The Relationship of Physical Activity and Fruit and Vegetable Intake on Pulse Wave Velocity

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By
Allison Nave
Exercise Science Major

The College at Brockport
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Thesis Director: Dr. Craig Mattern, Associate Professor, Exercise Science

Abstract:

Arterial stiffness has been found to be an independent predictor of cardiovascular disease (CVD). Those who consume a diet rich in fruits and vegetables, and participate in habitual physical activity may experience reduced arterial stiffness, thereby decreasing the risk of CVD. **Purpose:** To examine the relationship of fruit intake, vegetable intake, and moderate-vigorous physical activity (MVPA) on arterial stiffness in college students. **Methods:** 19 college students (age 19.8±1.1 yr, height 166.1±9.6 cm, weight 73.1±18.0 kg) completed a modified Dietary Guidelines for American Index (DGAI) questionnaire for 10 days. MVPA was assessed via accelerometery for an average of 12.7±4.66 days. Arterial stiffness was then measured using carotid-femoral pulse wave velocity (PWV). While supine, a cuff was placed around the right thigh and inflated. Concurrently, a tonometer was placed over the carotid artery and data were obtained from both carotid and femoral waveforms after 10 consecutive seconds. **Results:** Participants completed the DGAI for an average of 9.1±1.9 days, and the average servings per day of fruits and vegetables was 2.1±1.2 and 2.1±1.2, respectively. The average servings per day of fruits and vegetables combined was 4.2±2.02. Participants engaged in 42.0±17.9 min/day of MVPA. The average blood pressure was 126±13/72±9 mmHg and PWV was 5.1±0.99 m/s. Pearson correlation found no significant relationship between total fruit and vegetable servings/day and PWV (p=.68). A multiple regression was run to predict PWV from fruit servings/day, vegetable servings/day, and MVPA/day. There were no significant differences in the three variables combined in predicting PWV ($F_{(3,15)}$= .893, p=0.467, R=0.389). **Conclusion:** While most participants did not obtain the recommended 5 daily servings of fruits and vegetables, it had no affect on arterial stiffness. However, participants achieved the

recommended amounts of MVPA. It is possible that the onset of CVD has not yet been recognized due to the age and physical activity levels of the sample.

Introduction:

Dietary factors and physical activity play a substantial role in the health and well-being of all individuals. These factors are related to both the development and progression of CVD (1,2). Consuming fruits and vegetables has been shown to have a protective effect against the risk of CVD (1, 3). In addition, physical activity has been shown to have health enhancing effects and reduced risk of CVD (4). Despite news of these positive factors on disease risk, there still remains a low intake of fruits and vegetables worldwide and physical activity levels remain far below optimal (1,5).

CVD is the leading cause of death and disability in the United States and may be considered an “epidemic” (6). It can be characterized by atherosclerotic buildup of plaque inside the vessels and evidence suggests this process starts early in childhood (7). Arteries are designed to stretch and recoil as the heart beats which allows for buffering of the pulse wave sent by the heart producing optimal blood flow through the body (6). Those with CVD will have decreased surface area and compliance in the artery walls. Hypertension, diabetes, dyslipidemia, smoking and obesity are all factors contributing to CVD. Uncontrollable factors such as genetics and aging also play a role in the development of disease. As we age our arteries naturally get stiffer and less elastic adding to the decline in vascular endothelial function (6). In contrast to uncontrollable factors, many times individuals are at a higher risk of disease due to the lifestyle they acquire overtime. It is predicted that by the year 2030, more than 40% of the US population will have one or more forms of CVD (6).

The etiology of CVD can be explained from many different perspectives. Alissa and Ferns suggest that up to 2.6 million deaths worldwide and 31% of CVD could be attributed to low levels of fruit and vegetable consumption (2). Cardiorespiratory fitness and physical activity have also been shown to be inversely associated with CVD risk (8). When assessing CVD, an assessment of arterial stiffness can be used to predict the risk. A measure of arterial stiffness can be obtained by measuring PWV. PWV is a measurement of the time it takes the pressure wave to travel through the circulatory system. Compliant arteries allow for smooth flow through the system and thereby decreasing PWV, the speed at which the pressure wave returns to the heart. With this decreased speed of flow, it allows for the wave to return during diastole, thereby adding to the perfusion of blood through tissues. An increased PWV causes the blood to return while the heart is still in systole, which in turn increases the systolic pressure of the heart.

