influence expired gas volumes and concentrations, which would affect energy expenditure. The study design utilized the same episode of "The Big Bang Theory" for all three experimental visits, which should have standardized prompts to laugh across the experimental sessions. In fact, no difference in laughing frequency was observed across the three sessions ($p=0.460$), which most likely contributed to the finding of no difference in the pattern of results both with and without correction of laughing frequency.

The findings of no influence of laughing on energy expenditure is in contrast to other studies that have reported on the effects of laughing on energy expenditure. Buchowski et al[178] determined laughing elicited significantly higher energy expenditure than non-laughing baseline energy expenditure (difference = 0.2 ± 0.3 kcal/min)($p<0.001$). Buchowski et al[178] used audio equipment to measure voiced laughter, whereas the current study relied on the investigator to recorded episodes perceived to be laughter. Moreover, the design used by Buchowski et al[178] involved evoking 10 minutes of laughter, whereas the current study utilized a 30-minute television comedy sitcom show with no expectation of laughing frequency. These differences in study design and measurement may partially explain the lack of an influence of laughing observed in the current study, which is inconsistent with the findings of other studies.

5.1.3 Energy Expenditure and the Influence of Gender

The current investigation was able to conduct exploratory analysis of the effect of gender on energy expenditure. The results indicated that there was a significant Measure X Gender interaction ($p = 0.016$), and males achieved higher caloric energy expenditure than females when expressed as absolute energy expenditure (kcal). Despite this significant interaction, the pattern of energy expenditure across the three experimental conditions appeared to be consistent between males and females. When analyses were conducted separately for males and females, absolute energy expenditure was significantly higher in both COMM-TV and PATV compared to SED-TV, with no difference between COMM-TV and PATV. Thus, it appears that either COMM-TV or PATV would be viable alternative to SED-TV for increasing energy expenditure in both males and females. Unfortunately, other studies that have examined the influence of stepping during television commercials have not reported data based on gender[34], and therefore comparison of the current study to other studies is not possible.

Of interest is that studies of exercise, not specifically activity performed during television viewing, have shown that absolute energy expenditure is greater in males versus females for a comparable duration and intensity of physical activity[179]. For example, Donnelly et al[179] reported that for a similar intensity and duration of exercise, males expended 668 ± 116 kcal per session and females expended 439 ± 88 kcal per session. This current study also showed that absolute energy expenditure was greater in males versus females. This difference may be a result of differences in body size between genders. However, Donnelly et al[179] reported that even after correction for body weight, energy expenditure during exercise was higher in males versus females. In contrast, when the current study expressed energy expenditure relative to body weight (kcal/kg), the difference between men and women became non-significant (see Table 4). This

difference between the findings from the current study and other studies, such as Donnelly et al[179], warrants further investigation. Regardless, the finding that both COMM-TV and PATV significantly increase energy expenditure during television compared to what is observed during SED-TV in both males and females is an important finding, and may provide an effective strategy to increase physical activity and energy expenditure.

5.2 PHYSICAL ACTIVITY

The current investigation focused on determining the frequency of minutes that achieved or exceeded moderate intensity physical activity, through metabolic equivalents (METS) and age predicted heart rate maximum. Utilizing METS ≥3.0 to indicate an activity of at least moderate intensity, SED-TV resulted in zero minutes, COMM-TV resulted in 4.6 ± 3.6 minutes and PATV resulted in 4.3 ± 3.4 minutes. When defining moderate intensity as ≥ 50% of an individual's age predicted maximal heart rate, SED-TV resulted in 1.1 ± 4.9 minutes, COMM-TV resulted in a 5.7 ± 4.8 minutes and PATV resulted in a 7.2 ± 8.5 minutes. In the study conducted by Steeves et al[34] of stepping in place during television commercials, physical activity was defined based on periods of time when the individual was stepping in place during the 60-minute television session, and it was reported that this resulted in 21 ± 2 minutes of physical activity. Thus, even when the results of the current study are extrapolated across a 60 minute session, it appears that COMM-TV and PATV resulted in lower amounts of physical activity compared to Steeves et al[34].

The difference in the amount of physical activity in the current study compared to Steeves et al[34] may be due to a number of factors. First, this difference could simply be a result of there being more prompts to be physically activity in the prior study compared to the current study.

Moreover, this difference may be a result of differences in how physical activity was defined. For example, Steeves et al[34] quantified physical activity as periods of time when stepping was occurring, and this was regardless of the intensity of stepping. In contrast, the current study defined physical activity only as periods of time when the criterion for moderate intensity was achieved, which was defined as either achieving ≥3.0 METS or ≥50% of age predicted heart rate maximum. It is also possible that in the current study that there was a delay between the onset of physical activity and the physiological responses meeting the criteria for moderate intensity physical activity. Regardless, when extrapolated to a 60 minute session, stepping in place during television commercials resulted in approximately 140 to 150 kcal in both studies.

The findings from this study have important implications for reducing sedentary time resulting from television viewing. For example, intervention studies aimed at reducing television time did not necessarily see an increase in moderate physical activity, but rather a transition from television viewing to other forms of sedentary behavior[180-183]. Thus, rather than discouraging television viewing, the results from this study in combination with the findings from other studies[34] suggest that encouraging engagement in physical activity during periods of television viewing may be an effective strategy to increase physical activity and to reduce sedentary time.

The findings from this study also have important implications for reducing the negative health consequences of sedentary behavior that may arise from television viewing. It has been shown that very short intermittent bouts of activity (<6 minutes) can significantly improve fitness in sedentary adults that is similar in magnitude to one continuous bout of activity[184]. Moreover, having a higher number of breaks in sedentary time was associated more favorable waist circumference, BMI, triglycerides and 2-hour plasma glucose[28,82,83]. Whether the breaks in

sedentary television time achieved with either COMM-TV or PATV, as implement in this current study, would result in health improvements is unknown and warrants additional investigation.

5.3 ENJOYMENT

The current study included measures of enjoyment to determine if there was a preference between the television viewing sessions. First, enjoyment was compared based on the initial television viewing session performed (SED-TV, COMM-TV, or PATV). It was found that enjoyment in COMM-TV was significantly higher than SED-TV. However, while enjoyment also favored PATV over SED-TV, this different was not statistically significant. It is unclear why COMM-TV may have been more enjoyable that PATV when compared to SED-TV. However, based on speculation, it is possible that the study participants found it easier to respond to a commercial prompt than a variety of prompts within the television show to initiate physical activity. Further research is needed to determine if this hypothesis is confirmed.

Regardless of the initial difference in enjoyment based on the first experimental session that was completed, after study participants were individually exposed to all of the television viewing session, enjoyment favored both COMM-TV and PATV over SED-TV. This finding has important implications for interventions focused on reducing sedentary behavior and increasing physical activity. For example, Wankel[185] reported that enjoyment was predictive of retention in an exercise program. Moreover, Salmon et al[151] reported that enjoyment of physical activity was associated with greater participation in physical activity. Thus, identifying strategies to increase enjoyment in physical activity, particularly if this is perceived to be more enjoyable than a

sedentary alternative, may translate into improved engagement in physical activity in individuals who otherwise would remain sedentary.

5.4 CLINICAL IMPLICATIONS

From a public health perspective, current physical activity guidelines recommend that adults engage in 30 minutes of moderate intensity physical activity daily[186]. While the majority of adults in the United States do not achieve this level of physical activity, it has also been reported that the average adult watches 3 to 5 hours of television per day[29,35,36]. This study showed that both COMM-TV and PATV elicit 5-7 minutes of moderate physical activity during one 30-minute television show. Thus, if COMM-TV or PATV were implemented, 3 to 5 hours of daily television viewing would translate into 15 to 35 minutes of moderate intensity physical activity per day, which approaches the recommended level of physical activity to improve health.

Current physical activity guidelines also recommended that physical activity be accumulated in bouts of at least 10 minutes in duration[186]. Unfortunately, the physical activity sessions resulting from either COMM-TV or PATV in this study did not achieve this threshold, but rather totaled 5 to 7 minutes of physical activity accumulated across the entire 30 minute television viewing session. While there is some evidence that even bouts of activity that are less than 10 minutes in duration may be effective for increasing fitness[184], it is unclear if additional health benefits would be realized from this intervention approach for increasing physical activity participation.

One health benefit that could be realized from either COMM-TV or PATV may be prevention of weight gain, or potentially modest weight loss. Both COMM-TV and PATV

increase energy expenditure by approximately 30-35 kcal above the energy expenditure resulting from 30 kcal of SED-TV. When extrapolated across 60 minutes, this would result in an additional 60 to 70 kcal in energy expenditure. Hill et al. reported that an increase in energy expenditure of 50-100 kcals per day may be sufficient to prevent weight gain, which may be important for the prevention of overweight or obesity[37]. Thus, replacement of sedentary television viewing sessions with active television viewing, such as what can be achieved with COMM-TV or PATV, may be sufficient to prevent weight gain.

5.5 LIMITATIONS AND FUTURE DIRECTIONS

The following are recognized as limitations to this study, which should be the focus of future research studies on this topic:

1. This was a cross-sectional study and only measured acute differences among SED-TV, COMM-TV and PATV. Longer duration studies are needed to determine if chronic training effects on physiological measures are apparent, and if enjoyment scores of the active sessions withstand a longer duration of time.
2. Naturalistic extraneous movement was controlled for during the experimental sessions. Participants sat in an office chair, in an upright position with their hips, knees and ankles bent at 90-degree angles so their feet rested flat on the floor and hands rested in their lap. Cellphone use, engagement with investigator, and miscellaneous talking and walking around was not permitted during this experiment. Replication of this study design within a naturalistic environment that does not restrict movement should be conducted.

