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The Relationship Between Television Viewing Time and Cardiorespiratory Fitness in Adult Women

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and Cardiorespiratory Fitness in Adult Women

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A thesis submitted to the faculty of
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Master of Science

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ABSTRACT

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and Cardiorespiratory Fitness in Adult Women

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Purpose: The present investigation was conducted to assess the relationship between television viewing time and cardiorespiratory fitness.
Design: Cross-sectional.
Setting: Intermountain West.
Participants: 302 middle-aged women.
Method: TV viewing was assessed using a questionnaire. Cardiorespiratory fitness was measured using a maximal graded treadmill test. Physical activity (PA) was evaluated using Actigraph accelerometers worn over seven consecutive days, while body fat percentage (BF%) was measured using air displacement plethysmography (Bod Pod).
Results: (Mean ± SD) age: 40.2 ± 3.0 years. VO_2 max of the frequent (≥ 3hrs/day) TV group (32.6 ± 6.4) was significantly lower than both the moderate (1-2 hrs/day) (36.2 ± 7.2) and infrequent (<1hr/day) (36.5 ± 6.5) TV groups ($F = 8.0$, $P = 0.0004$). The infrequent and moderate groups did not differ significantly from each other. Differences in age, education, BMI, and season of assessment had no influence on the relationship when controlled individually. Adjusting for differences in physical activity ($F = 4.2$, $P = 0.0157$) weakened the relationship by 59.4%, and adjusting for differences in BF% ($F = 5.0$, $P = 0.0071$) weakened the association by 58.5%, but in both cases, the relationships remained significant. After controlling for both PA and BF% simultaneously ($F = 2.9$, $P = 0.0572$), the relationship was weakened by 80.7% and was only borderline significant.
Conclusion: Frequent female TV viewers have significantly lower cardiorespiratory fitness levels than moderate or infrequent viewers. This association appears to be largely a function of differences in both PA and BF%.

Keywords: media, physical activity, screen time, obesity, sedentary lifestyle

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Introduction

It is widely accepted that TV viewing is a sedentary activity and increases risk of disease and all-cause mortality.[1-3] It is also known that there exists a negative association between TV watching and physical activity (PA).[4,5] Given the positive relationship between cardiorespiratory fitness and physical activity,[6] one would also expect cardiorespiratory fitness levels to decrease as television viewing time increases. However, only a few studies have examined the television and fitness association, and a number of these have focused on components other than cardiorespiratory fitness.[7-10]

In 1986, Tucker studied high school males and found that infrequent TV viewers scored significantly better on a composite fitness index than frequent viewers.[7] In 1990, Armstrong et al. measured various components of fitness and found a weak and inconsistent negative relationship between the two variables in children.[8] Others[9] have found no significant relationship between TV viewing and fitness in children, leaving one to question the true connection between these variables.

In adults, only one study has directly examined the relationship between TV watching and cardiorespiratory fitness.[10] Using a step test to measure cardiorespiratory fitness in almost 9,000 adults, Tucker found that frequent viewers (> 4 hours of TV/day) were 0.37 times as likely to be physically fit as infrequent viewers (less than one hour of TV per day). The apparent lack of research involving TV viewing and cardiorespiratory fitness in adults warrants further study.

The purpose of this study was to assess the relationship between TV viewing and cardiorespiratory fitness using robust methodologies. To date, the one study that focused on TV and cardiorespiratory fitness in adults used a step test to measure cardiorespiratory fitness, a questionnaire to assess physical activity, and skinfold calipers to estimate body fat percentage

(BF%).[10] Although these measurement methods were likely the best for assessment of nearly 9,000 individuals at the time, they lack the validity and precision of a graded, maximal treadmill test [11] to measure maximum aerobic capacity, accelerometers to evaluate physical activity, and plethesmography (Bod Pod) to measure body composition. Furthermore, the methods proposed in this study were more objective than those used previously in either adults or children. Hence, the goal of the present study was to clarify the relationship between TV and fitness, especially in adult women.

Methods and Procedures

Design

The relationship between TV viewing, physical fitness, and potential confounding variables were explored using a cross-sectional design. Existing data was used as collected by the Brigham Young University Lifestyle Project, directed by Larry Tucker, Ph.D. This project was a ten year prospective cohort study, with five phases of investigation. This study represents one of those phases. Dozens of students participated in collecting data every other year. To substitute for not actively collecting data, an additional graduate course, HS 612 Program Planning and Evaluation, was taken by the candidate.