PWV has been accepted as an independent predictor of CVD and all-cause mortality, as well as the gold standard method of assessing arterial stiffness (1,9). A doubled risk of mortality from CVD has been associated with an increase in PWV of 5m/s (10). According to Diaz et al., when looking at healthy, asymptomatic individuals with no history of hypertension the average PWV in ages 10-19 years was 5.04 ± 0.72m/s (11). As age increases, PWV increases as well with the age groups of 20-29 and 30-39 years acquiring an average of 5.82 ± 0.92 and 6.32 ± 0.82m/s, respectively (11). In healthy aging individuals, both physical activity and dietary habits have been shown to determine the rate of arterial stiffening, and previous research has shown that fruit and vegetable consumption in childhood affects arterial stiffness in adulthood (1,12). Those obtaining extensive amounts of fruits and vegetables in childhood obtained a lower PWV in adulthood compared with those who had persistently low intakes (1). Furthermore, cardiorespiratory fitness has been inversely associated with arterial stiffness (8). Regular aerobic exercise has been shown to decrease age related stiffening of arteries (13). While these factors also contribute to reducing arterial stiffness, combining a fruit and vegetable rich diet along with physical activity to create a healthy lifestyle will provide the most optimal results to reducing the risk of disease.

Arterial aging is an inevitable process, but aerobic exercise has been shown to be one of the most powerful lifestyle interventions in slowing the stiffening (6). Fruit and vegetable consumption also play a role in the reduction and slowing of arterial stiffening. After six months of nutrition and exercise intervention in obese subjects, both large and small artery compliance has been shown to increase (14). Even small increases in fruit and vegetable servings per day can have a positive effect on cardiovascular health. These positive effects may be due to the food source containing dietary nitrate which can be converted into nitric oxide.

Nitric oxide plays a role in the heart and blood vessels assisting in dilation and maintaining vascular homeostasis (15). Nitrate intake, which is closely linked with vegetable intake, gets converted to nitric oxide allowing for your endothelium and smooth muscle to relax, thereby enhancing blood flow and reducing arterial stiffness (15). Specifically, flavonoid rich fruits, dark green leafy vegetables, and other phytochemicals found in fruits and vegetables contain more nitrate than other food sources (16). Research has shown that adding nitrate into the diet such as flavonoid rich apples and nitrate rich spinach causes a decrease in blood pressure and increases in both nitric oxide status as well as endothelial function (17). Furthermore, nitrate rich beetroot juice has been proved to increase plasma nitrate and nitrite levels thereby increase submaximal exercise performance at altitude (18).

Not only vegetable intake, but physical activity also causes the release of nitric oxide and vasodilation which can decrease blood pressure and arterial stiffness (6). During exercise blood flow increases causing an increase in nitric oxide release and vasodilation. The shear stress produced during exercise is what causes the endothelium to release nitric oxide causing vascular smooth muscle to relax (19). Sousa et al, showed this by analyzing nitric oxide in elderly women after completing an aerobic dance session (20). The increased levels of nitric oxide after the dance session prove physical activity to be an important component of vascular function. Similarly to the elderly population, in obese children, moderate physical activity has been shown to be inversely associated with PWV, indicating the need for intervention even at young ages (7).

The cardioprotective effect of fruits and vegetables may also be due to their antioxidant affect which could prevent the oxidation of LDL cholesterol (2). Antioxidant rich foods such as fruits and vegetables improve the vasodilation of blood vessels, improving blood pressure and arterial compliance. The antioxidants help to decrease free radicals which contributes to shortages of nitric oxide (21). Physical activity also enhances the endogenous effect of antioxidants. With exercise you are able to increase antioxidant activity, which will inhibit the breakdown of nitric oxide caused by free radicals (22).