3. To ensure all participants stood and stepped at the appropriate times, on-screen prompts and verbal prompts by the principle investigator ensured compliance with stepping protocol. It cannot be certain that without investigator oversight if subjects would engage in prompts to stand and step. During PATV, each prompt was to elicit a one-minute stepping bout that was timed for accuracy. Investigators cannot be certain how long a subject would stand and step without a timer. Future studies should examine these factors.
4. For PATV to be effective, common themes within a television program need to be present. PATV may not be an appropriate prompting tool for all television programs; therefore studies across a variety of television programs should be conducted.
5. The Big Bang Theory was the only television program used during this investigation. Preference of television program may have an effect on energy expenditure, heart rate, and enjoyment or engagement of prompted stepping. Additional studies should determine whether subject preference of television program affects study outcomes.
6. Subject eligibility characteristics were restricted in this study. Additional research should investigate various ages, BMI classifications, and a variety of health parameters to determine if this will alter the findings.
7. Stepping in place was the only mode of activity assessed during this study. Various populations may require stimulation of different activities in order to continually engage in this behavior. Future research should experiment with different activity modes among various populations to determine energy expenditure, activity intensity, enjoyment and potential adherence to these types of behaviors.
8. While this study observed differences in energy expenditure between the genders for absolute energy expenditure (kcal), this difference was diminished when adjusted for body weight.

However, this study did not include a more detailed measure of body composition, and therefore, it is unclear whether similar findings would be observed if energy expenditure was expressed relative to lean body mass rather than body weight.

5.6 SUMMARY

The data from this study indicate that PATV produced energy expenditure and heart rate comparable to COMM-TV, and both PATV and COMM-TV produced higher energy expenditure and heart rate than SED-TV. During 30 minutes, the energy expenditure of intermittent prompted stepping (either COMM-TV or PATV) elicited nearly twice the energy expenditure of viewing television in a seated position. Adults are spending on average at least 3 to 5 hours in front of the television screen daily. Additionally, only a small percentage of American adults engage in adequate amounts (30 min/day) of physical activity using standard approaches. Modifying television-viewing behaviors by having adults step in place during the television show could be useful in promoting physical activity. The advantage of utilizing PATV to elicit stepping during a television program is that television watching is already a behavior regularly engaged in the general population, stepping in place is a feasible physical activity for the general population and the prompted cues are embedded within the television show. Thus, the prompt for activity will not be lost if commercials are skipped over. Additional research as to the most effective delivery platform for this type of intervention and appropriate cues and physical activity for various populations needs to be assessed before this concept of PATV is to be marketed. Presenting the population with an opportunity to modify a sedentary behavior into an active behavior, to increase energy expenditure and decrease sedentary time in their own living room, and without any

additional cost, equipment or learned skill is an attractive alternative to traditional exercise regimes.

APPENDIX A

EVIDENCE TABLES

Table 10: Cohort Observational Studies

Citation	Study Design	Population Characteristics	Sample Size	Duration of Study (Observation Period)	Important outcomes related to sedentary behavior
Ball [187] ***Who does not gain weight?***	Longitudinal	Australian young women 18-23 years old at baseline	N = 8,726	4 year follow-up	• Only 44% women maintained BMI (within 5% of baseline BMI) • 41% gained weight • Controlling for SES, maintainers more likely to o Normal BMI at baseline o Report less time sitting o Consumed less take-out food

Bauman[60] ***The Descriptive Epidemiology of Sitting***	Cross-sectional	18-65 year olds 20 countries	N= 49,493	One time questionnaire IPAQ short form	• Of the 20 countries, 12 reported mean sitting >= 5 hours/day. • The more developed countries reported higher amount of sitting., consistent with other studies [1,2,5,25,56,188] • Different age patterns exist o culture, occupation, transport, technology use
Beunza[132] ***Sedentary Behaviors and the Risk of Incident Hypertension- SUN Cohort***	Dynamic- Prospective	Spanish university graduates living in Spain Mean age: 36 years old	N = 11,837	40 months Baseline – biennial questionnaires	• Self-report total sedentary behavior directly associated with higher risk of hypertension • Interactive sedentary behavior (driving/computer use) was associated with higher risk of hypertension o Non-interactive sedentary behavior (TV viewing) did not show a significant association with incident hypertension
Blanck[189] ***Sedentary Behavior, Recreational Physical Activity, and 7-Year Weight Gain among postmenopausal US women***	Longitudinal	U.S. postmenopausal women Age: 40-69 years old	N = 18,583	7 years Baseline, 2 follow-up time-points.	• Neither p.a. nor sedentary behavior was associated with a 5 -9 pound weight gain. • Among non-overweight women at baseline, odds of gaining more than 10 lbs. were 12% lower for those in the highest p.a. category, compared to lowest. • Neither p.a. nor sedentary behavior was associated with risk of gaining more than 10 lbs. among women who were overweight at baseline.
Boone[133] ***Screen time and physical activity during adolescence: longitudinal effects on obesity in young adulthood***	Longitudinal	Add Health (National Longitudinal Study of Adolescent Health) U.S. school-based population Grades 7-12	N = 9,155	Baseline, 4 follow-up time points	• In males, obesity was strongly predicted by MVPA bouts • In females, greater MVPA bouts and lower screen time correlated with lower prevalent obesity • Adolescent screen hours had a stronger influence on incident obesity in females than males

Bowman[119] ***Television-Viewing Characteristics of Adults: Correlations to Eating Practices and Overweight and Health Status***	Cross-Sectional USDA's Continuing Survey of Food intakes by Individuals	Adults 20 years and older	N = 9,157	One-time, self-report/ recall data	• More than 2 hours/day TV viewing associated with o high BMI and overweight/obesity in men and women o being 50 years old or older o having high school education or less o being unemployed o income below poverty level • Adults who watched more than 2 hours TV /day o Had high intakes of energy and macronutrients o More likely to be overweight o More energy from snacks/supper • Higher percentage of adults with health conditions watched more than 2 hours of TV per day compared to adults without health conditions
Brown [25] ***Identifying the Energy Gap: Magnitude and Determinants of 5-Year Weight Gain in Mid Age Women***	Longitudinal Prospective ALSWH (Australian Longitudinal Study on Women's Health)	Women National Medicare health insurance database 18-23; 45-50; 70-75 years old at baseline BMI: 26.6 ± 5.2	N =8,071	Baseline and 3 time-points, 5 years	• Gained 0.5 kg (1.1 lbs.) per year • Baseline BMI category significantly associated o Energy balance ▪ Physical activity ▪ Sitting time ▪ Energy intake • Independent relationship between the odds of gaining >5 kg (11 lbs.) and: o lower levels of habitual o more time spent sitting o energy intake (only in women with BMI > 25 at baseline) • Average weight gain equates with an energy imbalance of only ~ 10 kcals/day
Ching [53] ***Activity Level and Risk of Overweight in Male Health Professionals***	Cross-sectional and prospective Health Professionals Follow-up Study	US male health professionals 40-75 years old	N = 22,076	Baseline, 2 years follow-up	• Odds of being overweight were 50% lower for men in the highest quintile of non-sedentary activity level compared with the lowest • Men watching 41 hours or more TV / week odds of being overweight were 4.06 times greater than men watching no more than 1 hour of TV/week • Higher levels of non-sedentary activity and lower levels of TV viewing were independently associated with lower relative risks for becoming overweight.

Coakley[190] ***Predictors of weight change in men: Results from The Health Professionals Follow-Up Study***	Prospective cohort	US male professionals 40-75 years old	N = 19,478	Baseline, 4 years follow-up	• Vigorous activity was associated with weight reduction • TV/VCR viewing and eating between meals was associated with weight gain • Men who increased their exercise, decreased TV viewing and stopped eating between meals, lost an average of 1.4 kg (3 lbs.). • Prevalence of obesity was lowest among those who maintained high levels of vigorous p.a. compared to sedentary.
Crawford[122] ***Television viewing, physical inactivity and obesity***	Cross-sectional	Men High income women Low income women 20-45 years old	N = 881	Baseline, 3 annual follow-ups	• TV viewing positively associated with BMI among women, but not men o Relationship strongest among low-income women • No significant relationships between o change in BMI and number of hours of TV viewing at baseline o average number of hours of TV viewing over 3 year follow-up o change in number of hours of TV viewing form baseline to 3 years
Dunstan [97] ***Television Viewing Time and Mortality***	Longitudinal	AusDiab study ≥25 years old	N = 8,800	Mean 6.6 years follow-up	• After adjustment for age, sex, waist circumference and exercise, for each 1-hour increment in TV viewing time per day o 1.1 for all-cause mortality o 1.18 for CVD mortality o 1.09 for cancer mortality • Compared with TV viewing time <2 h/d, fully adjusted HR o All-cause mortality was : ▪ 1.13 for ≥2 to <4 h/d ▪ 1.46 for ≥4 h/d o CVD morality was: ▪ 1.19 for ≥2 to <4 h/d ▪ 1.80 for ≥4 h/d • associations with cancer mortality and non-CVD mortality were non-significant

