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Impact of Physical Activity and Sugar Sweetened Beverage Consumption on Arterial Stiffness

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Impact of physical activity and sugar sweetened beverage consumption on arterial stiffness

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Abstract:

Purpose: Previous research has indicated that physical inactivity (PI) is linked to arterial stiffness. Similarly, a significant link between sugar-sweetened beverages (SSB) and poor cardiovascular health has been identified. The majority of previous research relating to arterial stiffness has involved studying older populations. However, few studies have examined college students. The purpose of this study is to examine the impact of PI and SSB consumption on arterial stiffness in college students. *Methods:* 10 male college students (age 22.0±1.8 yrs, height 175.7±6.3 cm, weight 75.0±12.1kg) and 7 female college students (age 20.7±3.1 yrs, height 160.6±4.4 cm, weight 64.9±9.7 kg) voluntarily participated in this study. Participants completed an International Physical Activity Questionnaire- short form (IPAQ-S), wore an accelerometer for 10 days, and participated in an SSB consumption interview. Arterial stiffness was measured via pulse wave velocity using the Sphygmocor Xcel non-invasive system. *Results:* No statistically significant results were found from this study ($p>0.05$) when examining the relationship between PWV and age, height, weight, waist-hip ratio, body fat percentage, sugar-sweetened beverage consumption, and physical activity minutes. *Conclusion:* Previous research has indicated that there is a relationship between SSB consumption, physical inactivity, and arterial stiffness. Significant relationships may not have been found because the majority of the participants in this study were students in the Exercise Science major, so they may be more physically active than the general student population. College students also tend to walk as their main source of transportation to and from classes, potentially negating the impact of SSB on arterial stiffness. Further research should be conducted on this population with a larger sample size and more diverse subjects.

Introduction

Physical inactivity (PI) has been independently linked to a host of disease including obesity, cardiovascular disease, and type II diabetes [1]. Yet, Americans still spend at least 55% of their waking day sitting or reclining [5]. According to Hamilton et. al (2007), it is not uncommon for people to spend half of their waking day sitting, with relatively idle muscle activity. The other half of the day typically includes non-exercise physical activity such as cleaning around the house, work related activities, and light walking [1]. Even more alarming is the increasing rate of PI from childhood through adulthood [7]. College students, in particular, may be especially susceptible to acquiring excessive amounts of PI as a result of prolonged sitting both during classes and while studying. In addition, this population is one that heavily relies on technology in the home, workplace, and at school, potentially contributing to increased PI. However, these students may also spend more time walking on campus to get to classes, meals, and social events-thereby reducing overall PI. Yet, it is unknown if this walking is enough physical activity to thwart off the complications associated with PI.

There is an abundance of research over the last decade highlighting the importance of physical activity in maintaining health. Recent epidemiological studies suggest that sitting, sedentary behaviors, and low nonexercise activity levels may a have a significant direct relationship with mortality, cardiovascular disease, type 2 diabetes, metabolic syndrome risk factors, and obesity. More specifically controlled laboratory studies have provided evidence that PI is detrimental at the cellular level. These studies examined the impact of PI on skeletal muscle lipoprotein lipase (LPL), a protein involved in controlling plasma triglyceride catabolism, high density lipoprotein cholesterol, and several other metabolic risk factors. These findings revealed that normal spontaneous standing and ambulatory time had a greater effect on LPL regulation than vigorous exercise training in addition to normal nonexercise activities. They concluded that the average person who does not participate in regular exercise may become even more metabolically unfit if they sit too much, and limit normally high volumes of intermittent non-exercise physical activity in everyday activities. In short, it is important to maintain nonexercise physical activity throughout the day as it is beneficial to ward of the dangers of prolonged sitting [5].

Other previous research has indicated that poor cardiorespiratory fitness, low physical activity, and PI are linked to higher levels of arterial stiffness [7]. Arterial stiffness refers to the general elasticity or compliance of the arteries in the cardiovascular system. Subsequently arterial stiffness contributes to pressure in the aorta and other blood vessels, increasing the risk for cardiovascular disease. We see this occur naturally with aging, for example, where the compliance of the vessels generally declines. Yet those participating in regular physical activity have shown an attenuation of stiffening in the vessels [2]. In fact, moderate to vigorous physical activity exercise that is specifically designed to improve cardiorespiratory fitness, was associated with more compliant vessels and reduced arterial stiffness [11]. Based on a study conducted by Boreham et al. (2004), cardiorespiratory fitness and sports-related physical activity (but not leisure- and work-related physical activity) were inversely associated with arterial stiffness in young adults [8]. According to the American Journal of Hypertension, arterial stiffness is recognized as a critical precursor of cardiovascular disease making it essential to understand the role of lifestyle modifications in preventing and reversing arterial stiffening [2]. Subsequently, PI may be an independent predictor of arterial stiffening and should be examined further.

