2006

An assessment of obese and non obese girls' metabolic rate during television viewing, reading, and resting.

Theodore V. Cooper, *University of Texas at El Paso*
L. M. Klesges
M. W. DeBon
R. C. Klesges
M. L. Shelton

Available online at www.sciencedirect.com
SCIENCE DIRECT®
Eating Behaviors 7 (2006) 105–114
EATING BEHAVIORS

An assessment of obese and non obese girls' metabolic rate during television viewing, reading, and resting

Theodore V. Cooper [a,*], Lisa M. Klesges [b], Margaret DeBon [c], Robert C. Klesges [d], Mary Lee Shelton [e]

[a] Department of Psychology, University of Texas at El Paso, 500 University Avenue, El Paso, Texas 79968-0553, Unites States
[b] Division of Epidemiology, Department of Health Sciences Research, Mayo Clinic, United States
[c] Department of Preventive Medicine, University of Tennessee Health Sciences Center, United States
[d] Departments of Medicine and Psychiatry/Psychology, Mayo Clinic, United States
[e] Department of Psychology, The University of Memphis, United States

Received 20 January 2005; received in revised form 8 August 2005; accepted 18 August 2005

Abstract

While childhood obesity has been linked to television (TV) viewing, specific mechanisms are not well understood. Obesity related to TV viewing might plausibly be related to decreased physical activity, increased food intake, reductions in metabolic rate, or combinations of these. The current investigation sought to ascertain the metabolic effects of quiet rest, listening to a story, watching a passive TV program, and watching an active TV show. Counter-balanced conditions were presented to 90 pre-pubertal girls ranging in body mass index from underweight to obese. In addition, effects between resting energy expenditure (REE) and race, body mass index, skinfold measures, physical activity, pubertal stage and average hours spent viewing TV were explored. Results indicated no significant differences in metabolic rate between weight groups nor between activity conditions (story listening and TV viewing) and rest conditions. A significant dose-response relationship was found in which REE decreased as average weekly hours of TV viewing increased, after adjusting for body mass index and puberty stage. Additionally, later stages of pubertal development compared to earlier stages were related to higher levels of REE. Results of this study suggest that metabolic rate alone cannot account for the consistently observed relationship between television viewing and obesity. Future studies should focus on energy intake, physical inactivity, or combinations of these with metabolic rate in seeking specific mechanisms responsible for television viewing related to obesity.

Keywords: Children; Energy expenditure; Television; Obesity

1. Introduction

1.1. Childhood obesity and energy balance

The increasing prevalence of childhood obesity (Hedley et al., 2004; Ogden, Flegal, Carroll, & Johnson, 2002; Troiano & Flegal, 1998), its persistence into adulthood (Srinvasan, Bao, Wattigney, & Berenson, 1996; Valdez,

* Corresponding author. Tel.: +1 915 747 6270; fax: +1 915 747 6553.
E-mail address: tvcooper@utep.edu (T.V. Cooper).

1471-0153/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eatbeh.2005.08.007

Greenlund, Wattigney, Bao, & Berenson, 1996), and associations with adult health risks (Sinaiko, Donahue, Jacobs, & Prineas, 1999), places childhood obesity among the highest national health concerns (Schwimmer, Burwinkle, & Varni, 2003; Troiano & Flegal, 1998; USDHHS, 2000). According to recent reports, as many as 25% of children in the United States are currently overweight (defined as a BMI greater than the 85th percentile) (Troiano & Flegal, 1998) and prevalence trends have risen approximately two to six percent in most sex, age, and ethnic groups since the late1980’s and 1990’s (NHANES III) (Ogden et al., 2002). In fact, some studies suggest that obesity is becoming the leading cause of morbidity and mortality in the United States (Mokdad, Marks, Stroup, & Gerberding, 2004).

This increased prevalence of overweight in children supports a population trend towards disequilibrium in energy balance. That is, energy intake in the form of food consumption is greater than energy expenditure that results in positive energy balance leading to weight gain. Studies comparing normal weight and overweight children on elements of the energy balance equation however, have typically found that overweight children do not report a higher dietary intake (Laessle, Wurmser, & Pirke, 1997; Seidell, 1999), are not less physically active (Robertson et al., 1999), and do not demonstrate lower resting energy expenditure (Laessle et al., 1997; Puhl, 1989) compared to normal weight children. However, studies are inconsistent such that some do find clear differences between obese and normal children on measures of energy balance (see Kiess et al., 2001 for review), and consistent with the growing number of studies of childhood obesity, other factors (e.g., heredity, lifestyle) have been suggested as potential contributors to obesity in children.