Ekelund [191] ***Objectively measured moderate- and vigorous-intensity physical activity but not sedentary time predicts insulin resistance in high-risk individuals***	Prospective ProActive UK trial	Adults with family history of type 2 diabetes	N = 192	Baseline and 1 year follow-up	• Baseline MVPA was significant predictor of fasting insulin at follow-up o Association approached significance for HOMA-IR, independent of time spent sedentary, light intensity, age, sex, smoking, waist circumference and self-reported TV viewing • Time spent sedentary and at light-intensity activity were not significantly associated with insulin resistance • Change in MVPA between baseline and follow-up was inversely related to fasting insulin and HOMA-IR at follow-up after adjustment. • Moderate-intensity activity for improving insulin sensitivity and other metabolic risk factors to prevent type 2 diabetes
Ekelund [192] ***Time spent being sedentary and weight gain in healthy adults: reverse or bidirectional causality?***	Prospective	Middle-aged healthy whites	N = 393	Baseline and 5.6 year follow-up	• At baseline, sedentary time was significantly correlated with o Fat mass after age/sex adjustment o Waist circumference after age/sex adjustment • At follow-up, sedentary time was significantly correlated with o Body weight o BMI o Waist circumference o Fat mass • Sedentary time did not predict any of the obesity indicators at follow-up.
Friberg[193] ***Physical activity and risk of endometrial cancer***	Prospective cohort Mammography Cohort	Central Swedish Women	N = 33,723	Baseline and 7.25 years follow-up	• After adjustment for potential confounders, the RR for endometrial cancer for the second to fourth quartile of total physical activity compared with lowest quartile was 0.80, 0.87 and 0.79. • High leisure time inactivity (≥5 hours daily) compared with low was associated with increased risk of endometrial cancer • The associations were not modified by BMI • Total physical activity is weakly inversely associated with endometrial cancer risk and leisure time inactivity is statistically significantly associated with increased risk for endometrial cancer.

Fung[134] ***Leisure-Time physical activity, television watching, and plasma biomarkers of obesity and cardiovascular disease risk***	Cross-sectional and prospective Health Professionals Follow-up Study	US male health professionals 40-75 years old	N = 468	Baseline, 10 years follow-up	• Physical activity significantly positively associated with HDL and inversely with leptin and C-peptide. • Average number of hours of TV watched was significantly positively associated with LDL cholesterol and significantly inversely associated with HDL and apoliprotein A1. • Average hours of TV/week and vigorous activity with leptin and HDL cholesterol were independent of each other • Physical activity and TV were significantly associated with several biochemical markers of obesity and CVD risk.
Gierach[194] ***Physical activity, sedentary behavior, and endometrial cancer risk in the NIH-AARP Diet and Health Study***	Prospective study	Members of AARP 50-71 years old 8 US states White Predominately Women	N = 109,621	Baseline, ~8 years follow-up	• Vigorous activity was inversely associated with endometrial cancer in a dose-response manner for >5 times/week vs. never/rarely o Association more pronounced among overweight and obese women than lean women • No association with light/moderate, daily routine or occupational physical activities, risk did increase with number of hours of daily sitting
Gollenberg [195] ***Sedentary Behaviors and Abnormal Glucose Tolerance among Pregnant Latina Women***	Prospective Study	Latina gestational diabetes mellitus study Massachusetts Age 16-40	N = 1231	During Pregnancy	• Sedentary behaviors in pre-pregnancy or early pregnancy were not associated with abnormal glucose tolerance • In mid-pregnancy, low levels of participation in sports or exercise and increasing total sedentary activity were associated with increased risk for abnormal glucose tolerance
Gore [196] ***Television viewing and snacking***	Cross-sectional	Overweight women seeking obesity treatment Had diabetes and being treated	N = 74	One time • FFQ; Food Frequency Questionnaire over the past 6 month	• Snacking, not necessarily eating meals, while watching TV is associated with increased overall caloric intake and calories from fat
Hagströmer [56] ***Levels and Patterns of Objectively Assessed Physical Activity***	Cross-sectional	US; NHANES Sweden; Attitude Behavior and Change Study Ages 18-75	N = 1,172 Swedish N = 2,925 US Total N = 4097	Objective accelerometer data	• Older respondents and those with higher BMI had lower activity levels • Swedish men spent 36 minutes/day and US men spent 33 minutes/day moderate or higher physical activity. • Swedish men spent 32 minutes/day and US men spent 19 minutes/day moderate or higher physical activity. • Older Swedes were more active in moderate or higher intensity activities than older US adults. • Younger Swedish males had more sedentary behavior time than did younger US males.

Hancox [111] **Association between child and adolescent television viewing and adult health**	Longitudinal	New Zealand children	N = 1,000	Baseline and 8 follow-up assessments over 21 years	• Average weeknight viewing between age 5 and 15 years old was associated with o Higher body-mass indices o Lower cardiorespiratory fitness o Increased cigarette smoking o Raised serum cholesterol • Childhood/adolescent viewing had no significant association with blood pressure o Associations persisted after adjustment for confounding factors • In 26-year olds, population attributable fractions indicate that 17% of overweight, 15% raised serum cholesterol, 17% smoking and 15% poor fitness can be attributed to watching TV for more than 2 h/d during childhood/adolescence • TV viewing in childhood/adolescence is associated with overweight, poor fitness, smoking and raised cholesterol in adulthood. Excessive viewing might have long-lasting adverse effects on health.
Healy[28] ***Breaks in Sedentary Time: Beneficial associations with metabolic risk***	Cross-sectional	Age: 53.4 ± 11 years BMI: 27.2 ± 4 Australian Diabetes Study	N=168	Day 1: Metabolic, demographic and behavioral measures 7 day accelerometer data	• 57% waking hours sedentary • 39% light physical activity • 4% MVPA • Average break: 5 minutes, light intensity • Independent of sedentary time, total number of breaks in sed. time was associated w/ sig. lower waist circumference, BMI, TG, 2-h plasma glucose. • Advice to regularly break up/interrupt sustained sed. time may be feasible to implement across settings
Healy [15] ***Objectively Measured Light-Intensity Physical Activity is independently associated with 2-h Plasma Glucose***	Cross-sectional	Age: 53.4 ± 11 years BMI: 27.2 ± 4 Australian Diabetes Study	N = 173	Day 1: Metabolic, demographic and behavioral measures 7 day accelerometer data oral glucose tolerance test	• After adjustments for cofounders, sedentary time was positively associated with o 2-h plasma glucose o Light-intensity activity time o Moderate - to vigorous- intensity activity time • Light-intensity activity remained significantly associated with 2-h plasma glucose following further adjustment for moderate-vigorous activity. • Objective evidence that light-intensity p.a. is beneficially associated with blood glucose and that sedentary time is unfavorable associated with blood glucose

Healy [9] ***Objectively Measured Sedentary Time, Physical Activity, and Metabolic Risk***	Cross-sectional	Age: 53.4 ± 11 years BMI: 27.2 ± 4 Australian Diabetes Study	N = 169	Day 1: Metabolic, demographic and behavioral measures 7 day accelerometer data	• Independent of time spent in moderate-to-vigorous intensity activity, there were significant associations of; sedentary time, light-intensity time, mean activity intensity with; o Waist circumference o Clustered metabolic risk • Independent of waist circumference, moderate-to-vigorous activity time was significantly beneficially associated with triglycerides
Helmerhorst [93] ***Objectively Measured Sedentary Time May Predict Insulin Resistance Independent of Moderate- and Vigorous- Intensity Physical Activity***	Cross-sectional	Age: 53.4 ± 11 years BMI: 27.2 ± 4 Australian Diabetes Study	N = 376	Day 1: Metabolic, demographic and behavioral measures 7 day accelerometer data Followed ~5.6 years	• Time spent sedentary at baseline was significantly and positively associated with fasting insulin at follow-up independent of (age, sex, fat mass, fasting insulin, smoking, follow-up time) o After further adjustment for MVPA, this association was strengthened • Time spent sedentary predicts higher levels of fasting insulin independent of the amount of time spent at moderate- vigorous- intensity activity levels.
Howard [197] ***Physical activity, sedentary behavior, and the risk of colon and rectal cancer in the NIH-AARP Diet and Health Study***	Prospective	NIH-AARP Diet and Health Study Aged 50-71 years	N = 300, 673	Baseline questionnaire Follow-up questionnaire one year later	• Engaging in exercise/sports five or more times per week compared to never or rarely exercising was associated with a reduced risk of colon cancer among men o A suggestive decrease in risk among women • Engaging in exercise/sports was associated with a decreased risk of rectal cancer in men • Men: observed inverse relations in both low-intensity and moderate to vigorous intensity to colon cancer risk • Sedentary behavior was positively associated with colon cancer among men o Similar but less pronounced relations in women • Engaging in physical activity of any intensity is associated with reductions in colon and rectal cancer risk. Conversely, time spend sedentary is associated with increased colon cancer risk.
Hu [16] ***Physical Activity and Television Watching in Relation to Risk for Type 2 Diabetes Mellitus in Men***	Prospective	40-75 year old Men	N = 37,918	10 years follow-up Biennial questionnaires	• Time spent watching TV was significantly associated with higher risk for diabetes • Increasing physical activity is associated with a significant reduction in risk for diabetes o Sedentary lifestyle indicated by prolonged TV watching is directly related to risk