Variables

The predictor variable for the current study was hours of TV watched per week. The criterion variable in this study was cardiorespiratory fitness. The control variables were physical activity, body fat percentage, season of assessment, age, and education level.

Participants

Recruitment of participants was conducted via flyers, advertisements, and company e-mails in two metropolitan areas in the Mountain West. Phone interviews were used to ensure all women met the inclusion requirements. Eligible women were healthy, non-smokers, pre-menopausal, between 35 and 45 years old, and could not be pregnant. Each woman signed a written informed consent before participation in the study.

Procedures

All appointments occurred at the BYU Human Performance Research Center in Provo, Utah. Before any testing commenced, participants were informed of all risks and benefits of the study via the consent form. Additionally, all participants completed a physical activity readiness questionnaire (PAR-Q) to determine if there were any complications that could affect the participant during testing.

Participants were then administered a questionnaire that assessed demographics and television viewing behavior. After filling out the questionnaire, the subjects were educated regarding how to properly wear the accelerometer for the next seven days. Following this instruction, body fat percentage was estimated using the Bod Pod and the appointment was completed. After one week, participants returned the accelerometer and participated in the maximal graded exercise test. After review of the data, participants were sent a $25 gift certificate, individual test results, and a letter of appreciation.

Television Viewing

A questionnaire was used to assess TV viewing behavior and other demographic characteristics, including age, and education. The specific question used to catalog TV watching was "How many hours do you spend watching TV and videos per day or week?" Possible responses were: (a) < 4 hr per week, (b) 4-6 hr per week, (c) 1 hr per day, (d) 2 hr per day, (e) 3 hr per day, (f) 4 hr per day, (g) 5-6 hr per day, (h) 7 or more hours per day. These responses were then used to categorize participants as infrequent viewers: 1 hr or less per day, moderate viewers: 2 hr per day, and frequent viewers: 3 hr or more per day. This method of collecting TV viewing behavior has been used in several other published studies.[10,12-14]

Cardiorespiratory Fitness

After completion of a PAR-Q, participants performed a maximal graded treadmill test (GXT) to assess cardiorespiratory fitness (VO_2 max). The GXT was conducted using American College of Sports Medicine safety guidelines and the modified Arizona State University protocol.[11,15,16]

A double, cross validation procedure with high r values (≥ 0.95) and low standard error of the estimate (< 2.0) demonstrated that the ASU protocol has stable results for men and women aged 18-65.[11] Furthermore, the intraclass test-retest reliability of this protocol is 0.99.[11]

Using a self-selected pace at a 5% grade, participants walked on a motor-driven Quinton Model 5 treadmill (Quinton, Seattle, WA) for the first 3-minute stage of the GXT. For the second stage, the grade was changed to level and participants selected a comfortable jogging pace to run at for 3 minutes. For the third and final stage, the grade was increased 1.5% every minute until the participant was unable to continue due to volitional fatigue.

Heart rates were measured using Polar heart rate monitors (Polar, Inc., Westbury, NY). Perceived exertion was measured using a Borg rating scale (6-20). Both heart rate and perceived exertion were measured after the initial two 3-minute stages and after each subsequent minute. The ACSM formula was used to estimateVO_2 max (ml/kg/min), based on the speed and grade of the treadmill during the last stage concluded by the participant.[17] The GXT was considered maximal when heart rate was within 15 beats per minute of age-predicted maximum (220 - age), when perceived exertion was 19 or 20, and when the participant reached the point of exhaustion.

If the participant was unsuccessful in achieving a maximal test, she was asked to repeat the GXT one week later.

Physical Activity

Actigraph model 7164 accelerometers (Actigraph, Pensacola, FL, formerly CSA) were used to objectively measure physical activity. Liu et al. and Bassett et al. have both shown the Actigraph accelerometer to be a valid and reliable method of measuring physical activity.[18,19] Furthermore, reliability of the Actigraph accelerometers was evaluated in a pilot study using fifteen middle-age women from this study. Subjects participated in 17 different activities, including walking and jogging on a treadmill at different speeds and grades and walking up and down stairs at different speeds. Subjects were retested using precisely the same activities within one week. Intraclass correlations showed that test-retest reliability for each activity was high ($r > 0.90$). Moreover, by summing the activity counts for each of the 17 activities together and then comparing this total to the retest total showed very high reliability ($r > 0.98$).

Participants were trained and asked to wear the accelerometer on the left side of the body over the hip for seven consecutive days, only to be removed for bathing or other water activities. The accelerometer was attached using a nylon belt placed just above the hip. If participants were non-compliant with the instructions for proper wearing of the accelerometer, they were asked to repeat the day of testing for which they failed to wear the accelerometer correctly or they were dropped from the study. Total activity counts collected over the seven consecutive days was used to index total physical activity in each participant.