1.2. Childhood obesity and television viewing

Children and adolescents spend a substantial amount of time watching television, as much as three years between the ages of 2 and 17 years (Robinson, 1998). In addition, the majority of studies assessing the relationship between television viewing and childhood obesity have found that television viewing appears to be an important contributor to increased body fatness (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Dietz & Gortmaker, 1985; Dietz & Strasburger, 1991; Fontvieille, Harper, Ferraro, Spraul, & Ravussin, 1993; Gortmaker et al., 1996; Hernandez et al., 1999). The National Growth and Health Study, a cohort study that assessed growth in 9–10 year-old African American and Caucasian children, showed a significant association between hours of television viewed and girls’ body mass index (Obarzanek et al., 1994). Another study suggested that television watching was positively associated with obesity in girls even after controlling for age, ethnicity, family income, weekly physical activity, and energy intake (Crespo et al., 2001). In addition, initial intervention studies attempting to reduce weight via reductions in television viewing have met with promising results (Robinson & Killen, 1995). Further, population based studies have found that television viewing is positively associated with increased risk of obesity while other sedentary behaviors, such as art, are negatively associated with being overweight (Tremblay & Willms, 2003). In an attempt to determine the mechanisms underlying the television viewing and obesity relationship, studies have examined the three components comprising the energy balance equation.

1.3. Television viewing and energy intake

First, television viewing may be related to increased energy intake, specifically intake of calorically dense foods. Studies of energy intake and television viewing have indicated that youths who watch a greater number of hours of television have higher fat diets (Robinson & Killen, 1995). Also, time spent viewing television correlated positively with children’s requests for and parents’ purchase of foods advertised on television (Taras, Sallis, Patterson, & Nelson, 1989), foods typically having a high fat content (Story & Faulkner, 1990), as well as with consuming a greater number of fast foods and soft drinks in adolescents (French, Story, Neumark-Sztainer, Fulkerson, & Hannan, 2001). In one study it was found that children consumed more red meat, pizza, snack foods, and soda when families had more frequent meals in front of the television (Coon, Goldberg, Rogers, & Tucker, 2001). In a recent study of African American girls, from one-fourth to one-third of average daily energy intake was consumed while watching television, and 40–50% of evening meals were consumed while watching television (Matheson et al., 2004).

1.4. Television viewing and physical activity

Second, television watching may be related to decreased physical activity and fitness in children. Research findings to date demonstrate equivocal relationships between television viewing and physical activity, with multiple studies demonstrating only a weak association between television viewing and components of physical activity and fitness (Armstrong, Sallis, Alcaraz, Kolody, & McKenzie, 1998; DuRant, Baranowski, Johnson, & Thompson, 1994; Katzmarzyk, Malina, Song, & Bouchard, 1998; Robinson et al., 1993). In fact, a meta-analysis of this literature concluded that the relationship between television viewing and physical activity is a weak negative one and suggested that single markers of sedentary behavior (e.g., television viewing) are not adequate to account for the relationships between sedentary behavior and obesity (Marshall, Biddle, Gorely, Cameron, & Murdey, 2004). Other studies however have found stronger relationships between television viewing, physical inactivity, and obesity (Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005; Janssen, Katzmarzyk, Boyce, King, & Pickett, 2004). Taken together, it seems that decreased physical activity cannot alone sufficiently account for observed differences in weight with increased television viewing; however, decreased physical activity in combination with other energy balance changes associated with television viewing certainly remains a possible explanation for increased weight.

1.5. Television viewing and metabolism

Finally, television viewing may be related to a lowered resting metabolic rate. That is, watching TV may lower energy expenditure to a greater extent than other sedentary behaviors such as sitting quietly or reading. Studies examining the potential link between metabolism and children's television viewing have been sparse. To date, we are aware of three studies describing this relationship (Dietz, Bandini, Morelli, Peers, & Ching, 1994; Horswill, Kien, & Zipf, 1995; Klesges, Shelton, & Klesges, 1993). Horswill et al. (1995) measured resting energy expenditure in eight adolescents while walking at 40% peak oxygen uptake, playing a stringed instrument, and watching television. The results of this study suggested that walking or playing an instrument resulted in greater energy expenditure than did television viewing. Horswill et al. (1995) concluded that television viewing was not associated in this study with reduced metabolic rate. Similarly negative findings were reported by Dietz et al. (1994) in which resting metabolic rate was assessed in nine obese and eighteen nonobese girls during television viewing, reading, and sitting quietly. There were no differences in metabolic rate across activity conditions for either group (Dietz et al., 1994). In addition, this study examined fidgeting during the activities and found that although children appear to fidget more while sitting quietly as opposed to watching television or reading, fidgeting appears to affect only "minute to minute variation of resting metabolic rate," not the general level of resting energy expenditure (Dietz et al., 1994). Contrary to the findings of these two studies, Klesges et al. (1993) found that resting energy expenditure in 15 obese and 16 normal weight prepubertal girls was significantly reduced while watching television. In this study, although the differences in change in REE between obese (−228 kcal/24 h) and non-obese (−104 kcal/24 h) children were not statistically significant, these findings seem clinically significant and worth exploring with a larger sample. It should be noted that all three studies of metabolism and television viewing have used small samples and television viewing during metabolic measurement. Studies assessing a relationship between regular patterns of television viewing and obesity have been performed (e.g., Crespo et al., 2001); however, studies assessing metabolic differences based on viewing patterns are lacking in the literature.

