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Original scientific paper

RELATIONSHIP BETWEEN BODY FAT COMPOSITION AND MARKERS OF PHYSICAL FITNESS IN COLLEGE AGED STUDENTS WHO ENGAGE IN TELEVISION VIEWING LEISURE TIME ACTIVITY

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Abstract

Aim: Television viewing is one of the most popular sedentary activities in America, and with an increase in leisure time activity research has demonstrated a converse decrease in physical activity time. This increased sedentary behavior has been linked to increased risk of obesity, hypertension, cardiovascular disease, and all-cause mortalities. While many studies have focused on associations between children and middle aged to older adults, there is a dearth of literature regarding young college-aged students. The purpose of this study was to examine the associations between body fat mass and physical fitness markers in individuals who engaged in high volumes of daily television leisure time activity. **Methods:** The sample population consisted of 171 Northern Illinois University young college-aged students. Subjects completed a screening visit that included IRB consent, inclusion criteria, a 7-day recall screen time viewing survey, and body composition assessment via bioimpedance analysis. Seven days later the subjects returned to complete the physical fitness testing which consisted of PACER test, vertical jump, pushups, sit ups, and sit-reach test, and provide their step count vie pedometer from the previous week. **Results:** Subjects were percentile ranked by volume of viewing time into infrequent TV viewer (IV), moderate TV viewer (MV), and frequent TV viewer (FV). Body fat mass in the frequent viewing group was more significantly negatively correlated with PACER test (-.610), vertical jump (-.525), pushups (-.542) and sit ups (-.416) compared to the other viewing groups. **Conclusions:** Students who engaged in a greater volume a daily TV viewing time (> 6.0 hours) displayed a greater negative association between body fat mass and decreased markers of physical fitness compared to individuals who engaging in a lower viewing time per day (< 2.0 hours).

Keywords: Physical fitness markers, countermovement jump, body composition, television viewing, PACER

1. Introduction

Television viewing time, as a marker of sitting time, has become one of the most prevalent sedentary behaviors in the United States. An estimated 50% to 70% of Americans spend 6 or more hours sitting in a day. In addition to these hours, 20% to 35% spend 4 hours or more daily watching television (Nelson & Zeratsky, 2012). Yang et al., (2019) evaluated trends in sedentary behavior among the U.S. population and found that sitting watching television or videos accounted for 2 h/d or more between 2001 through 2016 which remained high and stable. While sedentary behavior is multifaceted in its etiology television viewing has been shown to be the most prevalent sedentary behavior in adults and youth (Gorely, 2007). Recent evidence suggests that greater television viewing time and daily sitting time may be independently

associated with adverse health outcomes, such as higher prevalence of diabetes, cardiovascular disease, and all-cause mortality, even after adjusting for physical activity and cardiovascular risk factors (Patterson et al., 2018, Matthews et al., 2012; Pate et al., 2008; Grøntved & Hu, 2011; Johansson et al., 1988). And in the United States, the average number of daily hours of TV viewing has recently been reported to be 5 hours (Nelson, 2011).

TV viewing plays a dominant role in sedentary behavior and an important question is to what extent does this leisure time activity affect health and wellness. Television (TV) watching has become a prevalent behavior across the life span and often is associated with the use of other screen-based media and broader sedentary behavior exposure (Sugiyama et al., 2008). According to the American Heart Association (AHA), sedentary behavior has been identified as one of the leading preventable causes of death, and an inverse linear relationship exists between the volume of PA and all-cause mortality (Marcus et al., 2006). Sedentary behavior has been defined as any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents, while in a sitting, reclining or lying posture (Park et al., 2020, Tremblay et al., 2017,). It is estimated that sedentary time can account for 60% of waking hours (6–10 h/day) and behaviors such as TV viewing are associated with increased risk of all-cause and cardiovascular mortality independent of smoking, hypertension, hypercholesterolemia, and diet. (Owen et al., 2010; Owen et al., 2014). It has been widely accepted that low levels of physical activity and large amounts of sedentary behavior play a causal relationship in the etiology of excess body fat accumulation and TV time has been associated with BMI and waist circumference in older adults independently of physical activity participation [Stamatakis et al., 2012). And observational and experimental studies have provided a direct relation between TV viewing time and increased body fat in children (Jago et al., 2005), adolescents (Berkey et al., 2003), and adults (Zick et al., 2011).