Nutrition may also play a significant role in the compliance of the blood vessels. More specifically, recent literature has identified a significant link between sugar-sweetened beverages (SSB) and poor cardiovascular health including hypertension [12] and coronary artery calcification [7], subsequently contributing to arterial stiffness. While the consumption of soda has been found to decline from childhood into young adulthood, nontraditional SSBs such as energy drinks have replaced them, ultimately contributing to increased SSB consumption [3]. Therefore, independent of PI, SSB may also be a contributor to arterial stiffness, especially among college students.

The majority of previous research has been conducted on aging populations because there is a known natural development of arteriosclerosis that occurs with age. Young adults are an often overlooked population in regard to cardiovascular disease. Yet, research has shown that the development of atherosclerosis begins in childhood [1]. Furthermore, this period of emerging adulthood is marked by important transitions such as leaving home and increasing autonomy in decision-making and may be the best age for establishing long-term health behavior patterns, such as choosing to be less physically active and/or consuming more SSB than necessary [6]. In a college environment there is easy access to SSBs and typically a substantial desire to consume these beverages. According to Tanaka and Safar (2005), available evidence indicates that lifestyle modifications, in particular aerobic exercise and sodium restriction, appear to be clinically effective therapeutic interventions for preventing and treating arterial stiffening [12]. Therefore, it is important to understand the role of physical activity, PI, and SSB on arterial stiffness in younger populations. If significant data regarding arterial stiffness, SSB consumption, and PI were found in this young population, it would indicate a need for implementation of intervention, education, or preventative measures in colleges and universities to avert future cardiovascular implications. This study examined the impact of PI and SSB consumption on arterial stiffness in. We hypothesized that, compared to those with low levels of PI and SSB consumption, those with high PI and SSB consumption will have greater arterial stiffness.

Methods

Procedure

This study was a cross sectional analysis of 17 college students at The College at Brockport (age 21.5±2.4 yrs, height 169.5±9.4 cm, weight 70.8±12.0 kg). Included in these 17 students were 10 males (age 22.0±1.8 yrs, height 175.7±6.3 cm, weight 75.0±12.1 kg), and 7 females (age 20.7±3.1 yrs, height 160.6±4.4 cm, weight 64.9±9.7 kg). Exclusion criteria included cardiovascular, metabolic, pulmonary, or renal disease, musculoskeletal injury, and pregnancy.

Subjects came to the research lab on two separate visits. On visit 1, subjects were familiarized with the process of the study, the time commitment involved, and reviewed and signed an informed consent. Next, they were instructed to fill out a Health History Questionnaire (HHQ) and demographic questionnaire. Once the paperwork was completed, the subjects' height and weight were collected via stadiometer and a load cell scale (Seca, Chino CA). After data collection, the subject was given an accelerometer (Actigraph, LLC., Pensacola FL) to wear for 10 days. The accelerometer was to be worn on their dominant hip, taken off during excessive physical activity involving physical contact with other people or objects (i.e. rugby, football, volleyball, etc.), or during activities that involved getting wet (swimming, showering, etc.). The subjects were instructed to keep it on during sleep hours unless the apparatus was excessively uncomfortable. Subjects were then instructed to come back for further testing after the 10 day period.