1.6. Pubertal development and metabolism

Studies have demonstrated a link between pubertal development and obesity, such that BMI and pubertal development are positively correlated (Burrows, Diaz, & Muzzo, 2004; Mendel, Zimlichman, Mimouni, Grotto, & Kreiss, 2004); however, far fewer studies have assessed differences in metabolic rate based on pubertal development. Molnar and Schutz (1997) examined the relationship and found that resting metabolic rate advanced with pubertal stage; however, this relationship was no longer significant after controlling for fat mass and fat free mass. Conversely, another study of children and adolescents found that energy expenditure *decreased* with advancing pubertal stage (Harrell et al., 2005). To add to these discrepant findings, one other study of obese and non obese children and adolescents found no significant contribution of pubertal development to REE (Rodriguez et al., 2002). As a result, continued assessment of this relationship is warranted in an effort to further clarify the relationship between pubertal development and metabolism.

1.7. Aims

Given inconsistent correlations observed in studies of obesity and television viewing as well as the limited and discrepant findings from studies exploring metabolic effects of television viewing, there is a clear need to further investigate these associations. Therefore the purposes of the present study are two-fold. The first aim is to examine the effect of television viewing on energy expenditure in obese and non-obese girls by comparing the metabolic effects of a resting condition with two different types of television (passive versus active/stimulating) programs and a non-television attentional activity (i.e., listening to a story). Secondary analyses were performed to determine whether REE was related to average weekly television viewing patterns and stage of pubertal development.

2. Methods

2.1. Participants

Prepubertal girls, between the ages of 7 and 12, were recruited from the Memphis community by advertisement. To ensure the recruitment of a biracially balanced sample, girls were recruited through a number of means (e.g., specialty newspapers, churches), and not only were monetary incentives provided ($75), but also babysitting of other children was arranged if needed. Selection criteria included meeting the age range requirements, no current medication use, no history of attention deficit disorder (with or without hyperactivity), and at the time of the study, no history of menstruation (i.e., pubertal development less than Tanner Stage 4). The sample was balanced on ethnicity to achieve a 50% African American representation. Ninety girls met the eligibility criteria and agreed to participate in the study that was approved by an appropriately constituted institutional review board at the University of Memphis. Parents or legal guardians provided informed consent for their child.

Participants averaged 9.4 years of age (SD = 1.5), had a mean height of 55.9 inches (SD = 4.29), had a mean weight of 80.96 pounds (SD = 19.6), had a mean BMI of 18.02 (SD = 2.92), had a mean resting metabolism of 1346.5 kcal/day (SD = 217.8), were equally divided biracially, over half had the highest category of income, and the majority of participants watched between 7 and 14 h of television per week.

2.2. Measures

In addition to demographic measures of age and race/ethnicity, the girls were assessed on pubertal development, body mass index, skinfold thickness, and energy expenditure under various study conditions. Additionally, a short questionnaire included items on the number of hours of television viewed each week.

2.2.1. Tanner staging

Pubertal development was assessed according to the Tanner Scale for both breast and pubic hair (Marshall & Tanner, 1969). Tanner stages range from 1 to 5, with increasing stages indicating advancing breast and pubic hair development. All staff that assessed pubertal development were trained by the lab supervisor.

2.2.2. Anthropometrics

A trained technician obtained a height measurement to the nearest 0.6 cm with a height chart affixed to a wall. Weight was measured with a hospital-grade electronic scale, accurate to +0.09 kg calibrated once weekly. Both measures were determined without shoes. Body mass index was determined by the formula (kg/m^2).

Skinfold thickness (triceps and subscapular) was measured with a Lange caliper by a singular trained technician. The triceps skinfold was measured halfway between the acromion and the olecranon process, and the subscapular skinfold was taken in the area just below the lower part of the shoulder blade. Triplicate measures were made according to a standardized protocol and averaged for analyses.

2.2.3. Obesity status

Participants were considered obese in this study if 1) their weight measurement was greater than 20% of the average weight for their height, age and sex (as indicated in the National Department of Health and Human Services norms (USDHHS, 1987) and; 2) tricep and subscapular skinfold thickness was greater than or equal to the 85th percentile (Slaughter et al., 1988). Participants considered normal weight were required to score within the normal-weight range on both criteria (Klesges et al., 1993).

2.2.4. Television viewing

A single item was used to obtain parent-reported hours of television watched, “Approximately how many hours does your child spend watching television each week?” Parents chose from 4 categorical responses: 1) less than 7 h, 2) 7–14 h, 3) 14–21 h, and 4) more than 21 h.

2.2.5. Energy expenditure assessment

Energy expenditure measurements were obtained in one metabolic laboratory where participants could be observed at all times. Measurements were taken by lab technicians trained and certified to assess energy expenditure through the protocol. Resting energy expenditure was measured using a Critical Care Monitor Desktop Analysis system (Medical Graphics Corporation, Minneapolis, MN), which includes a microcomputer, a pneumotach, and two gas (CO_2, O_2) analyzers. REE was determined through indirect calorimetry, the measurement of the heat of metabolism via oxygen consumption and carbon dioxide production. During the testing, the participant’s expired air was collected through a canopy system that consists of a clear, plastic, space-helmet design enclosing the head. A tube connects the canopy to a gas analyzer where breath-by-breath observations were recorded and immediately sent to a digital computer for monitoring. This breath-by-breath technology allows for immediate evaluation of subtle changes in metabolic rate. These methods have shown to be highly replicable and valid (Jequier, 1986; Isbell, Klesges, Meyers, & Klesges, 1991).