Hu [17] ***Television Watching and Other Sedentary Behaviors in Relation to Risk of Obesity and Type 2 Diabetes Mellitus in Women***	Prospective	Nurses' Health Study	N = 50,277	6 Years follow-up	• Time spent watching TV was positively associated with risk of obesity and type 2 diabetes. • After adjustments, each 2-h/d increment in TV watching was associated with a 23% increase in obesity and 14% increase risk in diabetes. o Each 2-h/d increment in sitting a work was associated with a 5% increase in obesity and 7% increase in diabetes. • Standing or walking around at home (2h/d) was associated with a 9% reduction in obesity and a 12% reduction in diabetes. • Independent of exercise levels, sedentary behaviors (especially TV watching) was associated with significantly elevated risk of obesity and type 2 diabetes. o Light to moderate activity was associated with substantially lower risk •
Jeffery [126] ***Epidemic Obesity in the United States: Are Fast Foods and Television Viewing Contributing?***	Cross-sectional and longitudinal	Men High-income women Low-income women 20-45 years old	N = 1,059	1 year follow-up	• Fast food meals and TV viewing hours were positively associated with energy intake and BMI in women but not men. • TV viewing predicted weight gain in high-income women
Katzmarzyk [75] ***Sitting Time and Mortality from All Causes, Cardiovascular Disease and Cancer***	Prospective	Canadians 18-90 years old	N = 17,013	Average 12 years follow-up	• After adjustment, progressively higher risk of mortality across higher levels of sitting time from all causes and CVD but not cancer o Independent of physical activity
Koh-Banerjee [198] ***Prospective study of the association of changed in dietary intake, physical activity, alcohol consumption and smoking with 9-y gain in waist circumference***	Prospective	US men 40-75	N = 16,587	9 year follow-up	• 20-h/wk. increase in TV associated with 0.59-cm waist gain • Increases of 25 METs h/wk. in vigorous physical activity and of ≥ 0.5 h/wk. in weight training were associated with 0.38-cm and 0.91-cm decreases in waist circumference. •

Landhuis [129] ***Programming Obesity and Poor Fitness: the Long-term Impact of Childhood Television***	Prospective	Unselected birth cohort New Zealand children	N = 1,037	Baseline and 7 follow-up assessments over 27 years	• childhood and adult TV viewing was significantly associated with higher BMI and lower cardiorespiratory fitness at 32 years • Childhood TV was a better predictor of adult BMI and fitness than adult viewing o Remained significant predictor after adjustment • After adjusting for adult viewing, the odds of adult obesity increase by a factor of 1.25 and poor fitness increased by a factor of 1.40 for each hour of mean weekday TV during childhood. • The association between childhood TV and obesity and poor fitness in adulthood is not mediated by adult viewing. The detrimental health effects of watching too much television during childhood persist into adulthood.
Leitzmann [199] ***The Relation of Physical Activity to Risk for Symptomatic Gallstone Disease in Men***	Prospective	Men 40-75 years old US. Health professionals	N = 45,813	12 year follow-up, 5 time-points	• After adjustment, increased physical activity was inversely related to risk for symptomatic gallstone disease • Sedentary behavior was positively related to risk for symptomatic gallstone disease • Men who watched TV more than 40 hours/week had higher risk than men who watched less than 6 hours per week.
Levine [24] ***Inter-individual Variation in Posture Allocation***	observational	Lean and mildly obese sedentary individuals	N = 20	10 days	• Obese individuals were seated, 2 hours longer per day then lean individuals •
Manson [46] ***Waling compared with vigorous exercise for the prevention of cardiovascular events in women***	prospective	Postmenopausal women 50-79 years old Women's Health Initiative Observational Study	N = 73,743	5.9 years follow-up	• Increasing physical-activity score had a strong, graded, inverse association with the risk of both coronary events and total cardiovascular events o Similar findings among white and black women • Inverse gradient between total MET score and risk of cardiovascular events remained strong • Walking and vigorous exercise were associated with similar risk reductions o Results did not vary according to rage, age or BMI • Brisker walking pace and fewer ours spent sitting daily predicted lower risk

Matthews [103] ***Amount of time spent in sedentary behaviors and cause-specific mortality***	Prospective	NIH-AARP Diet and Health Study Adults 50-71 years old	N = 240,819	8.5 years follow-up	• Sedentary behaviors were positively associated with mortality after adjustment for age, sex, education, smoking, race, diet and MVPA • Those who reported the most TV (≥7 h/d compared with <1 h/d) were at greater risk for all-cause, CV and cancer mortality after MVPA adjustment. • Overall sitting was associated with all-cause mortality • Even among adults reporting high levels of MVPA (>7 h/wk.), high amounts of TV (≥7 h/d) remained associated with increased risk of all-cause and CV mortality compared with those reporting least TV (<1h/d).
Mekary [200] ***Physical Activity in Relation to Long-term Weight Maintenance after Intentional Weight Loss in Premenopausal Women***	Prospective	Nurses Health Study II Female nurses Age 25-42	N = 4,558	6 year follow-up	• An increase of 30 min/day in total discretionary activity was associated with less weight regain, than increased walking or other activities • Compared to women who remained sedentary, women were less likely to regain >30% of lost weight if they maintained 30+ min/day of discretionary PA, or increased to this activity level • Risk was elevated in women who decreased their activity • Increased PA is associated with better maintenance of weight loss • The benefits of activity were greater among overweight/obese than normal weight women

Oken [201] ***Television, Walking, and Diet***	Prospective	Project Viva Women	N = 902	12-months postpartum	• After adjustment, odds ratio of retaining at least 5kg was 1.24 per daily hour of TV, 0.66 per daily hour of walking, and 1.33 per 0.5% increment in daily energy intake from trans fat. • Women who watched less than 2 hours of television, walked at least 30 minutes and consumed trans fat below the median had an odds ration of 0.23 of retaining at least 5kg.
Parsons [130] ***Television viewing and obesity: a prospective study in the 1958 British birth cohort***	Prospective	British birth cohort	N = 11,301	45 year follow-up 7 time-points	• Watching television 'often' at 16 years was associated with a faster gain in BMI between 16 and 45 years in males and females. • More frequent television viewing at 11,16 and 23 years was associated with a faster gain in BMI between 23 and 45 years in females, but not males • TV viewing at 23 years was associated with waist-hip ratio at 45 years o Participants watching ≥ 5 times /w had waist—hip ratio 0.01 higher than those watching less often • At 45 years, those watching TV for ≥ 4h/d has waist-hip ratio 0.03-0.04 higher than those watching for <1 h/d. • More frequent TV in adolescence and early adulthood is associated with greater BMI gains through to mid-adulthood and with central adiposity in mid-life.
Patel [52] ***Leisure Time Spent sitting in Relation to Total Mortality in a Prospective Cohort of US Adults***	Prospective	CPS-II Men and women 50-74 years old	N = 184, 190	14 month follow-up	• After adjustments, time spent sitting (≥ 6 vs. <3 h/d) was associated with mortality n both men and women • Relative risks for sitting ≥ 6 h/d and physical activity <24.5 MET h/wk., combined were 1.94 in women and 1.48 in men. • Associations were strongest for CVD mortality. • Time spent sitting was independently associated with total mortality, regardless of physical activity level.

Patel [79] ***Recreational Physical Activity and Sedentary Behavior in Relation to Ovarian Cancer Risk in a Large cohort of US Women***	Prospective	CPS-II Postmenopausal women 50-74 years old	N = 97,786	Follow-up every 2 years for 11 years	• No overall association was observed between past p.a. or recreational p.a. at baseline and risk of ovarian cancer • Prolonged duration of sedentary behavior was associated with an increased risk (≥ 6 vs. <3). • High levels of sedentary behavior may increase risk of ovarian cancer, but no major impact of light and moderate p.a. on ovarian cancer risk
Patel [202] ***The role of body weight I the relationship between physical activity and endometrial cancer***	Prospective	CPS-II Nutrition Cohort Women 50-74 years old	N= 42,672	Follow-up every 2 years for 11 years	• All measures of physical activity and the avoidance of sedentary behavior were associated with lower endometrial cancer risk • BMI significantly modified the association between physical activity and endometrial cancer risk o Inverse relationship was only seen among overweight/obese women
Raynor [128] ***Television viewing and Long-Term Weight Maintenance: Results from the National Weight Control Registry***	Cross-sectional; prospective	National Weight Control Registry Adults	N = 1422	1 year follow-up	• 62% participants reported watching 10 or fewer hours TV/week • 36% reported watching < 5 h/wk. o 12% watched ≥ 21 h/week • baseline TV viewing and increases in TV viewing over follow-up were significant predictors of 1-year weight regain o independent of physical activity and dietary behaviors
Sanchez-Villegas [135] ***Physical Activity, Sedentary Index and Mental Disorders in the SUN Cohort Study***	Prospective	SUN Cohort Spanish University Graduates	N = 10,381	6 year follow-up	• The Odds Ratio for subjects who spent more than 42 h/week watching TV and/or computer was 1.31 as compared to less than 10.5 h/week • Joint association of leisure-time physical activity and sedentary behavior on incidence of mental disorders
Sardinha [162] **Objectively Measured Time Spent Sedentary is Associated with Insulin Resistance Independent of Overall and Central Body Fat**	Cross-sectional	School-based children 9-10 year old Portuguese children European Youth Heart Study	N = 308	4 days	• Time spent sedentary was significantly and positively associated with insulin resistance • Time spent in moderate and vigorous intensity p.a. inversely associated with insulin resistance • For every hour spend sedentary/day (objectively measured) children were more likely to be obese. o Once analysis adjusted for p.a. relationship no longer significant.
Stamatakis [101] ***Screen-Based Entertainment Time,***	Prospective	Scottish Health Survey 2003 Aged ≥ 35	N = 4,512	4 year follow-up	• The co-variable adjusted hazard ratio for all-cause mortality was 1.52 and for CVD events was 2.30 for