On visit 2, height and weight were measured again and this data was used in the data analysis. Waist and hip circumferences were then measured in duplicate using a Gullick tape measure (Baseline, White Planes NY), and body fat percentage was measured using bioelectrical impedance analysis (BIA) (Body Stat, British Isles UK). The BIA involves the subject lying in a supine position while two electrodes were placed on the right ankle and two on the right wrist. While remaining still, a safe battery generated signal was transmitted through the body measuring impedance at a fixed frequency of 50 kHz. Following body fat percent, arterial stiffness was measured via central arterial pressure waveform analysis using the Sphygmocor Xcel non-invasive system (AtCor Medical, West Ryde AUS). The main measure examined was carotid-femoral pulse wave velocity (PWV). To measure PWV, a blood pressure cuff was placed around the right femoral artery on the upper thigh to measure the femoral artery waveform. Once the cuff was on, three distances were measured in millimeters and entered into the software: the carotid artery to the sternal notch, the sternal notch to the top of the femoral cuff, and the femoral artery to the top of the femoral cuff. After the distances were measured, the cuff was inflated and an applanation tonometer was simultaneously pressed into the side of the neck over the carotid artery pulse to measure the carotid artery waveform. The velocity was determined through the software by dividing the distance the blood traveled by the pulse transit time between the carotid and femoral waveform. Upon completion of the PWV test, the subjects were given a SSB consumption interview and were instructed to complete the International Physical Activity

Questionnaire-Short form (IPAQ-S). The SSB consumption interview was completed first. Subjects were asked the quantity of SSB consumed on an average day and how many ounces of each beverage. Beverages included on the survey were coffee (with addition of cream and/or sugar), juice, sports drinks (i.e. Gatorade, Propel), soft drinks, flavored milk substitutes, alcoholic mixed drinks, and any other drinks the subject lists that contain sugar. The IPAQ-S required the subject to answer how many hours/minutes were spent performing vigorous and moderate activity, walking, and sitting. At the end of the second visit, the subjects' accelerometers were collected. The accelerometer data was analyzed using Actilife software. The main values drawn from the Actilife software included time spent in a sedentary state, time spent performing light activity, and time spent performing moderate and vigorous activity. The accelerometer data was the primary source of objective physical activity data, but the IPAQ-S was used as a subjective measure as a back-up for the accelerometers.

Data collected was analyzed using SPSS Statistics Software(IBM Version 21, Chicago, IL). A two tailed t-test was performed and Pearson correlation values were noted. Descriptive data are listed as means ± SD.

Results:

For the purpose of this study 10 male subjects (age 22.0±1.8 yrs, height 175.7±6.3 cm, weight 75.0±12.1 kg), and 7 female subjects (age 20.7±3.1yrs, height 160.6±4.4 cm, weight 64.9±9.7 kg) enrolled at The College at Brockport voluntarily participated in this study (Table 1).

Table 1. Subject Characteristics

	Male (n=10)	Female (n=7)
Age (yrs)	22.0±1.8	20.7±3.1
Height (cm)	175.7±6.3	160.6±4.4
Weight (kg)	75.0±12.1	64.9±9.7

yrs=years, cm=centimeters, kg=kilograms

Subject values tested include waist-hip ratio, pulse wave velocity, body fat percentage, sugar-sweetened beverage consumption, and physical activity minutes. The average waist-hip ratio (WHR) for males was found to be .79±.04, while the average female WHR was .73±.06. The average male pulse wave velocity (PWV) was 5.8±.93 m/s, and the average female PWV was 6.7±3.3 m/s. The average male body fat percent (BF%) was 14.3±7.0 (%), and the average female BF% was 24.1±7.6 (%). The average SSB consumed for males was 7.7±7.8 (cups/day), and the average SSB consumed for females was 6.0±4.2 (cups/day). The average time spent in sedentary conditions for males was 688.0±243.9 (min/day), and for females was 614.7±66.5 (min/day). The average time spent performing light activities for males was 222.7±58.6 (min/day), and for females was 229.8±42.1 (min/day). The average time spent performing moderate to vigorous physical activity (MVPA) for males was 48.2±21.7 (min/day), and for females was 54.0±26.7 (min/day) (Table 2).

Table 2. Subject Test Values

	Male(n=10)	Female(n=7)
WHR	.79±.04	.73±.06
PWV (m/s)	5.8±.93	6.7±3.3
Body Fat (%)	14.3±7.0	24.1±7.6
SSB consumption (cups/day)	7.7±7.8	6.0±4.2
Sedentary (min/day)	688.0±243.9	614.7±66.5
Light (min/day)	222.7±58.6	229.8±42.1
MVPA (min/day)	48.2±21.7	54.0±26.7

WHR=Waist-Hip Ratio, PWV=pulse wave velocity, m/s=meters per second, %=percent, SSB=sugar-sweetened beverage, min/day=minutes per day, MVPA=moderate to vigorous physical activity.