2.3. Procedure

Participants were scheduled for one morning session, lasting no more than three hours. To control for the effects of digestion, caffeine and physical activity on metabolic rate, participants were instructed not to eat, drink (excluding water), chew gum, or exercise after 10:00 p.m. the night before they came into the laboratory.

To control for possible effects of time of day, participants were randomly assigned to arrive at the laboratory at 7:00 or 9:00 a.m. in a fasting state. Upon arrival, informed consent was obtained from the participants and their parents. Participants’ height, weight, and skinfold measurements were then taken.

After the anthropometric measures were completed, participants were asked to assume a reclining position on the bed and to place their head in the canopy. The bed was set at a 120° angle, and the canopy was affixed to the bed. The experimenter observed the subject throughout the four metabolic tests to ensure that the subject remained awake and comfortable.

The first measure of REE data consisted of a five-minute acclimation of pre-treatment data. Because a respiratory quotient (RQ) greater than .85 is indicative of recent food or drink consumption, it was necessary for all participants to have an RQ of .85 or less for the baseline REE test. If RQ was greater than .85, participants were rescheduled for testing on another day.

Next, four, randomly counterbalanced, 25 min measures of REE were obtained, which included: 1) a resting baseline or no television condition; 2) an active/stimulating television show (an episode of “Full House”); 3) a passive television show (an episode of “Wonder Years”); and 4) being read to by a research staff member (an excerpt from *Sweet Valley High*). To control for adaptation and acclimation to the testing procedure, the first five minutes of each metabolic test were discarded. At the end of the testing session, participants were fed a high carbohydrate snack and received $75 compensation for their participation. The entire testing session lasted between 2.5 and 3 h.

To determine what shows should be selected and considered active or passive, 300 girls between first and sixth grade were surveyed on the television shows they watched most often. Approximately 90% of them responded that they watch both “Wonder Years” and “Full House.” In the earlier study of metabolic effects of television viewing (Klesges et al., 1993), “Wonder Years” was viewed and produced a reduction in metabolic rate. As such, this show was considered the passive show for this study. To determine the active show, girls were asked to use Likert scales to rate the interest levels and excitement levels of various programs. “Full House” was rated both most interesting and by far most exciting, so this show was chosen as the active television program in the current study. This method of selecting programs is thought to have differentiated between active and passive programs without resulting in an active program that theoretically could elevate metabolic rate via arousal, for example a thrilling sporting event. It was determined that participants should be read to, rather than read themselves based on reading level differences, and the desire to standardize the protocol such that the timing of the reading session in consistent across participants.

2.4. Statistical analyses

All analyses for this report were conducted with SPSS® (version 12.0; SPSS Inc., Chicago, IL, USA). Preliminary analyses consisted of descriptive statistics and univariate comparisons between obesity status on various sample characteristics using chi-square tests for frequency measures and t-tests for continuous variables.

To address our first aim, a split-plot analysis of variance (ANOVA) approach was used to test potential differences between energy expenditure conditions using *a priori* contrasts. The within-subjects contrasts included comparisons of the resting condition with each of the other three conditions (passive TV program, stimulating TV program, listening to a story read) and the design included a between-subjects factor of relative weight status (either not obese vs. obese) as well as the interaction term between REE condition and weight status.

Secondary analyses were also conducted. To address our interest in the association between the amount of television that children normally view during a week and resting energy expenditure, general linear models using Type III sum of squares were analyzed. Models included REE from the resting condition as the dependent variable, hours of television viewed per week was entered as a between-subjects factor and candidate covariates of race, BMI, triceps skinfold, and Tanner breast stage. Candidate models were scrutinized until a final model was reached, with only covariables at $p<.10$ being retained.

To address potential influences of hormonal and metabolic aspects of pubertal development on resting energy expenditure, general linear models using Type III sum of squares were analyzed with resting REE as the dependent variable, Tanner stage of breast development as a between-subjects factor and candidate covariates of race, BMI, triceps skinfold, and television viewing. Candidate models were scrutinized until a final model was reached, with only covariables at $p<.10$ being retained.

3. Results

The demographic characteristics by weight status are displayed in Table 1. Available for analyses were 90 girls in the reading and active television conditions, 89 girls in the resting condition, and 87 girls in the passive television condition. The only significant univariate differences between the normal weight and obese groups were BMI and subscapular skinfold, as would be expected. Although REE was somewhat higher in the obese group, these differences were not statistically significant.

The average energy expenditure for resting state was 1346 kcal/day (SD=218), for story listening was 1320 kcal/day (SD=196), for viewing a passive TV program was 1329 kcal/day (SD=204), and for viewing an active TV

Table 1
Demographic characteristics of girls assessed on metabolic rate by obesity status ($n=90$)