All-Cause Mortality, and Cardiovascular Events					participants engaging in ≥ 4 h/day of screen time relative to <2 h/day. o Adjusting for p.a. attenuated these associations slightly • Recreational sitting (TV time) is related to raised mortality and CVD risk regardless of physical activity participation • Inflammatory and metabolic risk factors partly explain this relationship
Thomson [203] ***The Association of Television Viewing with Snacking Behavior and Body Weight of Young Adults***	Cross-sectional	Canada Undergraduate university students 18-25 years old	N = 613	Single time-point	• Students reporting medium or high TV viewing snacked more frequently while watching TV and recognized more advertising than students who were considered low viewers • High-viewers reported more consumption of energy-dense snacks • Male students and medium viewers had higher odds of being overweight or obese • Associations found among TV viewing, energy-dense snack consumption and snacking behavior and TV viewing and body weight status
Viner [131] ***Television viewing in early childhood predicts adult body mass index***	Prospective	1970 British Birth Cohort	N = 11,261	30 years follow with 3 time-points	• Mean daily hours of TV viewed at weekends predicted higher BMI at 30 years, when adjusted for TV viewing and activity level at 10 years • Each additional hour of TV watched on weekends at 5 years increased risk for adult obesity by 7%
Warren [78] ***Sedentary Behaviors Increase Risk of Cardiovascular Disease Mortality in Men***	Longitudinal	Aerobics Center Longitudinal Study Men, free of CVD at baseline	N = 7,744	21 years follow-up	• Time riding in a car and combined time spent in sedentary behaviors were positively associated with CVD death • Men >10 hrs./week riding in a care or > 3 hr./week of sedentary behavior had 82% and 64% greater risk of dying from CVD than those who reported <4 hr./week or <11 hr./week. • Regardless of amount of sedentary activity; being older, normal weight, normotensive and physically active was associated with a reduced risk of CVD disease

Table 11: Intervention/Experimental Manipulation Studies

Citation	Study Design	Population Characteristics	Sample Size	Duration of Study (Intervention Period)	Interventions (one per line)	Important outcomes related to sedentary behavior

Anand[170] ***A Family-based Intervention to Promote Healthy Lifestyles in an Aboriginal Community in Canada***	Randomized open trial	Families from Six Nations Reserve in Ohsweken, Canada Canadian Aboriginal children aged ≥5 years old	N=57 households (174 individuals)	6 months	• Usual Care Group o Received *Canada's Food Guide to Healthy Eating* and *Canada's Physical Activity Guide to Healthy Living* • SHARE-ACTION intervention o Regular home visits by indigenous health counselors who provided advice in decreasing sedentary behavior in addition to diet, p.a. goals for each household member	• Trend toward reductions in children's sedentary behavior in intervention compared to control.
Bey[21] ***Suppression of skeletal muscle lipoprotein lipase activity during***	Experimental animal study	Sprague-Dawley Rats of equal weight, environment and food protocol	N= 190	Acute phase: o 12 h hind-limb uploaded followed by 4h ambulatory Chronic phase:	• Control rats; freely ambulatory • Hind-limb unloading (HU) group o Rear limbs elevated off floor, unrestricted movement otherwise	• Skeletal muscle is one of major sites for clearance of both plasma triglycerides [21] and oral glucose load from plasma [204] o One potential mechanisms for detrimental changes is the absence of

physical inactivity: a molecular reason to maintain daily low-intensity activity				o 10h/day hind-limb unloaded for 11 days		skeletal muscle contractions • Plasma triglycerides and HDL cholesterol clearance was impaired locally during low ambulation, o Associated with ~90% reduction in skeletal muscle LPL activity in hind-legs. • Changes in biomarkers were corrected with light intensity activity.
Ceriello [205] ***Effect of Postprandial Hypertriglyceridemia and hyperglycemia on Circulating Adhesion Molecules and Oxidative Stress Generation***	Double-blind, crossover, placebo	Normal and diabetic subjects	N = 50	3 tests at 3 month intervals	• 3 different meals o high-fat meal o 75 g glucose alone o high-fat meal plus glucose • Diabetics took simvastatin or placebo	• High-fat load and glucose alone produced an increase of nitrotyrosine, ICAM-1, VCAM-1 and E-selectin plasma levels in normal and diabetic subjects • These effects were more pronounced when high fat and glucose were combined • Independent and cumulative effect of postprandial hyperglyceridemia and hyperglycemia on ICAM-1, VCAM-1, and E-selectin plasma levels, suggesting oxidative stress as a common mediator of such effects.
Dunstan [147] ***Breaking up prolonged sitting reduces postprandial***	Acute crossover trial	Overweight/obese adults Age 45-65 years	N = 19	Approximately 6 weeks An experimental session every 6-14 days	• Uninterrupted Sitting • Sitting + light-intensity activity breaks o 20 minutes seated then 2-minute light intensity walking bout, repeated 14 times	• Glucose AUC was reduced after both activity conditions compared with uninterrupted sitting • Insulin AUC was reduced with both activity-break conditions • No sig. difference between activity conditions

glucose and insulin responses					• Sitting + moderate-intensity activity breaks o 20 minutes seated then 2-minute moderate intensity walking bout, repeated 14 times	•
[206]Epstein ***A Randomized Trial of the Effects of Reducing Television Viewing and Computer Use on Body Mass Index in Young Children***	RCT	Age: 4-7 BMI: at or above 75th percentile for age/sex 14 h/week TV/computer	N= 70	2 years, assessment baseline and every 6 months	• Monitoring group, no screen reduction • Intervention group; overall reduction screen time by 50% of baseline. Financial incentives for under budget, parental praise for alt. behavior.	• -Intervention group greater reduction in sedentary behavior and energy intake compared to monitoring group. • SES moderated BMI change, intervention worked better in lower SES families • Change in TV related to change in energy intake, but not to change in p.a. o reducing TV could reduce cues to eat o Budgeting technology gives child control of TV time and reduces need for parental diligence.
Esposito [207] ***Regression of Carotid Atherosclerosis by***	Randomized Single-blind trial	Drug-naïve patients with type 2 diabetes 35-70 years old	N = 175	12 months	• Repaglinide • Glyburide	• Reduction of postprandial hyperglycemia in type 2 diabetic patients is associated with carotid intima-media thickness

Control of Postprandial Hyperglycemia in Type 2 Diabetes Mellitus						
[208] **Ford, Sophia** ***Primary Care Intervention to Reduce Television Viewing in African-American Children***	RCT	Age: 9 yr. +- 1 Black 53% female BMI: 21.9 +- 5 Low SES	N=28 (families with 7-12 yr. old AA children)	Baseline and intervention session; 4 weeks follow-up	• Counseling intervention: prepared script discussing potential problems w/ excessive TV use (5-10 mins) • Counseling intervention + behavior intervention: additional 15-50 min discussion based in Social-Cognitive Theory, ID/Choose/Stick to TV budget	• Both groups: decrease time spend watching TV and total TV use • C +B intervention: sig. increase in organized p.a., trend playing outside • Behavioral int. parents reported device as helpful
[100]**Gardiner** ***Feasibility of reducing older adults' sedentary time***	Pre-post design	Age: 74 +- 9 BMI: 27 +- 4 75% women Australian Self-report >= 2 hr. TV/day	N=59	6-day baseline assessment, 1 intervention session, 6-day follow-up	• "Stand up for your Health" stand-up and move after 30 minutes o review accelerometer sedentary time o sedentary time feedback given comparison o goal setting to reduce sedentary time o behavior specific action plan	• Sig reduction in sedentary time • Increase # of breaks/day, % time spend in light p.a. and mvpa. • Overall, hour dependent on behavior • high approval of program

Gortmaker[209] ***Reducing Obesity via a School-Based Interdisciplinary Intervention Among Youth***	Randomized, controlled, field trial	Ethnically diverse Grades 6-7 Massachusetts	N = 1295	2 school years	• Planet Health Sessions o PE materials, wellness sessions, classroom lessons, teacher training, fitness funds. • Control	• Prevalence of obesity among girls in intervention schools was reduced compared with controls, controlling for baseline obesity o No differences among boys • Greater remission of obesity among intervention girls vs. control girls • Intervention reduced TV hours among girls/boys, and increased fruit/vegetable consumption and resulted in smaller increment in total energy intake among girls • Reductions in TV predicted obesity change and mediated intervention effect • Among girls, each hour of TV reduction predicted reduced obesity prevalence.

Hamilton [210] ***Role of local contractile activity and muscle fiber type on LPL regulation during exercise***	Experimental	Female Sprague-Dawley rats	N = 12	14-20 days	• Voluntary Run Training Model o High intensity activity for cumulative duration of 3.4 h/d o Control • Hind Immobilization o Legs casted for 7 days o control	• Short-term voluntary run training increased LPL mRNA concentration and LPL immune-reactive mass about threefold in white skeletal muscles • Training also increased total and heparin-releasable LPL enzyme activity in white hind-limb muscles and in post-heparin plasma • Training did not enhance LPL regulation in a white muscle that was not recruited during running • In resting rats, local electrical stimulation of a motor nerve to a predominately white muscle caused a significant rise in LPL mRNA, immune-reactive mass, and enzyme activity relative to the contralateral control muscle of same animals. • LPL expression was several times greater in a red muscle of rats with normal postural activity than rats with immobilized hind-limbs • Support the hypothesis that local contractile activity is required for increasing LPL expression during exercise training and for maintaining a high level of LPL expression in postural muscles

Lautenschlager [211] ***Effect of Physical Activity on Cognitive Function in Older Adults at Risk for Alzheimer Disease***	RCT	Individuals with memory problems but not dementia individuals Aged 50 years+	N = 138	24 weeks, 18-month follow-up	• Usual Care • Intervention; Home-Based program of physical activity (150 min moderate p.a.)	• Intervention group improved 0.26 points, those in the usual care group deteriorated 1.04 points at end of intervention on Alz. Cognitive scale • At 18 months, intervention group improved 0.73 points and those in the usual care group improved 0.04 points (on Alz. Cognitive scale.
Levine [212] ***Role of Nonexercise Activity Thermogenesis in Resistance to Fat Gain in Humans***	Experimental trial	Non-obese adults 25-36 years old	N = 16	8 weeks	• Supervised overfeeding by 1,000 kcal/d	• Two-thirds of increase in total daily energy expenditure due to increased NEAT • Changes in NEAT accounted for 10-fold differences in fat storage that occurred and directly predicted resistance to fat gain with overfeeding • Suggests that, as humans overeat, activation of NEAT dissipates excess energy to preserve leanness and that failure to activate NEAT may result in ready fat gain.