Promoting physical fitness by incorporating active lifestyles and behaviors has become an important topic to various research studies. A consensus has been agreed that for adults' enjoyable activities that promote improvement in physical fitness components can have positive effects on weight management, cardiorespiratory performance, and musculoskeletal functionality. There are several components of physical fitness that can be distinguished according to different levels of functionality and their relations to health and motor skills. These include muscular endurance, flexibility, body composition and muscular strength, coordination, balance, power, agility, speed, and reaction time associated with motor-related abilities. Physical fitness allows for the development of suitable physical abilities necessary to perform (ADLs) activities of daily living (Napradit & Pantaewan, 2009). and physiological factors such as age, sex, body fat, lean body mass, as well as genetic factors related to cardiorespiratory fitness, muscular endurance, flexibility and agility, all influence physical fitness (AghaAlinejad et al., 2009).

Research has clearly demonstrated the beneficial effects of enhanced physical fitness on all-cause mortality and reducing the risk for the development of cardiovascular disease. Yet on the other end of the spectrum physical inactivity and sedentary behavior can lead to a lower energy expenditure and is associated with a decline in musculoskeletal and aerobic fitness. And the increasing prevalence of obesity has been linked as a contributing factor to these declines in physical activity and CRF. A sizable body of literature demonstrates the positive association between sedentary behaviors – TV viewing in particular – and the odds of overweight and obesity, independent PA (Wanner et al., 2017; Golubic et al., 2015; Hu et al., 200;

Heinonen et al., 2012, & Inoue et al., 2012). Clarifying the relationship between leisure time sedentary behavior, PA and obesity is important for prioritizing prevention strategies. Hence, the current study was designed to quantify students' sedentary leisure TV viewing time and evaluate the association between body fat mass with markers of physical fitness in college students for assessment based on television viewing habits.

2. Methods

Participants

Subjects were recruited from the student body population of a midsize university (15,000 students) located in the Midwest region of the Unites States. For initial inclusion into the study, subjects had to be a current university student, classified as a non-university athlete, and free of cardiovascular disease as assessed by the health history questionnaire (HHQ) and PARQ. Institutional Review Board approval was obtained prior to any data collection and informed consent was collected from all participants after a detailed explanation of the aims, benefits, and risks involved with this investigation. Data collection occurred in the fall and spring semesters of the academic calendar year.

Screening visit

Following the HHQ and consent, anthropometric measurements were quantified by bioimpedance analysis using the Inbody 520 (Version 520DM-1520; Biospace, Inc., Los Angeles, CA, USA) and a standard stadiometer. Participants remained standing for 15 minutes prior to testing to allow for normal circulation of blood and fluid movement according to the manufacturer's guidelines. The participants were instructed to refrain from consuming a meal two hours prior to arrival, void their bowels, to remain hydrated, and to abstain from moderate to intense exercise for 12-hours before the screening and testing sessions.

Subjects completed a recall survey for screen time usage for assessing time spent per week watching TV or movies. Average daily television time was assessed over the previous 7 days with a self-reported survey that was interviewer administered. TV viewing time was defined as engaging in concentrated viewing of television, television shows, movies, sporting activities, or videos without participating in other activities such as personal conversation, social media, schoolwork, or cell phone usage. The time frame was based on wake schedule of 8:00am until 12:00am with a sleep duration of 8 hours which was based on research in young adults showing a mean of 8.2 hours for sleep duration (Meyer et al., 2012). Subjects were asked to provide the amount of time for five weekdays and for two weekend days. Daily average was calculated as [(weekday total*5) + (weekend day total*2)/7] and time is reported as average hours per day. Subjects were sub-divided into three groups based on their TV viewing habits; infrequent (0.0 to 1.69 hours), moderate (1.70 to 3.49 hours), or frequent viewer (< 3.50 hours). Research by the university of Glasgow demonstrated that the majority of health risks associated with too much TV could be reduced if people limited their viewing time to two hours or less per day (Foster et al., 2020). And based on this research TV viewing time was examined as percentile ranks using the median for total viewing time per day in hours which allowed for the infrequent group to represent individuals who could be at a reduce risk for health complications by limited their TV time to less than two hours a day (mean 1.67 hours per day)