No statistically significant (p>0.05) relationships were found between age, height, weight, waist-hip ratio, pulse wave velocity, body fat percentage, sugar-sweetened beverage consumption, and physical activity minutes (Table 3).

Table 3. Correlations of anthropometrics, SSB consumption, PWV, and PI

Correlations										
		wc	BF	PWV	SSB	sedday	ltday	modday	vigday	MVPAday
wc	Pearson Correlation	1	.466	.367	.128	-.100	.210	-.221	-.209	-.252
	Sig. (2-tailed)		.059	.147	.624	.703	.420	.394	.421	.329
	N	17	17	17	17	17	17	17	17	17
BF	Pearson Correlation	.466	1	.451	.067	-.303	.228	-.008	-.065	-.023
	Sig. (2-tailed)	.059		.069	.800	.237	.379	.977	.804	.931

	N	17	17	17	17	17	17	17	17	17
PWV	Pearson Correlation	.367	.451	1	.058	.018	.194	-.178	-.229	-.218
	Sig. (2-tailed)	.147	.069		.825	.945	.456	.494	.376	.401
	N	17	17	17	17	17	17	17	17	17
SSB	Pearson Correlation	.128	.067	.058	1	.043	-.478	.011	-.379	-.081
	Sig. (2-tailed)	.624	.800	.825		.870	.053	.966	.133	.757
	N	17	17	17	17	17	17	17	17	17
sedday	Pearson Correlation	-.100	-.303	.018	.043	1	-.457	-.236	.143	-.181
	Sig. (2-tailed)	.703	.237	.945	.870		.065	.363	.585	.488
	N	17	17	17	17	17	17	17	17	17
ltday	Pearson Correlation	.210	.228	.194	-.478	-.457	1	.310	.353	.368
	Sig. (2-tailed)	.420	.379	.456	.053	.065		.227	.164	.147
	N	17	17	17	17	17	17	17	17	17
modday	Pearson Correlation	-.221	-.008	-.178	.011	-.236	.310	1	.250	.972**
	Sig. (2-tailed)	.394	.977	.494	.966	.363	.227		.334	.000
	N	17	17	17	17	17	17	17	17	17
vigday	Pearson Correlation	-.209	-.065	-.229	-.379	.143	.353	.250	1	.469
	Sig. (2-tailed)	.421	.804	.376	.133	.585	.164	.334		.058
	N	17	17	17	17	17	17	17	17	17
	Pearson Correlation	-.252	-.023	-.218	-.081	-.181	.368	.972**	.469	1

MVPAday	Sig. (2-tailed)	.329	.931	.401	.757	.488	.147	.000	.058	
	N	17	17	17	17	17	17	17	17	17
**. Correlation is significant at the 0.01 level (2-tailed).										

Discussion:

The purpose of this study was to determine the impact of PI and SSB consumption on arterial stiffness in college students. Variables that were studied relating to physical activity were minutes spent in sedentary conditions, time spent performing light physical activity, and time spent performing moderate to vigorous physical activity. WHR and body fat percentage were studied as they are anthropometric measures typically related to physical inactivity. To analyze arterial stiffness, pulse wave velocity was measured. Age, height, and weight were also included in the analysis to determine if there was any impact on these variables and PWV. However, no significant relationship was found between SSB, arterial stiffness, and physical inactivity across genders or the entire group. Therefore, our findings did not support our hypothesis that there would be a significant relationship between physical inactivity, SSB consumption, and arterial stiffness. However, previous research has indicated there is a relationship between physical activity and arterial stiffness. It is also known that the development of atherosclerosis begins in childhood and that there is a natural increase in arterial stiffness with age. Previous research has shown that excessive SSB consumption may lead to the development of plaque buildup, atherosclerosis, and, as a result, hypertension and increased stiffening of the arteries [3]. Little to no studies have analyzed this combination of variables, and/or college students. Consuming excessive SSB while concurrently engaging in high levels of physical activity, may negate the effects of SSB consumption. If they are physically inactive and consuming SSB, the natural development of arterial stiffness may be accelerated.