Consuming a Mediterranean or Dietary Approaches to Stop Hypertension (DASH) diet, which is high in fruits and vegetables, has been shown to increase endothelial function and decrease arterial stiffness (6). The Mediterranean diet may contain up to twenty times as much nitrate as the typical “western diet”, which is high in fat and sugar (6,15). Those consuming a diet rich in fruits and vegetables has been shown to be inversely associated with endothelial dysfunction which is related to arterial stiffness (23). College aged students tend to be limited in consumption of fruits and vegetables, and many do not achieve optimal levels of exercise (24). The Dietary Guidelines for Americans (DGA) are evidence-based recommendations to promote healthy eating patterns that will decrease disease risk (23). When looking at the DGAI from

2010, after completing a questionnaire on it, the higher that subjects scored, the lower their pulse wave velocity (23). The DGAI is a tool used to measure the degree that the DGA are met and it is plausible that the inverse relationship between the DGAI scores and PWV is due to the guidelines recommending high intake of fruits and vegetables. When looking at the results of the DGAI most of the inverse relationships were more pronounced in adults under the age of 50, yet only one in three college students consume a diet consistent with national recommendations and these diets tend to be low in fruit, vegetables and dietary fiber (23,24).

According to Small et al, daily fruit and vegetable consumption and daily physical activity levels declined significantly across seven semesters of college (24). Vegetable consumption has been shown to be an independent predictor of PWV in adults, yet we still see poor nutritional choices (1). Inverse correlations have been found between PWV and high vegetable intake compared with high rice intake which has no significant positive impact on PWV (25). The trend toward promoting fruit and vegetable consumption to positively influence PWV could still be ambiguous due to some individuals believing the decrease in PWV is independently high intakes of fruits and vegetables, while others believe there are additional nutritional factors involved.

With the ambiguity of different studies performed, a benefit could be found with further research on the topic. Many believe that an increased score on the DGAI questionnaire is due to high intakes of fruit and vegetables. In contrast, a study found that increased dairy consumption per week yields a lower PWV compared with lower intakes (26). While we see this trend, most of the dairy intake was low fat dairy products such as skim milk, and products such as dairy desserts, cream, and ice cream were consumed infrequently (26). Therefore, the DGAI results may also be due to the emphasis on low fat dairy products, wholes grains and lean meats. In addition, many times a healthy diet is accompanied with physical activity which has been shown to decrease PWV as physical activity levels increase (27). Increased arterial compliance has been shown in healthy middle aged and older men who were previously sedentary, showing physical activity to be an essential factor to reducing vascular stiffness (13). Since many college students do not meet recommended physical activity levels and fruit and vegetable consumption, we would expect to see a higher PWV in younger adults rather than older. Contrary to this assumption, the response of unhealthy eating and sedentary behavior may take a prolonged time to develop, so the onset of chronic disease may not be present yet in young individuals. In addition, while many studies show older adults obtaining a higher PWV this could be due to the aging process as well as other nutritional factors.

While the impact of Mediterranean and DASH diets has shown to have a positive influence on arterial stiffness, it is difficult to tell which part of the diet specifically contributed to the reduction in vascular stiffness. In addition, fruit and vegetable consumption in childhood predicts PWV in adulthood but, it is still not clear whether physical activity played a role in the reduction. Bondonno et al, believes that decreased arterial stiffness is due to dietary nitrate intake which allows nitric oxide to be release which in turn enhances vascular tone (14). Supplementing the diet with beetroot juice has shown sustained reduction in blood pressure, and parameters of aerobic fitness such as VO2 max were elevated after 15 days of supplementation (28). This increase after 15 days shows chronic intake of nitrate may yield desirable effects on health. Although this could be true, it is also plausible that this could be due to physical activity release of nitric oxide or as Alissa and Ferns believe, the antioxidant effect of fruits and vegetables (4). The difference in these views may be due to the focus on different variables being studied.

According to LaRocca et al, during the aging process it is the impact of both nutrition and lifestyle factors that influence the development and progression of arterial stiffness (15).