Physical fitness testing

Seven days following the screening subjects returned for the physical fitness testing. Subjects were instructed to refrain from consuming food for two hours before testing and to have abstained from moderate/intense physical activity 24 hours prior to the physical fitness testing. Aerobic fitness was assessed via the adult 20-meter Progressive Aerobic Cardiovascular Endurance Run (PACER) test administered by the primary investigator. The PACER shuttle test is a validated running test to estimate aerobic capacity (Matsuzaka et al., 2004). The shuttle test was conducted in a gymnasium with markers placed 20 meters apart. Participants ran from one marker (A) to another marker (B) set 20 meters apart, while keeping pace with a prerecorded cadence on the PACER recording compact disc. The recording provided a brief instructional tutorial on how to perform the test and questions were answered by the testing technicians. Subjects continued the test until voluntary exhaustion. When the subject failed to reach the 20-meter maker twice consecutively, the test was terminated. Subjects were encouraged to give maximal effort. Test data recorded was the total lengths of the PACER laps completed before exhaustion.

Muscular power was assessed using a vertical jump tower (Sports Imports, Hillard, OH) and subjects were instructed on how to perform the three phases of a countermovement jump (CMJ).

The countermovement phase starts in a standing position and with downward movement by flexing the knees and moving the hips to a comfortable position, the propulsion phase is when the hips and knees are extended in a high velocity and the takeoff phase is when the subject leaps off the floor reaching with their preferred hand to touch the displacement markers (Chomentowski et al. 2018). The subjects positioned themselves below and one step behind markers to allow for their arm swing momentum to reach the markers before starting. They then performed one practice jump and then performed three maximal velocity jumps. Maximal jump displacement recorded as the maximal jump height for each test and the best achieved jump was as the representative score.

Muscular endurance was assessed using the sit up test and correct SUT execution is provided by: The subject lay supine on the floor with 90° flexion in the knee joints, hands at the side of their head, and with elbows pointing straight forward. To do a correct sit-up execution the elbows should touch the knees and then go back so the shoulders touch the floor (Blomqvist et al. 2013). Number of repetitions performed was recorded to quantify the grade of endurance in each test for the participants at exhaustion. The condition of exhaustion consisted of the inability to perform another repetition. In addition, muscular endurance was assessed using the pushup test which was executed by having the participant assume the push-up position. The laboratory assistant emphasized hand placement under the shoulders, arms straight, fingers stretched out, and legs shoulder wide and aligned with the toes of the subject. Participants then bent their elbows to a 90-degree angle lowering their torso to touch a foam pad (four inches thick) and then returning to the full upright position. This was recorded as one repetition and subjects must of have kept their back parallel to the ground for the rep to be successful.

Flexibility was assessed using the sit and reach test using the procedures outlined in the ACSM manual (1998). Subjects sat with their feet approximately hip-wide against the testing box. They kept their knees extended and placed the right hand over the left, and slowly reached forward as far as they could by sliding their hands along the measuring board and moving the measuring scale as far as possible without bending

the knee of the extended leg. Each subject had two warmup movements for lumber flexibility and then completed three trials which were recorded.

Physical activity was measured using steps per day as quantified using a digital pedometer that the subjects were asked to wear each day. Subjects were instructed on how to place the pedometer for daily use and were asked to wear the device at normal waist belt height and in line with their thigh and patellar bone. They were instructed to wear the pedometer for the duration of the day and the subjects were given a daily day log sheet and asked to record the total steps at the end of each day before retiring to bed. Steps per day were quantified as the total displayed on the pedometer and cross-checked with the seven-day log sheet completed by the subjects.

3. Statistical Analysis

Results are presented as mean ± standard deviation. A Shapiro-Wilk's test was performed to assess for normal distribution. A one-way ANOVA, with Tukey pos hoc analysis was used to determine differences between groups for body composition, CRF markers, and time spent viewing television for television stratification groups. A Pearson's correlation coefficient test was run to assess the relationship between physical fitness and body composition. The correlations were distributed according to *r* values, which were classified as very weak (0.0-0.2), weak (0.2-0.4), moderate (0.4-0.7), strong (0.7-0.9), and very strong (0.9-1.0). Tukey Post Hoc analysis was performed to determine difference between television viewing time groups. Alpha level was set to $p < 0.05$ for ANOVA and Pearson's rank-order correlation coefficient test. All statistical analyses were performed using SPSS v.24 (IBM Corp., Armonk, New York).

Table 1. Subject baseline demographics by television viewing status.