Body Fat Percentage

Body fat percentage was objectively measured using air displacement plethysmography, specifically the Bod Pod (Life Measurements, Concord, CA). The Bod Pod was also used to directly measure thoracic lung volume. Calibration of the Bod Pod occurred each day before any measurements to reduce measurement error. Each participant was issued a swim cap and one-piece swimsuit to wear. Before the body composition measurement, subjects were asked to use the restroom. Two or more Bod Pod assessments were administered until two measurements were within one percentage point of each other. The two tests within one percentage point of each other were averaged and used as the final estimate of body fat percentage.

Studies that compare the Bod Pod to dual X-ray absorptiometry show the Bod Pod to be a valid and reliable measure of body fat percentage.[20,21] To establish reliability for the current study, 100 women from the study sample participated in a test-retest of the Bod Pod. The two tests showed an intraclass correlation of 0.999 ($p < 0.0001$).[22] Validity was also established using the same 100 women. Body composition results using dual energy X-ray absorptiometry (DEXA) (Hologic, Inc., Bedford, MA) were compared to the Bod Pod findings. Comparison of the two measurements yielded a Pearson correlation of 0.94 ($p < 0.001$) and an intraclass correlation of 0.97 ($p < 0.001$).[23]

Season of Assessment

Researchers have shown that season of assessment can have an impact on objectively measured physical activity.[24,25] Individuals tend to be more sedentary during winter months. For this reason, season of assessment was measured and controlled in this study. In this study, months were categorized into three groups based on their average temperature. November, December, January, and February were included in the cold group. March, April, May, and October made up the moderate group. Finally, June, July, August, and September were combined for the warm group.

Statistical Analysis

A power analysis was conducted using the PASS 6.0 statistical software to determine the statistical power using 302 subjects when comparing means across three groups using regression analysis, with alpha set at the 0.05 level. Under these conditions, results showed that statistical power is 0.88. All statistical analyses were conducted using the PC-SAS software program, version 9.3 (Cary, NC). For all calculations, television viewing was treated as a categorical variable (Frequent, Moderate, and Infrequent). Frequent watchers were those who reported viewing 3 hrs or more of TV per day, on average. Moderate viewers included women who watched 1-2 hours per day, and infrequent viewers were those who reported less than 1 hr per day of TV watching, on average. The extent to which mean fitness differed across the three categories of television viewing was determined using regression analysis and the General Linear Model (GLM) procedure. To assess the influence of specific potential confounders, such as age, education, season of assessment, body fat percentage, and physical activity, considered individually and collectively, on the relationship between fitness and TV viewing, partial correlations were computed using the GLM procedure. Adjusted means were calculated using the least-squares means procedure.

Results

A total of 302 women participated in the current study. The participants were middle-aged (40.2 ± 3.0 years), married (~80%), Caucasian (~90%), and were employed part- or full time (~60%). More than one-third reported having some college education. The means, standard deviations, minimum and maximum scores, and quartile values of the key variables can be found in Table 1.

Table 2 shows differences in VO_2 max (ml/kg/min) means across the three television viewing categories. Without controlling for potential confounders, VO_2 max of the frequent television viewing group (32.6 ± 6.4) differed significantly from both the moderate (36.2 ± 7.2) and infrequent (36.5 ± 6.5) viewing groups (F = 8.0, P = 0.0004). The infrequent and moderate groups did not differ significantly from each other. Age, education, BMI, and season of assessment had no mediating influence on the relationship between TV viewing and VO_2 max after statistically controlling for these variables individually. On the other hand, controlling for physical activity and body fat percentage each had a mediating effect. Adjusting for differences in physical activity (F = 4.2, P = 0.0157) weakened the relationship by 59.4%. Furthermore, adjusting for differences in BF% (F = 5.0, P = 0.0071) weakened the relationship by 58.5%. When controlling for both physical activity and body fat percentage simultaneously (F = 2.9, P = .0572), the relationship was weakened by 80.7% and was only borderline significant.

Differences in the potential confounding variables across the three television viewing categories are shown in Table 3. Age (F = 2.3, P = 0.0982) and BMI (F = 1.6, P = 0.1984) did not differ significantly across the TV viewing categories. However, activity counts (F = 4.6, P = 0.0112) differed significantly across the TV viewing categories. Specifically, frequent viewers had significantly fewer activity counts than moderate and infrequent viewers. However, there was no significant difference between the latter two groups. Body fat percentage (F = 3.1, P = 0.0447) differed significantly between the frequent and infrequent viewing groups, but not between any other groups. Frequent viewers had 2.7 percentage points higher body fat than infrequent viewers.