Characteristics	Normal weight ($n=57$)	Obese ($n=33$)	p
Age (years)	9.68 ± 1.58	8.88 ± 1.36	.14
Race (% African American)	32.2	17.8	.50
Height (inches)	56.40 ± 4.50	55.21 ± 3.85	.22
Weight (pounds)	75.03 ± 16.38	91.21 ± 20.69	.06
Body mass (kilograms/meter^2)	16.40 ± 1.64 Range: 13–21	20.82 ± 2.48 Range: 16–29	<.01
Subscapular skinfold (Percentile)	46.32 ± 21.89 Range: 5–93	85.17 ± 12.01 Range: 50–95	<.01
Tricep skinfold (Percentile)	41.93 ± 22.78 Range: 5–95	80.91 ± 16.75 Range: 40–95	<.01
Puberty stage			
Stage 1 (%)	47.4	48.5	.992
Stage 2 (%)	21.1	21.2	
Stage 3 (%)	31.6	30.3	
Television watched (hours per week)			
<7 (%)	14.0	9.1	.733
7 to 14 (%)	38.6	45.5	
14 to 21 (%)	36.8	30.3	
>21 (%)	10.5	15.2	
Energy expenditure at rest (kilocalories per day)	1316 ± 210.8	1400 ± 222.9	.557

Note: Chi square tests used for categorical variables; t-tests used for continuous variables. Values expressed with a plus/minus sign are means and standard deviations.

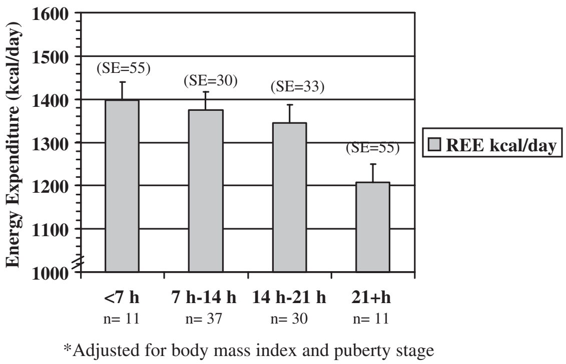

Fig. 1. A comparison of resting energy expenditure in kilocalories per day by number of hours of television watched per week, controlling for body mass index and pubertal development stage. ($n=89$).

program was 1321 kcal/day (SD = 193). The ANOVA related to the first study aim showed non-significant results ($p>.05$). The within-subjects *a priori* contrasts showed that resting energy expenditure (REE) was nonsignificantly higher compared to story listening [F (1,87) = 3.47, $p=.066$], watching a passive TV program [F (1,84) = 0.85, $p=.359$], and watching an active TV program [F (1,87) = 3.52, $p=.064$]. Interactions between REE conditions and weight status condition were nonsignificant for all comparisons (p's ≥ 0.48).

Secondary analyses using general linear modeling indicated significant REE effects with hours of television viewed per week [F (3, 83) = 2.71, $p=.05$], after adjusting for BMI and pubertal development. Children reporting more hours of television viewed per week had progressively lower REE values [linear trend, $p=.013$]. The overall model explained 35% of the total variability in REE [F (5, 83) = 8.93, $p<.001$]. Fig. 1 illustrates adjusted average REE values by the number of hours of television viewed weekly.

A final general linear model assessing REE associations with pubertal development was analyzed. Puberty stage showed significant effects with resting REE [F (2,84) = 11.75, $p<.001$] after controlling for the effects of BMI and average hours of TV watched. Adjusted resting REE significantly differed between those in pubertal stage 1 ($M=1251$, SE = 28) and stage 2 ($M=1383$, SE = 42) ($p=.011$) and between those in stage 1 and stage 3 ($M=1472$, SE = 36) ($p<.001$) but not between stage 2 and 3 ($p=.108$). The overall model explained 34% of the total variability in REE [F (4, 83) = 10.66, $p<.001$]. Fig. 2 displays the relationship between REE and pubertal stage adjusting for body mass index and television viewing.

4. Discussion

Resting energy expenditure in this investigation did not appear to be significantly influenced by the type of inactive condition to which girls were exposed. Whether girls rested, listened to a story, watched an active TV program, or watched a passive TV program, no differences in energy expenditure were found. This finding supports

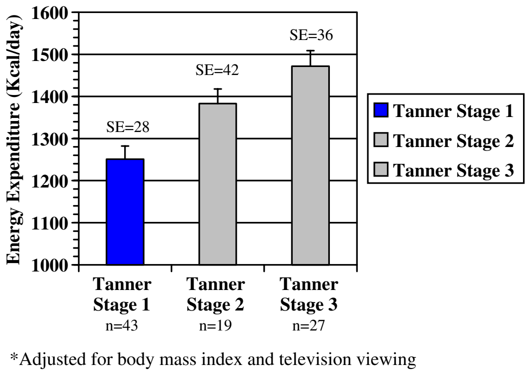

Fig. 2. A comparison of energy expenditure in kilocalories per day by pubertal development stage. ($n=89$).

the conclusions of Horswill and colleagues (1995) as well as the work of Dietz et al. (1994) that TV viewing in children does not suppress metabolic rate to a greater extent than rest alone. However, the current findings fail to replicate the results of Klesges et al. (1993) that suggested that REE was significantly lower while watching television compared to resting without television. These findings suggest that other mechanisms, such as increased food intake or decreased physical activity, or some combination of the elements of the energy balance equation are responsible for findings of increased weight associated with television viewing. Given this likelihood, future studies should consider including all aspects of energy balance and continue to explore their relative effects on television viewing and weight.