While multiple age groups have been studied, we tend to see an abundance of research in adults and aging populations. In addition, nutritional studies tend to focus on nutrition as a whole or a specific nutrient, rather than specific consumptions of fruits or vegetables. While we know that CVD can begin at young ages and has many modifiable risk factors, young adults are still sometimes overlooked. It has been found that physical activity, and fruit and vegetable consumption start low and gradually decrease throughout the college years, so determining its impact on arterial stiffness in this age group is key (8). With this knowledge, examining the consumption of fruits and vegetables as well as physical activity levels can help to provide insight into its impact on arterial stiffness. Determining the role of these factors on PWV may help to provide awareness on methods to regress and slow the progression of arterial stiffness. Therefore, the purpose of the investigation was to examine the impact of fruit and vegetable consumption, and physical activity on PWV in college students was examined during this study.

Methods:

Experimental Procedure:

This cross-sectional study included 19 college students, at a small liberal arts college in Western, NY. Participation was voluntary and exclusion criteria included existing documented cardiovascular, metabolic, pulmonary, or renal disease, musculoskeletal injury, and pregnancy. Participants voluntarily agreed to come into the research laboratory for two separate visits. Visit 1 included signing an informed consent and completing both a health history questionnaire (HHQ) and demographic questionnaire. Height and weight were recorded, and accelerometers were given to the participant to wear. A modified DGAI was given to the participant to fill out. Visit 2 occurred following 10 days of wearing the accelerometer. Height and weight were measured again, and waist and hip circumferences were measured. Both BMI and waist-hip ratio were calculated. Body fat percentage was measured, and both a sugary beverage and physical activity questionnaire were verbally answered. Arterial stiffness was assessed via carotid-femoral PWV.

Baseline Measurements:

Participants were familiarized with the procedures of the study, the requirements, and signed an informed consent. The HHQ and demographic questionnaire were both completed by the participant. Height and weight were obtained and recorded. Height was measured using a Seca 216 stadiometer (Seca, Chino, CA) and weight was measured using a load cell scale (Seca, Chino, CA). The values obtained for height and weight were used to calculate BMI.

Measurement of Physical Activity:

The participants were given and instructed on how to wear an accelerometer (Actigraph, Pensacola, FL) for ten days. Accelerometers were always worn on the waist over the right hip except for during activities involving physical contact such as football or rugby, and water activities such as showering or swimming. The accelerometers could be worn to sleep but taken off if discomfort was caused. The participant was then asked to verbally answer the International Physical Activity Questionnaire- Short form (IPAQ-S). This IPAQ-S had the participant self-report the number of hours/minutes per day they were involved in moderate and vigorous activity, walking, and sitting in the past week.

Measurement of Fruit, Vegetable, and Sugary Beverage Intake:

The participants were educated on serving sizes of various fruits and vegetables using plates and fake food products. Once educated, the modified DGAI questionnaire was given to the participant to fill out for at least seven of the ten days. The questionnaire included sections for various food groups. A check was to be placed in a box each time a serving was consumed of that food group. Half cup servings sizes were used, and participants were asked to record the dates in which their data were obtained. The second visit also included the participant answering questions on a Sugar Sweetened Beverage (SSB) interview. The SSB questionnaire had participants report the average number of SSB consumed in a day and how many ounces each beverage was. This interview included coffee with added cream or sugar, soda, juice, sports drinks, soft drinks, flavored milks, alcoholic beverages, and any other SSB not mentioned.

Measurement of Circumferences:

Waist and hip circumferences were measured twice using a Gulick tape measure. The participant stood with their feet together and arms at the side. Waist circumference was measured at the end of exhalation and at the narrowest part of the waist above the umbilicus and below the xiphoid process. Hip circumference was measured at the maximal circumference of the buttocks. Measurements were taken twice at each site and the average was taken. Waist to hip ratio was then calculated from the obtained values.

Measurement of Body Fat:

Body fat percentage was measured using bioelectrical impedance analysis (BIA) (Bodystat, British Isles). For the BIA measurement, the participant was instructed to relax in a supine position. The skin on the right ankle and right hand were thoroughly wiped using alcohol wipes.