Variables	All Subjects	Infrequent	Moderate	Frequent
Age	22.7 ± 2.9	23.3 ± 3.4	22.3 ± 2.5	22.6 ± 2.5
Weight (lbs.)	166.2 ± 36.2	162.2 ± 39.4	163.9 ± 31.8	172.3 ± 37.2
Height (in)	66.7 ± 5.2	67.6 ± 4.4	66.7 ± 3.9	65.9 ± 6.8
Lean body mass (lbs.)	125.8 ± 29.2	125.4 ± 32.5	123.9 ± 26.8	128.1 ± 28.6
Body fat mass (lbs.)	40.4 ± 21.1	36.8 ± 19.2	40.1 ± 19.4	44.2 ± 23.7
Percent body fat	23.7 ± 9.8	22.6 ± 9.0	24.1 ± 9.7	24.6 ± 10.6

Note: Values are mean±SD,

Table 2: Television viewing/screen time per group with Tukey post hoc analysis.

Variables	All Subjects	Infrequent	Moderate	Frequent

n	171	55	59	57
TV viewing time	3.85 ± 2.2	1.67 ± .78*[A]	3.48 ± .52*[B]	6.34 ± 1.8*[C]

Values are mean ± SD, viewing time was recorded as average hours per day, * = significant at $p < .01$, A was different than B, C, at $p < .01$, B different than A, C, at $p < .01$, C is different than A, B, at $p < .01$ for males and females.

Table 3: Physical fitness markers characteristics.

Variables	All Subjects	Infrequent	Moderate	Frequent
PACER (# laps)	41.4 ± 19.1	43.5 ± 17.7	41.7 ± 18.4	40.1 ± 20.4
Vertical Jump (in)	22.7 ± 6.4	22.5 ± 6.9	23.0 ± 6.2	22.5 ± 6.2
Sit Up Test	47.9 ± 23.1	51.2 ± 22.9	51.0 ± 25.8	40.9 ± 18.7*
Push Up Test	32.1 ± 15.3	35.8 ± 13.3	32.5 ± 15.2	31.9 ± 16.9
Sit and Reach (in)	14.5 ± 7.0	13.5 ± 4.3	15.4 ± 7.5	13.4 ± 5.2
Steps per Day	52,889 ± 25,374	56,306 ± 25,701	55,412 ± 27,273	46,982 ± 25,374

Note: Values are mean±SD,

Table 4: Pearson correlations between body fat mass and physical fitness markers.

	All Subjects	Infrequent	Moderate	Frequent
PACER (# laps)	-.540*	-.389*	-.586*	-.610*
Vertical Jump (in)	-.454*	-.388*	-.469*	-.525*
Sit Up Test	-.262*	-.147	-.192	-.416*
Push Up Test	-.431*	-.299	-.479*	-.542*
Sit and Reach (in)	-.068	-.198	-.045	-.030
Steps Per Day	-.230*	-.157	-.138	-.355*

Demographics:

One ninety-one Northern Illinois University students were recruited to complete this study and one hundred seventy-one subjects completed all testing. Subjects were not included if they had incomplete data for the analysis. Subjects were divided by tertial percentages based on the median total amount (hours) of viewing time they engaged in per day, Infrequent TV viewer (IV), Moderate TV viewer (MV), and Frequent TV viewer (FV). All variables were normally distributed as assessed by Shapiro-Wilk's test ($p > .05$) and homogeneity of variance was met for all variables. There was no statistically significant difference for age; F (2,168) = .929, p = .397, weight; F (2,168) = 1.263, p = .285, height; F (2,168) = 1.542, p = .217, lean body mass; F (2,168) = .300, p = .741, fat mass; F (2,168) = 1.716, p = .183, or percent body fat; F (2,168) = .647, p = .525. Table 1 represents demographic means and standard deviations.

Television viewing time:

Data is presented as mean ± standard deviation in table 2. The daily television viewing time for all subjects (hours per day) increased from the infrequent (n = 55, 1.673 ± .79), to moderate (n = 59, 3.488 ± .52), to moderate to frequent (n = 57, 6.341 ± 1.8) viewing groups. The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances (p = .002). The daily viewing times were statistically significantly different for different levels of viewing activity, Welch's F(2, 96.601) = 194.05, p < .001. Tukey post hoc analysis revealed that the increase from infrequent to moderate 1.8(95%, 1.2 to 2.3), which was statistically significant (p < .001), an increase from moderate to frequent 2.8(95%, 2.3 to 3.4) which was statistically significant (p < .001) and an increase from infrequent to frequent 4.6(95%, 4.1 to 5.2) which was also statistically significant (p < .001).