In addition, there were no significant group differences in REE based on weight categories. This finding is consistent with that of Klesges et al. (1993), as well as multiple studies of metabolism and obesity in children that indicate no differences in children based on obesity status (e.g., Puhl, 1989). This study using an adequate sample size suggests that there exist no observable relationships between television viewing, metabolic rate, and level of obesity.

Although metabolic rate did not significantly differ according to condition, an inverse association between average hours of weekly TV viewing and REE was noted. The finding suggests that as the amount of television viewed increases resting energy expenditure decreases. These differences were tested in the time limited sampling of REE in this study; however, these metabolic differences may become more pronounced and detectable over time. Such an interpretation may help explain inconsistencies in studies of metabolism and television viewing (Horswill et al., 1995; Klesges et al., 1993) such that the number of hours of television viewing may serve as a moderator of the metabolism and television relationship. However, since the majority of studies of metabolic rate, television, and body weight have concluded that no metabolic differences exist based on television viewing, it is perhaps more likely that deconditioning may occur via the inverse relationship between television and physical activity (Dietz et al., 1994; Katzmarzyk et al., 1998; Ross, Pate, Caspersen, Damberg, & Svilar, 1987) and/or the positive relationship between television and food intake (Matheson et al., 2004; Taras et al., 1989) such that children who are less active and/or more indulgent demonstrate lower metabolic rate at rest than children who are more active and have healthier dietary intake.

This study also found that Tanner pubertal stage was related to REE. Those girls in stage 1 of pubertal development demonstrated lower REE than girls in stages 2 or 3. Though Molnar and Schutz (1997) found a similar pattern of findings, after controlling for fat mass and fat free mass, REE differences were no longer significant. In this study, controlling for body fatness in analyses did not alter the differences in REE according to pubertal stage. Though others have suggested differences in REE based on physical development (e.g., Griffiths, Payne, Stunkard, Rivers, & Cox, 1990), this conclusion requires further study, especially in light of studies that have found the opposite relationship (Harrell et al., 2005) or no relationship (Rodriguez et al., 2002).

The strengths of this study include: ethnic diversity, comparisons of television viewing to a resting condition, as well as comparisons between obese and nonobese girls. Despite these positive features, the current study was limited in that these findings may not be generalizable, given the laboratory setting and the required supine condition for the metabolic test employed. More importantly, average weekly hours of TV viewing was reported by participants' parents. Future studies are needed that replicate this result with more objective measures of TV viewing, for example detailed diaries or electronic devices available that more accurately assess time spent viewing television.

The majority of published literature indicates that in controlled studies REE of children does not differ as a function of the children's activities including television viewing. However, the effects of television viewing on children's metabolism may not be acute in nature and/or the effect may be relatively small and difficult to detect in a laboratory setting. Rather TV viewing may have cumulative effects on energy balance over longer periods of time and this may lead to accumulated body mass and subsequent obesity. Based on these findings, perhaps the most plausible explanation for potential weight change associated with television viewing lies not with resting energy expenditure but within some combination of changes in energy intake and physical activity.

Acknowledgements

Theodore V. Cooper, Ph.D., The University of Texas at El Paso, Department of Psychology.
Lisa M. Klesges, Ph.D., Mayo Clinic, Department of Health Sciences Research.
Margaret W. DeBon, Ph.D., University of Tennessee Health Science Center, Department of Preventive Medicine.
Robert C. Klesges, Ph.D., Mayo Clinic, Departments of Medicine and Psychiatry/Psychology.
Mary Lee Shelton, Ph.D., University of Memphis, Department of Psychology.
This project was part of a larger study supported by the National Heart, Lung, and Blood Institute (HL 4992114).

Correspondence concerning this article should be addressed to Theodore V. Cooper, Ph.D., Department of Psychology, The University of Texas at El Paso, 500 W. University Avenue, El Paso, Texas, 79968.

References

Andersen, R. E., Crespo, C. J., Bartlett, S. J., Cheskin, L. J., & Pratt, M. (1998). Relationship of physical activity and television watching with body weight and level of fatness among children: Results from the Third National Health and Nutrition Examination Survey. *JAMA*, *279*, 938–942.

Armstrong, C. A., Sallis, J. F., Alcaraz, J. E., Kolody, B., & McKenzie, T. L. (1998). Children's television viewing, body fat, and physical fitness. *American Journal of Health Promotion*, *12*, 363–368.

Burrows, R. A., Diaz, N., & Muzzo, S. (2004). Variations of body mass index (BMI) according to degree of pubertal development. *Revista Medica de Chile*, *132*, 1363–1368.

Coon, K., Goldberg, J., Rogers, B., & Tucker, K. (2001). Relationships between use of television during meals and children's food consumption patterns. *Pediatrics*, *107*, e7.

Crespo, C. J., Smit, E., Troiano, R. P., Bartlett, S. J., Macera, C. A., & Andersen, R. E. (2001). Television watching, energy intake, and obesity in U.S. children. *Archives of Pediatric and Adolescent Medicine*, *155*, 360–365.

Dietz, W. H., Bandini, L. G., Morelli, J. A., Peers, K. F., & Ching, P. L. (1994). Effect of sedentary activities on resting metabolic rate. *The American Journal of Clinical Nutrition*, *59*, 556–559.

Dietz, W. H., & Gortmaker, S. L. (1985). Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. *Pediatrics*, *75*, 807–812.