Chi-square analysis showed that education, a categorical variable, was not related to TV viewing status ($\chi^2 = 9.8$, $p = 0.1318$). Furthermore, Chi-square analysis showed that season of assessment, another categorical variable, was also not related to TV viewing status ($\chi^2 = 4.5$, $p = 0.3392$).

Discussion

The findings of the current study reveal that frequent TV viewers have significantly lower cardiorespiratory fitness levels than moderate or infrequent viewers. The relationship remained significant despite adjustments for age, education, season of assessment, and BMI. Furthermore, the association remained significant after controlling for objectively measured PA and body fat percentage individually. However, controlling PA and body fat percentage simultaneously nullified the relationship. This demonstrates that the relationship between cardiorespiratory fitness and television viewing is largely a function of differences in PA and body fat percentage.

When comparing mean fitness levels across the three television viewing categories, differences were not only statistically significant, but meaningful. Specifically, the mean differences between frequent and infrequent viewers produced a moderate effect size of 0.56.

Infrequent viewers had a mean VO_2 max that was 3.9 mL/kg/min higher than frequent viewers, a difference of slightly more than 1 MET (3.5 ml/kg/min). Based on a sample of 4,834 women aged 40-49 from the Cooper Institute, the fitness level of infrequent viewers would place them in about the 70^{th} percentile compared to other women their age, whereas frequent viewers would be in about the 45^{th} percentile.[16] Additionally, given their measured cardiorespiratory capacities, infrequent TV viewers would have much better functional fitness than frequent viewers. For example, the average infrequent TV viewer could run 1.5 miles in 14 minutes and 33 seconds, whereas frequent viewers would take 16 minutes and 46 seconds.[16]

According to a meta-analysis conducted by Kodama et al., which included over 80,000 individuals, a 1 MET higher VO_2 max is associated with a risk reduction of 13% for all-cause mortality.[26] Furthermore, according to Kodama et al., for each 1 MET increase in VO_2 max, risk of coronary heart or cardiovascular disease events tends to fall by 15%.[26] Given these differences in risk, frequent television watchers may experience greater cardiovascular disease and overall mortality than infrequent viewers because of their significantly lower fitness levels.

This study is unique in that it directly compared objectively measured cardiorespiratory fitness to the amount of time watching television in adult subjects. Most of the research regarding the current relationship has been conducted using children. The findings of these studies involving children showed only weak or no relationship between cardiorespiratory fitness and television viewing.[8,27,28] For example, in 1998, Armstrong et al. showed a weak and inconsistent relationship between television viewing and cardiorespiratory fitness as measured using a one mile run/walk test.[8] Also in 1998, Katzmarzyk et al. showed a weak relationship between television viewing time and cardiorespiratory fitness as measured by a submaximal cycle ergometer test.[27] A 2010 prospective study conducted by Mota et al. showed that baseline television viewing predicted cardiorespiratory fitness over a 2 year period.[28] In 2011, Aires et al. found that television viewing was weakly and negatively associated with cardiorespiratory fitness using a 20-meter shuttle run test.[29]

In adults, only one study conducted in 1990 by Tucker[10] has directly investigated the TV/fitness relationship. Findings of the current study are consistent with the results of the 1990 investigation which included nearly 9,000 adults. That investigation showed that frequent television viewers were .37 times as likely to be physically fit as infrequent television viewers.[10] However, fitness was measured using a step test, whereas in the current study, fitness was measured using a maximal graded treadmill test. Furthermore, PA was self-reported in the previous study, while accelerometry was used to objectively assess PA in the current study. Finally, skinfold calipers were used in the previous study to estimate body fat percentage. In the current study, air displacement plethysmography (Bod Pod) was used to estimate body fat percentage.

There are multiple explanations for the findings of the current study. It is possible that frequent television viewers seek activities that require little physical exertion, leading to lower cardiorespiratory fitness. It is also possible that those with lower cardiorespiratory fitness levels choose sedentary activities such as television viewing, because higher intensity activities are viewed as less enjoyable or as more difficult. Lastly, it is possible that frequent TV viewing does not lead to lower levels of fitness and poor fitness does not lead to more TV watching. Instead, the relationship may be a result of other factors, third variables. This possibility was examined carefully in the present study and none of the potential confounding variables by themselves had a meaningful effect on the TV/fitness relationship. However, when both PA and BF% were controlled statistically, the relationship was no longer significant.