Physical fitness markers:

All variables were normally distributed as assessed by Shapiro-Wilk's test ($p > .05$) and homogeneity of variance was met for all variables. There was no statistically significant difference for PACER laps; F (2,168) = .449, p = .639, vertical jump; F (2,168) = .098, p = .907, pushups; F (2,168) = 3.290, p = .040, sit and reach test; F (2,168) = 1.964, p = .144, or steps per day; F (2,168) = 2.373, p = .096. The sit up test scores were statistically significantly different for the different television viewing groups, F (2,168) = 3.290, p = 040. Tukey post hoc analysis revealed that the difference between the infrequent and frequent viewing group was statistically significant (p = .049) and between the moderate and frequent viewing groups (p = 0.41). There was no significant difference between the infrequent and moderate groups for sit ups. Table 3 represents physical fitness data.

Body fat mass and markers of physical fitness

There were several weak to moderate statistically significant correlations between body fat mass and markers of physical fitness, table 4. There was a weak significant negative correlation between body fat mass and PACER scores in the infrequent TV viewing group, a moderate significant correlation for the moderate viewing group and frequent TV group (significant at p > 0.01). Vertical jump and steps per day similarly demonstrated a weak statistically significant correlation in the infrequent TV viewing group, a moderate significant correlation for the moderate viewing group and frequent TV group with body fat mass (significant at p > 0.01). The sit up test only yielded a moderate statistically significant negative correlation in the frequent viewing group (p > 0.01) and both the moderate and frequent groups demonstrated

statistically significant correlations between body fat mass and pushup test scores ($p > 0.01$). Data is represented in table 5.

4. Discussion and Conclusion:

In this cross-sectional study of college aged students, increased body fat composition was associated with decreased markers of aerobic and musculoskeletal physical fitness and this association was amplified in individuals who engaged in a greater amount of sedentary television viewing time compared to infrequent television viewers. This supports research that has demonstrated television (TV) viewing time as an independent sedentary behavior and has shown associations with obesity and other cardiovascular risk factors (Jakes et al., 2003; Thorp et al., 2010; Dunston et al., 2010). The NHANES study investigated TV viewing time in adults and found associations of TV viewing time with accelerometer-derived total sedentary time were statistically significant (Clark & Healy, 2011). Our study showed that for all individuals the quantity of TV viewing time per day didn't produce significant positive or negative associations with physical fitness test results. But when examined for associations for body composition individual body fat mass was significantly correlated with negative declines in participants physical fitness. And when stratified by individual sedentary leisure time activity (TV), participants who partook in a greater amount of time watching TV demonstrated greater negative inverse relationships with almost all physical fitness components measured.

Research has demonstrated that increased body fat mass is associated with decreased physical fitness in adolescents (Garcia-Pastor et al., 2016) and adults (Nikolaidis, 2013). Obesity has been clearly associated with numerous comorbidities such as diabetes, hypertension, hypercholesterolemia, and cardiovascular disease, which can result in serious health issues and even death (Stein & Colditz, 2004). An increase in body fat mass and inverse decline in physical fitness can have detrimental effects on activities of daily living and independent functional ability. Our study demonstrated that in young adults a relationship was already observed for negative relationships between decreased physical fitness and increased adiposity. And this led to the conclusion that for participants who have excess body fat mass early in life could have serious implications on physical fitness, weight management, and health outcomes later in life.

Physical activity and exercise improve cardiorespiratory and musculoskeletal fitness, but sedentary activity and behaviors have been shown to be inversely related to physical fitness performance. Physical fitness is an important determinant of health, and it is associated not only with the locomotor system, but also with the overall biological functioning of the body (Bangsbo et al., 2019). Scores in fitness tests are related to sex and age as well as body mass and to more detailed parameters such as body fat, muscle mass and body water percentage (Santana et al., 2017). Our results demonstrated that excess body fat mass has negative relationships with all measures of physical fitness in our participations. And this could be theorized that if young adults are already displaying lower physical fitness with excess body fat mass that there could be a greater decline in cardiorespiratory and musculoskeletal fitness with the normal aging process that is characterized by greater increases in body fat mass and sedentary behavior patterns.