Ni Mhurchu[167] ***Couch Potatoes to jumping beans: A pilot study of the effect of active video games on physical activity in children***	RCT	Children 12 years old 40% female	N = 20	12 week intervention	• Control; no intervention • Intervention o Received an active video game upgrade package for 12-weeks	• Children in intervention group spent less time playing video games compared to control • Average time spent in all physical activity (objectively measured) was higher in intervention compared to control • Positive effect of active video games in reduction of time spent seated
Ni Mhurchu [169] ***Effect of electronic time monitors on children's television watching***	RTC- home based intervention	Children 9-12 years old Watched more than 20 hours TV/week	N = 29	weeks	• Control o Verbal advice to restrict TV time • Intervention o Electronic TV time monitor, advice to restrict to 1 hr./d or less	• TV watching decreased 4.2 h/week in intervention compared with no change in control o no sig differences between TV monitoring group and control • Both groups reported decreases in energy intake form snacks and total screen time and increases in P.A. (objectively measured) o Between group differences not significant ** no additional TV limiting agents in this study

[99] **Otten** ***Effects of Television Viewing Reduction on Energy Intake and Expenditure in Overweight and Obese Adults***	RCT	42 +-13 years 70% female 31 +- 5 BMI 95% white 4 hour TV/day	N=36	Total 6 week protocol Phase 1 (3 weeks) observational period Phase 2 (3 week intervention/control period)	• Observation only • Intervention; reduce TV viewing by 50% from participants objectively measured phase 1 viewing time. Coded budget system	• Non-significant reduction in EI both groups • Intervention increased EE (119 kcal/d), greater reduction in BMI (-0.25). decrease time spent in sedentary activities. • Reducing TV viewing produced a statistically sig. increase in energy expenditure but no apparent change in energy intake after intervention • TV viewing decreased in both groups (seasonality issue?)
Reilly[171] ***Physical activity to prevent obesity in young children***	Cluster- RCT	Pre-school and home setting Scottish children aged 4 years	N= 545	24 week intervention; 6 and 12 months follow-up	• Control; no intervention • Intervention o Enhanced physical activity program in nursery (3-30 minute sessions/week for 24 weeks) o Home-based education to increase active play and reduce sedentary behavior	• Objectively measured total sedentary time was not significantly different between intervention and control children • Children in the intervention group had significantly higher performance in movement skill tests than control. • ** Inability to show an intervention effect on overall sedentary time suggest that children may have replaced TV viewing with other sedentary pursuits.
[213] **Robinson**	RCT- matched schools	8.9 year olds (3^{rd}/4^{th} grade)	N=206	6 months	• Control • Intervention; 18-lesson, 6-month classroom curriculum	• Intervention groups sig decreases in child-report TV viewing, meals eaten in front of TV.

Reducing Children's Television Viewing to Prevent Obesity		48% female			to reduce TV, video and game use.	• decreases in BMI, skin-fold, waist circumference • No differences for change in high-fat food intake, MVPA, fitness
Robinson[214] ***Dance and reducing television viewing to prevent weight gain in african-american girls: the stanford GEMS Pilot study.***	RCT; 2 arm parallel group	8-10 year olds African-American girls and their parents Low SES neighborhood	N=61	12 week	• active control intervention: disseminating newsletters and health education lectures • Treatment intervention: after-school dance classes, 5-lesson intervention delivered in home, to reduce TV, game use.	• all interventions received high satisfaction ratings • Treatment groups showed **trends** in; lower BMI, waist circumference, increased after school p.a., reduced TV time ~5 h/week. • Confirmed feasibility, acceptability, potential efficacy of using dance class and family-based intervention to reduce TV viewing in AA Girls

Salmon[174] ***A translational research intervention to reduce screen behaviors and promote physical activity among children: Switch-2-Activity***	RCT; school-based	Disadvantaged Australian schools Grades 5 and 6	N= 908	6 lessons over 7 weeks	• Wait-list control condition • Intervention Schools o 6 lessons to promote health behaviors (self-monitoring, behavioral contracts, TV budgeting).	• Reported positive effects on children's self-efficacy for reducing TV viewing and behavioral capability. • Small but positive effects on boys' self-reported weekend screen time (~20 min difference btw intervention and control)

[173,215]**Salmon** ***Reducing sedentary behaviour and increasing physical activity among 10-year-old children: overbiew and process evaluation of the "Switch-Play" intervention***	RCT (Switch-play)	Australian
		10-year olds, grade 5
		1 of 3 gov primary schools
		low SES suburbs
			N=306	adapted from SPARK
				19 sessions integrated into school curriculum
				*double (38 session) for combined BM/FMS groups
				1 school year
				6-mo and 12-mo follow-up
					• behavioral modification (BM)
					  o Reduce screen-based behaviors, identified p.a. alternative
					• fundamental motor skills (FMS)
					• Mastery of 6 skills: run, throw, dodge, strike, vertical jump, kick
					• combined behavior/motor skills (BM/FMS)
					  o both behavioral/motor lessons
					• Control
						• 42% self-report by children in the BM and BM/FMS group thought that the lessons made a difference in their physical activity
						• 88% of parents recalled signing their child's "switch off contract"
						• BM/FMS averages -1.88 BMI units less than control adjusting for food freq and MVPA, effects maintained 6,12-mon post intervention, also less likely to be overweight/obese at base and post
						• FMS had higher levels and more enjoyment of PA than control
						• BM has higher levels of PA and TV viewing across all 4 time-points (229 min more/week than control) (response-shift bias)
						• GENDER moderated intervention effects for participation and enjoyment of p.a. and fundamental motor skills
						• Intervention children reported higher levels of TV viewing at post-intervention than control children.

Spruijt-Metz[172] **Reducing sedentary behavior in minority girls via a theory-based, tailored classroom media intervention**	RCT school-matched	School with high Latina population
		Middle-school girls
		Age: 12.5 years old
			N = 459	5-7 days
				Measures 3 months prior to intervention and 3 months post intervention
					• Control; no intervention
					• Get Moving! Intervention
					  o 5-7 classroom sessions
					  o Behavioral theory based public service announcements aimed at increasing positive meaning of physical activity and intrinsic motivation for exercise
						• Intervention significantly reduced time spent on sedentary behavior, significantly increased intrinsic motivation

[33] **Steeves** ***Can sedentary*** ***behavior be made*** ***more active? A*** ***randomized pilot*** ***study of TV*** ***commercial stepping*** ***verus walking***	RCT	56 white; 2 black 52 +-b 8 yrs. old BMI: 33.5 +- 4 4.2 +- 1 hr./day TV viewing 4760 +1400 steps/day	N=58	6 months	• TV commercial stepping • Walking 30 min/day o Both: 6 monthly phone calls, monthly meetings first 3 months, monthly newsletters last 3 months.	• Commercial stepping and walking groups increased steps ~3,000 steps/day above baseline, no difference between groups. o Self-report TV viewing decreased in both groups, 1 hr. less than baseline o Biggest challenges in both groups, finding the time to be physically active, staying motivated. o both groups likely to continue intervention on own

Stephens [216] ***Effects of 1 day of inactivity on insulin action in healthy men and women***	Counterbalanced, cross-over	14 men and women (7 of each) 19-32 years old non-obese	N = 14	3; 24 hour experimental sessions	• NO-SIT o Active condition with minimal sitting • SIT o Prolonged sitting without concomitant reduction in energy intake • SIT-BAL o Inactivity with reduced energy intake	• Compared with NO-SIT, insulin action was reduced by; o 39% SIT o 18% SIT-BAL • Insulin action was higher in SIT-BAL compared with SIT • One day of sitting considerably reduced insulin action o This effect was minimized, but not prevented, when energy intake was reduced to match expenditure
Todd[168] ***Effect of a family-based intervention on electronic media use and body composition among boys aged 8-11 years***	Single-blind, between-group, treatment by time experimental design	Families with at least one boy between 8-11 years old Exceeded media use of 5.8 hours/day	N = 22	20-week intervention	• Control Group; matched • Experimental group o Enhanced awareness of electronic media use and sets goals to minimize use o TV Allowance and ENUFF (monitor)	• Reduction in TV time among experimental group • At 10 weeks, step counts increased by 534 steps/day on experimental and decreased by 340 steps/day in control • Steps in both groups were higher at 20 weeks • Meals/snack during media use decreased in intervention only. • **additional limiting agents used in this study

APPENDIX B

RECRUITMENT FORM

1. *Thank you for your interest in our study. My name is Lori Portzer and I would briefly like to tell you about this research study.*

2. **Procedure for Describing the Study and Obtaining Verbal Consent to Conduct the Phone Screen:** A description of the study will be read to participants, and this description includes important components of the informed consent process. Individuals who express an interest in participating in this study will be told the following to obtain verbal consent:

- **Investigators Component of Informed Consent:** *The study is being conducted by Lori Portzer at the University of Pittsburgh.*
- **Description Component of Informed Consent:** *The purpose of this study is to examine the effect of prompted stepping behavior during a television program. We are interested in recruiting 40 men and women, aged 18-55, who are able to walk for exercise. If you are found to be initially eligible for the study after this phone screening, we will invite you to the laboratory near the University of Pittsburgh Oakland Campus for an orientation session where the full details of the study will be described to you, you will have a chance to ask questions, and if you are interested in participating, you will be asked to sign a consent document. Next, we will ask you to complete a physical assessment, including measurement of your height and weight, and other factors that may influence your ability to participate in the study. It is possible that after this screening session, you may not be eligible to participate in the study. If you are determined to be eligible after the screening visit, you will be asked to complete three experimental sessions, whose order will be randomly assigned. Each experimental session will last for one hour. In one session you will be asked to sit quietly and watch a television program. During the other two sessions you will be*

prompted to stand and step in place during various segments of the television program. During each session, all participants will undergo testing of their energy expenditure and heart rate. Upon the full completion of all study procedures, you will be given $60 for your participation.