A few limitations of the current study warrant mention. First, the cross-sectional design of the study does not allow conclusions about temporality or cause-and-effect. Additionally, the 302 subjects were female, middle-aged, nonsmokers, and mostly white, non-Hispanic. This limits any generalizations to similarly characterized populations.

The strengths of the current study include the previously mentioned objective measures of cardiorespiratory fitness, PA, and BF%. Furthermore, as most research regarding cardiorespiratory fitness and television viewing has been conducted in children, the current study used adults. Finally, the current investigation had excellent statistical power (.88), increasing the likelihood that a real association between TV viewing and cardiorespiratory fitness would be revealed, if it existed.

In conclusion, frequent television viewing (≥ 3 hours of TV per day) is strongly associated with lower levels of cardiorespiratory fitness in adult middle-aged women. When age, education, BMI, physical activity, BF%, or season of assessment are controlled individually, the relationship remains significant. However, when both physical activity and BF% are controlled simultaneously, the relationship is nullified. Hence, differences in cardiorespiratory fitness across television viewing groups appear to be largely a function of differences in physical activity and BF%. Future research should consider employing either a prospective design or a randomized controlled trial to determine the effect of television viewing on cardiorespiratory fitness levels over time in adults.

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Table 1 Description information for all participants (n = 302)

Variables	Mean	SD	Min.	25th Percentile	50th Percentile	75th Percentile	Max.
Age (yrs)	40.2	3.0	34	38	40	43	46
Weight (kg)	65.4	10.0	42.1	58.3	64.4	71.6	95.5
Body Fat (%)	31.2	7.0	14.6	26.4	31.7	36.6	44.8
Activity (counts)*	2741	839	828	2121	2684	3201	6642
Body Mass Index	23.6	3.3	15.8	21.0	23.4	25.8	32.1

*Average activity counts measured objectively using accelerometers, divided by 1000.

Min. refers to the lowest score for each variable and Max. refers to the highest score for each variable.

Table 2 Differences in VO_2 Max Across Television Viewing Categories Before and After Controlling for Potential Confounders

	Television Viewing Category							
	Infrequent Viewing		Moderate Viewing		Frequent Viewing			
Key Variable	(n = 111)		(n = 123)		(n = 68)			
Variable Controlled	Mean	SD	Mean	SD	Mean	SD	F	p
VO_2 Max (ml/kg/min)								
None	36.5^a	6.5	36.2^a	7.2	32.6^b	6.4	8.0	0.0004
Age	36.6^a		36.1^a		32.7^b		7.7	0.0004
Education	36.5^a		36.1^a		32.6^b		7.6	0.0006
Physical Activity	36.0^a		36.1^a		33.7^b		4.2	0.0157
BF%	36.0^a		36.1^a		33.7^b		5.0	0.0071
BMI	36.2^a		36.4^a		32.9^b		7.7	0.0006
Season	36.6^a		36.2^a		32.6^b		8.1	0.0004
PA and BF%	35.7		36.1		34.3		2.9	0.0572
All covariates	35.5		35.8		34.2		2.3	0.1020

Means on the same row as a potential confounding variable are statistically adjusted for that variable.

Means on the same row with the same superscript are not significantly different ($p > 0.05$).

Infrequent Viewing included women who watched less than 1 hr of TV per day. Moderate Viewing included those who watched 1-2 hrs per day, and Frequent Viewing included those who watched 3 hrs or more per day of television.

Table 3 Differences in the Potential Confounding Variables Across the Television Viewing Categories

	Television Viewing Category							
	Infrequent Viewing (n = 111)		Moderate Viewing (n = 123)		Frequent Viewing (n = 68)			
Variable	Mean	SD	Mean	SD	Mean	SD	F	p
Age (yrs)	40.6	3.2	39.8	3.0	40.5	2.8	2.3	0.0982
Activity (counts)*	2864[a]	967	2772[a]	792	2485[b]	624	4.6	0.0112
Body Fat Percentage (%)	30.3[a]	7.2	31.1[a,b]	6.6	33.0[b]	7.0	3.1	0.0447
BMI	23.2	3.5	23.9	3.2	24.0	3.1	1.6	0.1984

Means on the same row with the same superscript are not significantly different ($p > 0.05$).

For the television viewing categories, Infrequent Viewing included women who watched less than 1 hr of TV per day. Moderate Viewing included those who watched 1-2 hrs per day, and Frequent Viewing included those who watched 3 hrs or more per day of television.

*Average activity counts measured objectively using accelerometers, divided by 1000.