5. Conclusion

TV viewing consumes roughly 55% of leisure time (Bureau of Labor and Statistics, 2012) and has been associated with lower levels of leisure-time and total physical activity (Guenther et al., 2008; Sugiyama et al., 2008) and lower cardiorespiratory fitness, (Tucker, 1990, Tucker et al., 2014). Associations between excess TV viewing time (sedentary time) and increased body fat mass has also been clearly demonstrated and an inverse relation has also been shown with markers of physical fitness. The current study demonstrated similar results with negative relationships between physical fitness components and body fat mass, and that individuals who engaged in more sedentary TV time exhibited more significant inverse associations which could led to a greater decline in physical functioning. And this could suggest that in younger adults who display a greater television time coupled with a decreased physical activity time may lead to greater sedentary behavior and increased fat mass with increased age.

Limitations:

This study was not without limitations. Aerobic fitness was quantified using the PACER test and not through indirect calorimetry which would have provided a better individual quantification. The PACER test can be daunting and challenging for individuals with a running concern or issue. Television viewing was quantified by means of recall from the previous week and not with a direct recording of daily time spent in on leisure time viewing. This could lead to a recall that was under or over estimated. Lastly, our participants were health and wellness college students who on average are more likely to be more physical active compared to their counterparts who may have majors that do not allow them access to more classes or activities that are by nature more physically active.

References:

[1]. Nelson JK, Zeratsky K. (2012). Do you have “sitting disease”? Nutrition and Healthy Eating. Mayo Clinic. http://www.mayoclinic.org/healthy-living/nutrition-and-healthy-eating/expert-blog/sitting-disease/bgp-2005623823. Accessed on July 10, 2017.

[2]. Yang, L., Cao, C., Kantor, E. D., Nguyen, L. H., Zheng, X., Park, Y., ... & Cao, Y. (2019). Trends in sedentary behavior among the US population, 2001-2016. *Jama*, *321*(16), 1587-1597.

[3]. Gorely, T., Marshall, S. J., Biddle, S. J., & Cameron, N. (2007). The prevalence of leisure time sedentary behaviour and physical activity in adolescent girls: an ecological momentary assessment approach. *International Journal of Pediatric Obesity*, *2*(4), 227-234.

[4]. Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J., Edwards, P., Woodcock, J., Brage, S., & Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *European journal of epidemiology*, *33*(9), 811–829. https://doi.org/10.1007/s10654-018-0380-1

[5]. Matthews, C. E., George, S. M., Moore, S. C., Bowles, H. R., Blair, A., Park, Y., ... & Schatzkin, A. (2012). Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. *The American Journal of Clinical Nutrition*, *95*(2), 437-445. Pate, R. R., O'neill, J. R., & Lobelo, F. (2008). The evolving definition of" sedentary". *Exercise and Sport Sciences Reviews*, *36*(4), 173-178.

[6]. Pate, R. R., O’Neill, J. R., & Lobelo, F. (2008). The evolving definition of" sedentary". *Exercise and Sport Sciences Reviews*, *36*(4), 173-178.

[7]. Grøntved, A., & Hu, F. B. (2011). Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. *Jama*, *305*(23), 2448-2455.

[8]. Johansson, S., Rosengren, A., Tsipogianni, A., Ulvenstam, G., Wiklund, I., & Wilhelmsen, L. (1988). Physical inactivity as a risk factor for primary and secondary coronary events in Göteborg, Sweden. *European Heart Journal*, *9*(suppl_L), 8-19.

[9]. Nielsen Co. TV usage trends: Q3 and Q4 2010. http://www.nielsen.com/content/dam/corporate/us /en/reports-downloads/2011-Reports/State%20of %20the%20Media%20TV%20Q3%20Q4%202010 .pdf. Accessibility verified May 16, 2011.

[10]. Sugiyama, T., Healy, G. N., Dunstan, D. W., Salmon, J., & Owen, N. (2008). Is television viewing time a marker of a broader pattern of sedentary behavior?. *Annals of behavioral Medicine*, *35*(2), 245-250.