Previous research has studied the effects of physical activity and training status on arterial stiffness levels. One previous study, conducted in 1993 by Vaitkevicius et al. involved analyzing the augmentation index (AGI) and aortic pulse wave velocity (APWV) in 146 male and female subjects age 21 to 96, free of cardiovascular disease. Aerobic capacity was determined by measuring VO_2 max during a treadmill test and this value was used as an assessment of physical conditioning status. The results of the study concluded that there is a 14% natural increase in arterial stiffness between the ages of 20 and 90 [13]. This study also concluded that individuals with higher physical activity and conditioning status, marked by high VO_2 values, had lower levels of arterial stiffness. Specifically AGI and APWV varied inversely with VO_2 max. Based on this study, the findings would suggest that interventions to improve aerobic capacity may attenuate the natural stiffening of peripheral arteries. The findings from this study support our hypothesis that individuals participating in regular physical activity would have lower levels of arterial stiffness, and individuals that spend substantial time in sedentary behavior may have relatively higher arterial stiffness[13].

Another study conducted by Fung et al. in 2009 analyzed the relationship between SSB consumption and coronary heart disease (CHD) in women. Coronary heart disease involves the build up of plaque on the artery walls, and therefore the development of arterial stiffness. This study involved women aged 34-59, without previous CHD. Other risk factors for CHD were accounted for and eliminated to analyze SSB individually. The results of the study indicated that regular consumption of SSBs is independently associated with increased risk of CHD women, even after other unhealthy lifestyle factors or dietary choices were accounted for [4]. Although this study was not conducted among college students, it supports our hypothesis that SSB consumption may be related to arterial stiffness. This study provides evidence that would support further research examining SSB consumption and arterial stiffness in college students.

A third study analyzed behavior patterns among college students and supports the hypothesis that college students typically do not spend substantial time exercising or consuming healthy foods. It is known that the shift from adolescence to adulthood is marked by behavioral changes and the establishment of long-term behavior patterns that affect long-term chronic disease risk and overall health. In 2012, Small et al. conducted a longitudinal study of college students to survey their fruit, vegetable, and sugared soda consumption, along with physical activity and sedentary behavior. The study tracked the students through 14 consecutive days over the course of seven semesters, and used web-based surveys to collect data. The results of the study indicated that few college students consumed fruits and vegetables or exercised at proper levels during the surveyed semesters. Fruit and vegetable consumption declined significantly from the first semester to the seventh. Physical activity also showed a steep decline over the surveyed semesters[10]. This study provides evidence that further research should be conducted in college due to the significant behavior change and increased autonomy to make lifestyle decisions that occurs at this age.

Although the current study did not find statistical significance regarding the impact of physical inactivity and SSB consumption, there is sufficient evidence from other studies to grant further research of these variables in college students. There were several limitations of this study that likely contributed to the lack of significance. If these limitations are addressed in future research there may be statistically significant findings.

The first limitation was the small subject population. Only 17 subjects were included in this study because several had to be eliminated based on data collection error and the development of disease during the study. There also needs to be increase in the size of the population studied. It is possible that if 50-100 subjects were studied, there would been more findings. Due to such a small population, there was also not much diversity among subjects. Most members involved were caucasian, with little to no other races and/or ethnicities represented. Moving forward, to get a more accurate representative population it would be imperative to represent a broad spectrum of races. A third limitation in this study that contributed to few findings was the fact that most, if not all participants were students in the Exercise Science major. This is problematic because they do not represent the "average" college student. These students are typically more physically active than the general student population. In order to find significance, in future studies it would be important to find students outside of the major, and have the majority of non-Exercise Science majors represented. Lastly, before the study was conducted, it was hypothesized that it would be easy to find sedentary college students based on the preconceived notion that a lot of college students spend the majority of their time in sedentary states. However, because students are walking to and from classes, there is a chance they are meeting the physical activity requirements strictly based on walking. In future studies it may be helpful to study these variables across different college campuses and analyze walking distances. If students attend classes on a more urban campus they may spend less time walking and more time in a car or sitting.

In conclusion, based on the study and previous literature, there is a need for future research on the impact of PI and SSB on arterial stiffness. There is potential for this study to be replicated if the limitations addressed above are accounted for. Other studies have provided evidence that physical inactivity and SSB consumption are related to cardiovascular health and arterial stiffness. There is no research to date that studies SSB consumption and physical inactivity together as they relate to arterial stiffness. There are even fewer research studies analyzing college students. Youthful post-adolescent populations are often overlooked. It is important to study these individuals because if there is an increase in arterial stiffness above and beyond the natural occurrence due to SSB consumption and PI it is important to increase prevention programs and education.

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