Dietz, W. H., & Strasburger, V. C. (1991). Children, adolescents, and television. *Current Problems in Pediatrics*, *1*, 8–31.

DuRant, R. H., Baranowski, T., Johnson, M., & Thompson, W. O. (1994). The relationship among television watching, physical activity, and body composition of young children. *Pediatrics*, *94*, 449–455.

Fontvieille, A. M., Harper, I. T., Ferraro, R. T., Spraul, M., & Ravussin, E. (1993). Daily energy expenditure by five-year-old children, measured by doubly labeled water. *The Journal of Pediatrics*, *123*, 200–207.

French, S., Story, M., Neumark-Sztainer, D., Fulkerson, J., & Hannan, P. (2001). Fast food restaurant use among adolescents: Associations with nutrition intake, food choices and behavioral and psychological variables. *International Journal of Obesity*, *25*, 1823–1833.

Gortmaker, S. L., Must, A., Sobol, A. M., Peterson, K., Colditz, G. A., & Dietz, W. H. (1996). Television viewing as a cause of increasing obesity among children in the US, 1986–1990. *Archives of Pediatrics and Adolescent Medicine*, *150*, 356–362.

Griffiths, M., Payne, P. R., Stunkard, A. J., Rivers, J. P. W., & Cox, M. (1990). Metabolic rate and physical development in children at risk of obesity. *Lancet*, *336*, 76–78.

Harrell, J. S., McMurray, R. G., Baggett, C. D., Pennell, M. L., Pearce, P. F., & Bangdiwala, S. I. (2005). Energy costs of physical activities in children and adolescents. *Medicine and Science in Sports and Exercise*, *37*, 329–336.

Hedley, A. A., Ogden, C. L., Johnson, C. L., Carroll, M. D., Curtin, L. R., & Flegal, K. M. (2004). Overweight and obesity among U.S. children, adolescents, and adults, 1999–2002. *JAMA*, *291*, 2847–2850.

Hernandez, B., Gortmaker, S. L., Colditz, G. A., Peterson, K. E., Laird, N. M., & Parra-Cabrera, S. (1999). Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *International Journal of Obesity and Related Metabolic Disorders*, *23*, 845–854.

Horswill, C. A., Kien, C. L., & Zipf, W. B. (1995). Energy expenditure in adolescents during low intensity, leisure activities. *Medicine and Science in Sports and Exercise*, *27*, 1311–1314.

Isbell, T. R., Klesges, R. C., Meyers, A. W., & Klesges, L. M. (1991). Measurement reliability and reactivity using repeated measurements of resting energy expenditure with a face mask, mouthpiece, and ventilated canopy. *Journal of Parenteral and Enteral Nutrition*, *15*, 165–168.

Jago, R., Baranowski, T., Baranowski, J. C., Thompson, D., & Greaves, K. A. (2005). BMI from 3–6 y of age by TV viewing and physical activity, not diet. *International Journal of Obesity and Related Metabolic Disorders*, *29*, 557–564.

Janssen, I., Katzmarzyk, P. T., Boyce, W. F., King, M. A., & Pickett, W. (2004). Overweight and obesity in Canadian adolescents and their associations with dietary habits and physical activity patterns. *Journal of Adolescent Health*, *35*, 360–367.

Jequier, E. (1986). Measurement of energy expenditure in clinical nutrition assessment. *Journal of Parenteral and Enteral Nutrition*, *11*, 586–589.

Katzmarzyk, P. T., Malina, R. M., Song, T. M., & Bouchard, C. (1998). Television viewing, physical activity, and health-related fitness of youth in the Quebec Family Study. *The Journal of Adolescent Health*, *23*, 318–325.

Kiess, W., Galler, A., Reich, A., Muller, G., Kapellen, T., & Deutscher, J., et al. (2001). Clinical aspects of obesity in childhood and adolescence. *Obesity Reviews*, *2*, 29–36.

Klesges, R. C., Shelton, M. L., & Klesges, L. M. (1993). Effects of television on metabolic rate: Potential implications for childhood obesity. *Pediatrics*, *91*, 281–286.

Laessle, R. G., Wurmser, H., & Pirke, K. M. (1997). A comparison of resting metabolic rate, self-rated food intake, growth hormone, and insulin levels in obese and nonobese preadolescents. *Physiology and Behavior*, *61*, 725–729.

Mandel, D., Zimlichman, E., Minouni, F. B., Grotto, I., & Kreiss, Y. (2004). Age at menarche and body mass index: A population study. *Journal of Pediatric Endocrinology and Metabolism*, *17*, 1507–1510.

Marshall, S. J., Biddle, S. J., Gorely, T., Cameron, N., & Murdey, I. (2004). Relationships between media use, body fatness, and physical activity in children and youth: A meta-analysis. *International Journal of Obesity and Related Metabolic Disorders*, *28*, 1238–1246.

Marshall, W. A., & Tanner, J. M. (1969). Variations in pattern of pubertal changes in girls. *Archives of Disease in Childhood*, *44*, 291–303.

Matheson, D. M., Wang, Y., Klesges, L. M., Beech, B., Kraemer, H. C., & Robinson, T. (2004). African American girls' dietary intake while watching television. *Obesity Research*, *12*(suppl), 32S–37S.