[11]. Marcus, B. H., Williams, D. M., Dubbert, P. M., Sallis, J. F., King, A. C., Yancey, A. K., ... & Claytor, R. P. (2006). Physical activity intervention studies: what we know and what we need to know: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity); Council on Cardiovascular Disease in the Young; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. *Circulation*, *114*(24), 2739-2752.
[12]. Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., ... & Chinapaw, M. J. (2017). Sedentary behavior research network (SBRN)–terminology consensus project process and outcome. *International journal of behavioral nutrition and physical activity*, *14*(1), 1-17.
[13]. Park, J. H., Moon, J. H., Kim, H. J., Kong, M. H., & Oh, Y. H. (2020). Sedentary lifestyle: overview of updated evidence of potential health risks. *Korean journal of family medicine*, *41*(6), 365.
[14]. Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: the population-health science of sedentary behavior. *Exercise and sport sciences reviews*, *38*(3), 105.
[15]. Owen, N., Salmon, J., Koohsari, M. J., Turrell, G., & Giles-Corti, B. (2014). Sedentary behaviour and health: mapping environmental and social contexts to underpin chronic disease prevention. *British journal of sports medicine*, *48*(3), 174-177.
[16]. Stamatakis, E., Hamer, M., & Mishra, G. D. (2012). Early adulthood television viewing and cardiometabolic risk profiles in early middle age: results from a population, prospective cohort study. *Diabetologia*, *55*(2), 311-320.
[17]. Jago, R., Baranowski, T., Baranowski, J. C., Thompson, D., & Greaves, K. A. (2005). BMI from 3–6 y of age is predicted by TV viewing and physical activity, not diet. *International journal of obesity*, *29*(6), 557-564.
[18]. Berkey, C. S., Rockett, H. R., Gillman, M. W., & Colditz, G. A. (2003). One-year changes in activity and in inactivity among 10-to 15-year-old boys and girls: relationship to change in body mass index. *Pediatrics*, *111*(4), 836-843.
[19]. Zick, C. D., Stevens, R. B., & Bryant, W. K. (2011). Time use choices and healthy body weight: a multivariate analysis of data from the American Time Use Survey. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 1-14.
[20]. Napradit, P., & Pantaewan, P. (2009). Physical fitness and anthropometric characteristics of Royal Thai Army personnel. *Journal of the Medical Association of Thailand= Chotmaihet Thangphaet*, *92*, S16-21.
[21]. AghaAlinejad, H., Delfan, M., Mirzaei Rabar, M., Lotfi, S., Mollanouri, M., & Mirakhori, Z. (2009). Effects of age, gender, body composition on cardio respiratory fitness in students aged 8–11 years using the FFMI-FMI regression model. *Iranian Journal of Endocrinology and Metabolism*, *11*(3), 301-306.
[22]. Wanner, M., Richard, A., Martin, B., Faeh, D., & Rohrmann, S. (2017). Associations between self-reported and objectively measured physical activity, sedentary behavior and overweight/obesity in NHANES 2003–2006. *International journal of obesity*, *41*(1), 186-193.
[23]. Golubic, R., Wijndaele, K., Sharp, S. J., Simmons, R. K., Griffin, S. J., Wareham, N. J., ... & Brage, S. (2015). Physical activity, sedentary time and gain in overall and central body fat: 7-year follow-up of the ProActive trial cohort. *International journal of obesity*, *39*(1), 142-148.
[24]. Hu, F. B., Li, T. Y., Colditz, G. A., Willett, W. C., & Manson, J. E. (2003). Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *Jama*, *289*(14), 1785-1791.
[25]. Heinonen, I., Helajärvi, H., Pahkala, K., Heinonen, O. J., Hirvensalo, M., Pälve, K., ... & Raitakari, O. T. (2013). Sedentary behaviours and obesity in adults: the Cardiovascular Risk in Young Finns Study. *BMJ open*, *3*(6), e002901.
[26]. Inoue, S., Sugiyama, T., Takamiya, T., Oka, K., Owen, N., & Shimomitsu, T. (2012). Television viewing time is associated with overweight/obesity among older adults, independent of meeting physical activity and health guidelines. *Journal of Epidemiology*, 1112070273-1112070273.
[27]. Meyer KA, Wall MM, Larson NI, Laska MN, and Neumark-Sztainer D. Sleep duration and body mass index in a sample pf young adults. Obesity (Silver Spring). 2012 June; 20(6): 1279–1287.
[28]. Matsuzaka, A., Takahashi, Y., Yamazoe, M., Kumakura, N., Ikeda, A., Wilk, B., & Bar-Or, O. (2004). Validity of the multistage 20-m shuttle-run test for Japanese children, adolescents, and adults. *Pediatric exercise science*, *16*(2), 113-125.
[29]. Chomentowski III, P. J., Perry, C.A., Summers, L. A., Sabin, M. J, Spigelman, T. H, Comier, J., Kuzma, M., Monhollen, C., & Larkin. J. (2018). The associations between countermovement vertical jump displacement and anthropometric measures in college aged students. *Sport and Health International*
[30]. Blomqvist, S., Olsson, J., Wallin, L., Wester, A., & Rehn, B. (2013). Adolescents with intellectual disability have reduced postural balance and muscle performance in trunk and lower limbs compared to peers without intellectual disability. *Research in Developmental Disabilities*, *34*(1), 198-206.*Journal of Sport Sciences and Health*, *5*(9), 136-142.
[31]. Jakes, R. W., Day, N. E., Khaw, K. T., Luben, R., Oakes, S., Welch, A., ... & Wareham, N. J. (2003). Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study. *European journal of clinical nutrition*, *57*(9), 1089-1096.
[32]. Thorp, A. A., Healy, G. N., Owen, N., Salmon, J., Ball, K., Shaw, J. E., ... & Dunstan, D. W. (2010). Deleterious associations of sitting time and television viewing time with cardiometabolic risk biomarkers: Australian Diabetes, Obesity and Lifestyle (AusDiab) study 2004–2005. *Diabetes care*, *33*(2), 327-334.
[33]. Dunstan, D. W., Barr, E. L., Healy, G. N., Salmon, J., Shaw, J. E., Balkau, B., ... & Owen, N. (2010). Television viewing time and mortality: the Australian diabetes, obesity and lifestyle study (AusDiab). *Circulation*, *121*(3), 384-391.