- *If you are interested in participating in this study, I will need to ask you a few questions about your demographic background and questions about your physical health and medical history to determine if you appear to be eligible to participate in this study. It will take approximately 5 minutes to ask you all of the questions. If we complete the interview, I will ask you for some specific information (your complete name, date of birth, and mailing address) so that we can contact you regarding your participation in tis study. I will then schedule you to attend a session that will explain all of the procedures of this study in greater detail.*

- *Your responses to these questions are confidential, and all information related to your health history or current behaviors that you are about to give me will be destroyed after this interview if you are found to be ineligible*

- *Do you have any questions related to any of the information that I have provided to you?* Principle Investigator will answer any questions. If the individual would like to think about their participation prior to proceeding with the Phone Screen, they will be provided with the telephone number that they can call if they decide to participate in the future.

- **Voluntary Consent Component of Informed Consent:** *Do you agree that the procedures that will be used to conduct this Phone Screen have been described to you, all of your questions have been answered, and you give me permission to ask you questions now as part of the initial Phone Screen?*

- If "YES", indicate the participant's agreement with this statement on the top of the next page, sign your name and date the form, and then complete the Phone Screen.
- If "NO", thank the individual for calling and <u>do not</u> complete the Phone Screen.

Phone Screen Interview

Telephone Screening Number_____

The caller gives verbal permission to conduct the Phone Screen:
_____ YES _____NO

Verbal Assent was given to:

_____
Staff Member Signature

_____
Date Verbal Assent was given:

Eligible based on telephone screening: ☐ Yes ☐ No
If "No", list reason for ineligibility:

_____
_____

1. Gender: ☐Male ☐Female
2. Age: ☐☐(18 - 55)
3. Current Weight: ☐☐☐pounds
4. Current Height: ☐feet ☐inches

Office Use: BMI _____ (18.5 to <40 kg/m^2)

5. Are you able to walk without an assistive device (like a cane or walker)?

☐Yes ☐No

6. Have you ever been told by a doctor or other medical person that you have any of the following conditions?

   a. Heart Disease ☐Yes **☐No**
   b. Angina ☐Yes **☐No**
   c. Hypertension ☐Yes **☐No**
   d. Heart Attack ☐Yes **☐No**
   e. Stroke ☐Yes **☐No**
   f. Diabetes ☐Yes **☐No**
   g. Cancer ☐Yes **☐No**

7. Do you take any prescription medication? ☐Yes **☐No**

   If "yes", specify the following:

Medication Name	Used to Treat:

WOMEN ONLY COMPLETE THE FOLLOWING QUESITONS

8. a. Are you currently pregnant? ☐Yes **☐No**
   b. Have you been pregnant in the last 6 months? ☐Yes **☐No**

c. Have you been breast-feeding in the past 3 months? ☐Yes ☐**No**

d. Are you currently lactating? ☐Yes ☐**No**

Contact Tracking Form

THIS PAGE IS COMPLETED ONLY IF THE RESPONDANT APPEARS TO QUALIFY FOR PARTICIPATION IN THIS SUTDY AND IS SCHEDULED FOR THE ORIENTATION VISIT

DATE: _____/_____/_____

Staff Member Completing Form: _____

Name: _____

Street Address: _____

City: _____ State: _____ Zip Code: _____

Phone Number: _____

OFFICE USE ONLY:

Eligible: ☐ YES ☐ NO

Invited to Orientation Session: ☐ YES ☐ NO

Date of Orientation Session: _____/_____/_____

If the participant appears to be eligible tell the participant that their information will be reviewed by the investigators and if eligible they will be notified by mail or telephone call to be invited to an orientation session.

APPENDIX C

EXPERIMENTAL SESSION FORMS

SED-TV Session

Session Script

□ Current Time: _____ AM / PM

- □ Time of last meal: _____ AM/ PM
- □ Have you exercised in the past 24 hours? YES / NO
    - o If YES, what was the time of your last exercise bout: _____AM/PM
- □ Fit heart rate monitor
- □ **Read the following script prior to fitting the facemask**
  Sedentary Television Viewing Session (SED-TV): *You are about to watch 'The Big Bang Theory', Season 1 Episode 6 "The Middle Earth Paradigm". During this episode we ask that you remain seated during the entire show and the commercials, and not engage with the investigators unless you feel an emergency coming on. This would include dizziness, nausea, light-headedness or any other cause for concern. As you are seated we ask that you keep your feel flat on the floor, and keep your ankles, knees and hips at right angles, with relaxed arms and hands rested in your lap like so.* **(Investigator will demonstrate proper sitting position)**. *Do you have any questions before we start?*
- □ Fit Oxycon unit
- □ 5 minute rest
- □ Start SED-TV Video
- □ Remove Oxycon unit and heart rate monitor

SED-TV Session

Heart Rate Sheet

□ 80% AGE PREDICTED MAX HEART RATE: _____

SED-TV Session

Heart Rate Sheet

□ 80% AGE PREDICTED MAX HEART RATE: _____

	Time	Heart Rate	Time	Heart Rate	Time	Heart Rate	Time	Heart Rate
	0:00	Warm-up	7:30	bpm	18:00	bpm	28:30	bpm
	1:00	Warm-up	8:00	bpm	18:30	bpm	29:00	bpm
	2:00	Warm-up	8:30	bpm	19:00	bpm	29:30	bpm
	3:00	Warm-up	9:00	bpm	19:30	bpm	30:00	bpm
	4:00	Warm-up	9:30	bpm	20:00	bpm		
	5:00	Warm-up	10:00	bpm	20:30	bpm		
START RECORDING	0:00	bpm	10:30	bpm	21:00	bpm		
	0:30	bpm	11:00	bpm	21:30	bpm		
	1:00	bpm	11:30	bpm	22:00	bpm		
	1:30	bpm	12:00	bpm	22:30	bpm		
	2:00	bpm	12:30	bpm	23:00	bpm		
	2:30	bpm	13:00	bpm	23:30	bpm		
	3:00	bpm	13:30	bpm	24:00	bpm		
	3:30	bpm	14:00	bpm	24:30	bpm		
	4:00	bpm	14:30	bpm	25:00	bpm		
	4:30	bpm	15:00	bpm	25:30	bpm		
	5:00	bpm	15:30	bpm	26:00	bpm		
	5:30	bpm	16:00	bpm	26:30	bpm		
	6:00	bpm	16:30	bpm	27:00	bpm		
	6:30	bpm	17:00	bpm	27:30	bpm		
	7:00	bpm	17:30	bpm	28:00	bpm		

COMM-TV Session

Session Script

- □ Current Time: _____ AM / PM
- □ Time of last meal: _____ AM/ PM
- □ Have you exercised in the past 24 hours? YES / NO
    - o If YES, what was the time of your last exercise bout: _____AM/PM
- □ Fit heart rate monitor
- □ **Read the following script prior to fitting the facemask**
- □ **Commercial Stepping Television Viewing Session (COMM-TV):** *You are about to watch 'The Big Bang Theory', Season 1 Episode 6 "The Middle Earth Paradigm". During this episode we ask that you remain seated during the entire show. During the commercials breaks you will be asked to stand and step in place for the entire duration of the commercial break. An on-screen remembrance prompt will appear in the bottom right hand corner of the screen in the form on a stick man* **(investigator will point to the area on screen prompt will appear)** *to remind you of when you should start stepping. The remembrance prompt will disappear when you should cease stepping. If you have not stood when you are supposed to, I will verbally prompt you as "Stand". If you have not ceased stepping when you are supposed to, I will verbally prompt you as "Sit". As you are seated we ask that you keep your feel flat on the floor, and keep your ankles, knees and hips at right angles, with relaxed arms and hands rested in your lap like so.* **(Investigator will demonstrate proper sitting position)**. *When you step in place we ask that you stand and step in place continuously at a 'moderate-pace', with each foot stepping off the ground about 15-20 centimeters. I will show you an example of what 15-20 centimeters will look like.* **(Investigator will demonstrate proper foot height)**. *Please notice we are asking you to step at a pace that is moderate for you, we will not give you any feedback on how fast or slow you should step, unless you are stepping at level that exceeds 80% of your age-predicted maximal heart rate. If this were to occur we would ask you to reduce your stepping cadence until you heart rate is below this level. I will signal you as follows.* **(Investigator will demonstrate low to signal lowering stepping cadence).** *We ask that you not engage with the investigators unless you feel an emergency coming on. This would include dizziness, nausea, light-headedness or any other cause for concern. Do you have any questions before we start?*
- □ Fit Oxycon unit
- □ 5 minute rest
- □ Start COMM-TV Video
- □ Remove Oxycon unit and heart rate monitor