Mokdad, A. H., Marks, J. S., Stroup, D. F., & Gerberding, J. L. (2004). Actual causes of death in the United States, 2000. *JAMA*, *291*, 1238–1245.

Molnar, D., & Schutz, Y. (1997). The effect of obesity, age, puberty, and gender on resting metabolic rate in children and adolescents. *European Journal of Pediatrics*, *156*, 376–381.

Obarzanek, E., Schreiber, G. B., Crawford, P. B., Goldman, S. R., Barrier, P. M., Frederick, M. M., & Lakatos, E. (1994). Energy intake and physical activity in relation to indexes of body fat: The national heart, lung, and blood institute growth and health study. *The American Journal of Clinical Nutrition*, *60*, 15–22.

Ogden, C. L., Flegal, K. M., Carroll, M. D., & Johnson, C. L. (2002). Prevalence and trends in overweight among US children and adolescents. *JAMA*, *288*, 1772–1773.

Puhl, J. L. (1989). Energy expenditure among children: Implication for childhood obesity: I. Resting and dietary energy expenditure. *Pediatric Exercise Science*, *1*, 212–229.

Robertson, S. M., Cullen, K. W., Baranowski, J., Baranowski, T., Hu, S., & de Moor, C. (1999). Factors related to adiposity among children aged 3 to 7 years. *Journal of the American Dietetic Association*, *99*, 938–943.

Robinson, T. N. (1998). Does television cause childhood obesity? *JAMA*, *279*, 959–960.

Robinson, T. N., Hammer, L. D., Killen, J. D., Kraemer, H. C., Wilson, D. M., & Hayward, C., et al. (1993). Does television viewing increase obesity and reduce physical activity? Cross sectional and longitudinal analyses among adolescent girls. *Pediatrics*, *91*, 273–280.

Robinson, T. N., & Killen, J. D. (1995). Ethnic and gender differences in the relationships between television viewing and obesity, physical activity and dietary fat intake. *Journal of Health Education/Association for the Advancement of Health Education*, *26*, S91–S98.

Rodriguez, G., Moreno, L. A., Sarria, A., Pineda, I., Fleta, J., & Perez-Gonzalez, J. M., et al. (2002). Determinants of resting energy expenditure in obese and non-obese children and adolescents. *Journal of Physiology and Biochemistry*, *58*, 9–15.

Ross, J. G., Pate, R. R., Caspersen, C. J., Damberg, C. L., & Svilar, M. (1987). The national children and youth fitness study: II. Home and community in children's exercise habits. *Journal of Physical Education, Recreation & Dance*, *58*, 85–92.

Schwimmer, J. B., Burwinkle, T. M., & Varni, J. W. (2003). Health-related quality of life of severely obese children and adolescents. *JAMA*, *289*, 1813–1819.

Seidell, J. C. (1999). Obesity: A growing problem. *Acta Paediatrica. Supplement*, *88*, 46–50.

Sinaiko, A. R., Donahue, R. P., Jacobs, D. R., & Prineas, R. J. (1999). Relation of weight and rate of increase in weight during childhood and adolescence to body size, blood pressure, fasting insulin, and lipids in young adults. The Minneapolis children's blood pressure study. *Circulation*, *99*, 1471–1476.

Slaughter, M. H., Lohman, T. G., Boileau, R. A., Horswill, C. A., Stillman, R. J., & Van Loan, M. D., et al. (1988). Skinfold equations for estimation of body fatness in children and youth. *Human Biology; An International Record of Research*, *60*, 709–723.

Srinvasan, S. R., Bao, W., Wattigney, W. A., & Berenson, G. S. (1996). Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: The Bogalusa heart study. *Metabolism, Clinical and Experimental*, *45*, 235–240.

Story, M., & Faulkner, P. (1990). The prime-time diet: A content analysis of eating behavior and food messages in television program content and commercials. *American Journal of Public Health*, *80*, 738–740.

Taras, H. L., Sallis, J. F., Patterson, T. L., & Nelson, J. A. (1989). Television's influence on children's diet and physical activity. *Journal of Developmental and Behavioral Pediatrics*, *10*, 176–180.

Tremblay, M. S., & Willms, J. D. (2003). Is the Canadian childhood obesity epidemic related to physical activity? *International Journal of Obesity*, *27*, 1100–1105.

Troiano, R. P., & Flegal, K. M. (1998). Overweight children and adolescents: Description, epidemiology, and demographics. *Pediatrics*, *101*, 497–504.

U.S. Department of Health and Human Services. (2000, November). Healthy People 2010. *Understanding and improving health* (2nd ed.). Washington, DC: U.S. Government Printing Office.

United States Department of Health and Human Services. (1987). *National Center for Health Statistics: Anthropometric Reference Data on Prevalence of Overweight: United States, 1976–1980* (p. 20). Hyattsville, M.D.: DHHS Publication No. 88-1688.

Valdez, R., Greenlund, K. J., Wattigney, W. A., Bao, W., & Berenson, G. S. (1996). Use of the weight-for-height indices in children to predict adult overweight: The Bogalusa heart study. *International Journal of Obesity and Related Metabolic Disorders*, *20*, 715–721.