[34]. Clark, B. K., Healy, G. N., Winkler, E. A., Gardiner, P. A., Sugiyama, T., Dunstan, D. W., ... & Owen, N. (2011). Relationship of television time with accelerometer-derived sedentary time: NHANES. *Medicine and science in sports and exercise*, *43*(5), 822.
[35]. Garcia-Pastor, T., Salinero, J. J., Sanz-Frias, D., Pertusa, G., & Del Coso, J. (2016). Body fat percentage is more associated with low physical fitness than with sedentarism and diet in male and female adolescents. *Physiology & behavior*, *165*, 166-172.
[36]. Nikolaidis, P. T. (2013). Body mass index and body fat percentage are associated with decreased physical fitness in adolescent and adult female volleyball players. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, *18*(1), 22.
[37]. Stein, C. J., & Colditz, G. A. (2004). The epidemic of obesity. *The Journal of Clinical Endocrinology & Metabolism*, *89*(6), 2522-2525.
[38]. Bangsbo, J., Blackwell, J., Boraxbekk, C. J., Caserotti, P., Dela, F., Evans, A. B., ... & Viña, J. (2019). Copenhagen consensus statement 2019: physical activity and ageing. *British Journal of Sports Medicine*, *53*(14), 856-858.
[39]. Santana, C. C. D. A., Azevedo, L. B. D., Cattuzzo, M. T., Hill, J. O., Andrade, L. P., & Prado, W. L. D. (2017). Physical fitness and academic performance in youth: A systematic review. *Scandinavian Journal of Medicine & Science in Sports*, *27*(6), 579-603.
[40]. Bureau of Labor and Statistics. American Time Use Survey. 2012 www.bls.gov/tus/tables/a1_2013.pdf.
[41]. Guenther, P. M., Reedy, J., & Krebs-Smith, S. M. (2008). Development of the healthy eating index-2005. *Journal of the American Dietetic Association*, *108*(11), 1896-1901.
[42]. Sugiyama, T., Healy, G. N., Dunstan, D. W., Salmon, J., & Owen, N. (2008). Is television viewing time a marker of a broader pattern of sedentary behavior?. *Annals of behavioral Medicine*, *35*(2), 245-250.
[43]. Tucker, L. A. (1990). Television viewing and physical fitness in adults. *Research Quarterly for Exercise and Sport*, *61*(4), 315-320.
[44]. Tucker, L. A., Arens, P. J., LeCheminant, J. D., & Bailey, B. W. (2015). Television viewing time and measured cardiorespiratory fitness in adult women. *American journal of health promotion*, *29*(5), 285-290.