COMM-TV Session

Heart Rate Sheet

□ 80% AGE PREDICTED MAX HEART RATE: _____bpm

	Time	Heart Rate	Time	Heart Rate	Time	Heart Rate	Time	Heart Rate
	0:00	Warm-up	7:30	bpm	18:00	bpm	28:30	bpm
	1:00	Warm-up	8:00	bpm	18:30	bpm	29:00	bpm
	2:00	Warm-up	8:30	bpm	19:00	bpm	29:30	bpm
	3:00	Warm-up	9:00	bpm	19:30	bpm	30:00	bpm
	4:00	Warm-up	9:30	bpm	20:00	bpm		
	5:00	Warm-up	10:00	bpm	20:30	bpm		
START RECORDING	0:00	bpm	10:30	bpm	21:00	bpm		
	0:30	bpm	11:00	bpm	21:30	bpm		
	1:00	bpm	11:30	bpm	22:00	bpm		
	1:30	bpm	12:00	bpm	22:30	bpm		
	2:00	bpm	12:30	bpm	23:00	bpm		
	2:30	bpm	13:00	bpm	23:30	bpm		
	3:00	bpm	13:30	bpm	24:00	bpm		
	3:30	bpm	14:00	bpm	24:30	bpm		
	4:00	bpm	14:30	bpm	25:00	bpm		
	4:30	bpm	15:00	bpm	25:30	bpm		
	5:00	bpm	15:30	bpm	26:00	bpm		
	5:30	bpm	16:00	bpm	26:30	bpm		
	6:00	bpm	16:30	bpm	27:00	bpm		
	6:30	bpm	17:00	bpm	27:30	bpm		
	7:00	bpm	17:30	bpm	28:00	bpm		

COMM-TV Session

Step Sheet

COMM-TV Session

Step Sheet

Time Commercial Started	Time Ppt Stood Up	Time Commercial Ended	Time Ppt Sat Down
2:49		3:47	
12:10		16:08	
24:36		28:54	

Please place an asterisk (*) to the left of the "Time Commercial Started/Ended" if a verbal prompt was needed to elicit start or ending stepping action.

PATV Session

Session Script

- □ Current Time: _____ AM / PM
- □ Time of last meal: _____ AM/ PM
- □ Have you exercised in the past 24 hours? YES / NO
    - o If YES, what was the time of your last exercise bout: _____AM/PM
- □ Fit heart rate monitor
- □ **Read the following script prior to fitting the facemask**
- □ **Prompted Active Television Viewing Session (PATV):** *You are about to watch 'The Big Bang Theory', Season 1 Episode 6 "The Middle Earth Paradigm". During this episode you will be asked to remain seated during the commercial breaks. During the television show, you will be prompted to stand and step in place when the following character mannerisms/prompts occur.* **(Investigator will give subject list of character mannerisms/prompts).** *When one of these prompts occurs you will be asked to stand and step in place for 60 seconds. Each prompt will elicit a 60-second stepping bout, therefore, if a second prompt occurs during a bout in which you are already stepping, an additional 60-seconds is to be added to the end of that bout. An on-screen remembrance prompt will appear in the bottom right hand corner of the screen in the form on a stick man and countdown clock* **(investigator will point to the area on screen prompt will appear)** *to remind you of when you should start stepping, and how long you should step for, if a second prompt occurs during a bout in which you are already stepping, the additional 60-seconds will be added to the countdown clock. The remembrance prompt will disappear when you should cease stepping. If you have not stood when you are supposed to, I will verbally prompt you as "Stand". If you have not ceased stepping when you are supposed to, I will verbally prompt you as "Sit". As you are seated we ask that you keep your feel flat on the floor, and keep your ankles, knees and hips at right angles, with relaxed arms and hands rested in your lap like so.* **(Investigator will demonstrate proper sitting position)**. *When you step in place we ask that you stand and step in place continuously at a 'moderate-pace', with each foot stepping off the ground about 15-20 centimeters. I will show you an example of what 15-20 centimeters will look like.* **(Investigator will demonstrate proper foot height)**. *Please notice we are asking you to step at a pace that is moderate for you, we will not give you any feedback on how fast or slow you should step, unless you are stepping at level that exceeds 80% of your age-predicted maximal heart rate. If this were to occur we would ask you to reduce your stepping cadence until you heart rate is below this level. I will signal you as follows.* **(Investigator will demonstrate low to signal lowering stepping cadence).** *We ask that you not engage with the investigators unless you feel an emergency coming on. This would include dizziness, nausea, light-headedness or any other cause for concern. Do you have any questions before we start?*
- □ Fit Oxycon unit
- □ 5-minute rest

- □ Start PATV Video
- □ Remove Oxycon unit and heart rate monitor

Heart Rate Sheet

□ 80% AGE PREDICTED MAX HEART RATE: _____bpm

	Time	Heart Rate	Time	Heart Rate	Time	Heart Rate	Time	Heart Rate
	0:00	Warm-up	7:30	bpm	18:00	bpm	28:30	bpm
	1:00	Warm-up	8:00	bpm	18:30	bpm	29:00	bpm
	2:00	Warm-up	8:30	bpm	19:00	bpm	29:30	bpm
	3:00	Warm-up	9:00	bpm	19:30	bpm	30:00	bpm
	4:00	Warm-up	9:30	bpm	20:00	bpm		
	5:00	Warm-up	10:00	bpm	20:30	bpm		
START RECORDING	0:00	bpm	10:30	bpm	21:00	bpm		
	0:30	bpm	11:00	bpm	21:30	bpm		
	1:00	bpm	11:30	bpm	22:00	bpm		
	1:30	bpm	12:00	bpm	22:30	bpm		
	2:00	bpm	12:30	bpm	23:00	bpm		
	2:30	bpm	13:00	bpm	23:30	bpm		
	3:00	bpm	13:30	bpm	24:00	bpm		
	3:30	bpm	14:00	bpm	24:30	bpm		
	4:00	bpm	14:30	bpm	25:00	bpm		
	4:30	bpm	15:00	bpm	25:30	bpm		
	5:00	bpm	15:30	bpm	26:00	bpm		
	5:30	bpm	16:00	bpm	26:30	bpm		
	6:00	bpm	16:30	bpm	27:00	bpm		
	6:30	bpm	17:00	bpm	27:30	bpm		
	7:00	bpm	17:30	bpm	28:00	bpm		

PATV Session

Step Sheet

Time Prompt Started	Time Ppt Stood Up	Time Prompt Ended	Time Ppt Sat Down
0:14		1:14	
3:50		4:50	
4:59		5:59	XXXXXXXXXX
5:45	XXXXXXXXXX	6:59	XXXXXXXXXX
6:52	XXXXXXXXXX	8:00	
17:34		18:34	
21:41		22:42	XXXXXXXXXX
21:48	XXXXXXXXXX	23:42	
28:55		29:55	
Please place an asterisk (*) to the left of the "Time Prompt Started/Ended" if a verbal prompt was needed to elicit start or ending stepping action.			

APPENDIX D

MPACES QUESTIONNAIRES

Subject ID: _____ Date: _____

mPACES – 1st Session

Place an "X" in the box that best corresponds with your answer to each statement related to the television viewing session that you just completed.

	Disagree a Lot	Disagree Somewhat	Neither Agree or Disagree	Agree Somewhat	Agree a Lot
1. I enjoyed it					
2. I felt bored					
3. I disliked it					
4. I found it pleasurable					
5. It was not fun at all					
6. It gave me energy					
7. It made me feel depressed					
8. It was very pleasant					
9. My body felt good					
10. I got something out of it					
11. It was very exciting					
12. It frustrated me					
13. It was not interesting at all					
14. It gave me a strong feeling of success					
15. It felt good					
16. I felt as though I would rather be doing something else					

Subject ID: _____ Date: _____

mPACES-COMM-TV

Compare the Commercial Stepping session to the Sedentary Television session for each of the following statements. Place an "X" in the box that best corresponds with your answer to each statement.

	Commercial Stepping Session	Neither (Neutral)	Sedentary Television Session
1. Which did you enjoy more?			
2. Which made you feel more bored?			
3. Which did you like most?			
4. Which did you find to be more pleasurable?			
5. Which was more fun?			
6. Which gave you more energy?			
7. Which made you feel less depressed?			
8. Which was more pleasant?			
9. Which made your body feel good?			
10. Which did you feel you got something out of it?			
11. Which was more exciting?			
12. Which frustrated your more?			
13. Which was more interesting?			
14. Which gave you a strong feeling of success?			
15. Which felt good?			
16. Which made you feel as if you would rather be doing something else?			

Subject ID: _____ Date: _____

mPACES-PATV

Compare the Prompted Active Television session to the Sedentary Television session for each of the following statements. Place an "X" in the box that best corresponds with your answer to each statement.

	Prompted Active Television Session	Neither (Neutral)	Sedentary Television Session
1. Which did you enjoy more?			
2. Which made you feel more bored?			
3. Which did you like most?			
4. Which did you find to be more pleasurable?			
5. Which was more fun?			
6. Which gave you more energy?			
7. Which made you feel less depressed?			
8. Which was more pleasant?			
9. Which made your body feel good?			
10. Which did you feel you got something out of it?			
11. Which was more exciting?			
12. Which frustrated your more?			
13. Which was more interesting?			
14. Which gave you a strong feeling of success?			
15. Which felt good?			
16. Which made you feel as if you would rather be doing something else?			

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