Two electrodes were placed on the right foot, one behind the second toe and one on the ankle between the medial and lateral malleoli. The next two electrodes were placed on the right hand, one behind the knuckle of the middle finger and the other on the wrist next to the ulnar head. The four alligator clips were attached to the four electrodes. While remaining in a still, supine position, a safe electrical current was transmitted through the body to measure impedance through body fluids.

Measurement of Pulse Wave Velocity:

Arterial stiffness was measured by using the Sphygmocor Xcel non-invasive system to measure central arterial pressure waveform analysis (AtCor Medical, West Ryde AUS). The measurement examined with this system was carotid-femoral PWV. To measure PWV, the participant remained in a relaxed supine position. A cuff was placed around the right thigh and the participant was instructed on how to palpate for their femoral artery. Once the femoral pulse was found, measurements were performed with a Gulick tape measure from the femoral artery to the thigh cuff, from the sternal notch to the cuff, and from the carotid artery to the sternal notch. These values were put into the software in millimeters. The participant was then directed to turn their head to their left in order palpate for the carotid artery. Once it was located the applanation tonometer was placed on the neck over the carotid artery while the thigh cuff simultaneously inflated to measure the waveforms. After 10 consecutive seconds of simultaneous carotid and femoral waveforms the software determined the pulse wave velocity by using the distance the blood traveled and the time it took the pulse to travel between the carotid and femoral arteries.

Statistics:

Data collected were analyzed using SPSS Statistics Software (IBM, Chicago, IL). Data are presented as means ± SD. A significance level of $p < 0.05$ was set *a* priori. Pearson analysis was performed to determine the relationship between fruit & vegetable consumption, and PWV. A regression analysis was employed to predict PWV from fruit intake, vegetable intake, and moderate-vigorous physical activity (MVPA).

Results:

19 college students, 17 females and 2 males, at a college in Western, NY voluntarily participated in the study. The average age, height, and weight were measured and recorded. BMI and waist to hip ratio were calculated.

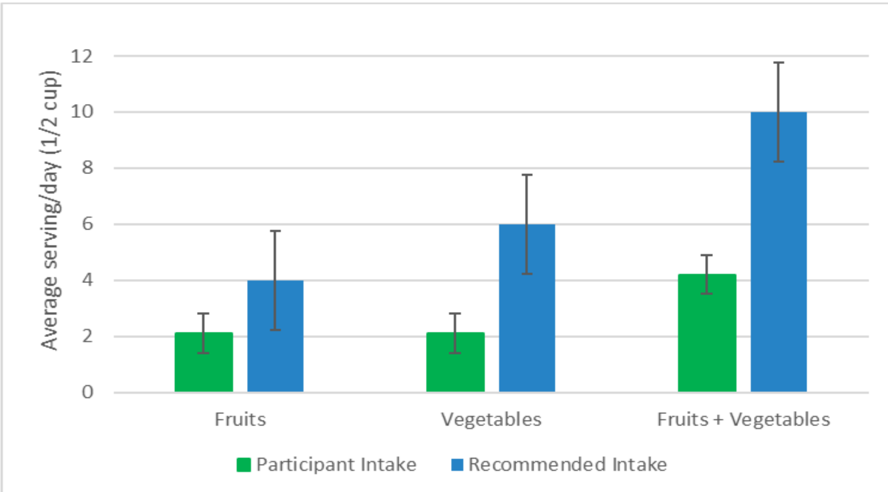
Table 1. Participant Characteristics

Age (yrs)	19. 8 ± 1.1
Height (cm)	166.1 ± 9.6
Weight (kg)	73.1 ± 18.0
WHR	.79 ± .07
BF (%)	28.1 ± 11.3

yrs=years, cm=centimeters, kg=kilograms, WHR= waist to hip ratio, BF=body fat, %= percentage

Table 1 shows participant baseline characteristics. BIA was used to measure body fat and participants obtained an average body fat of 28.1 ± 11.3%.

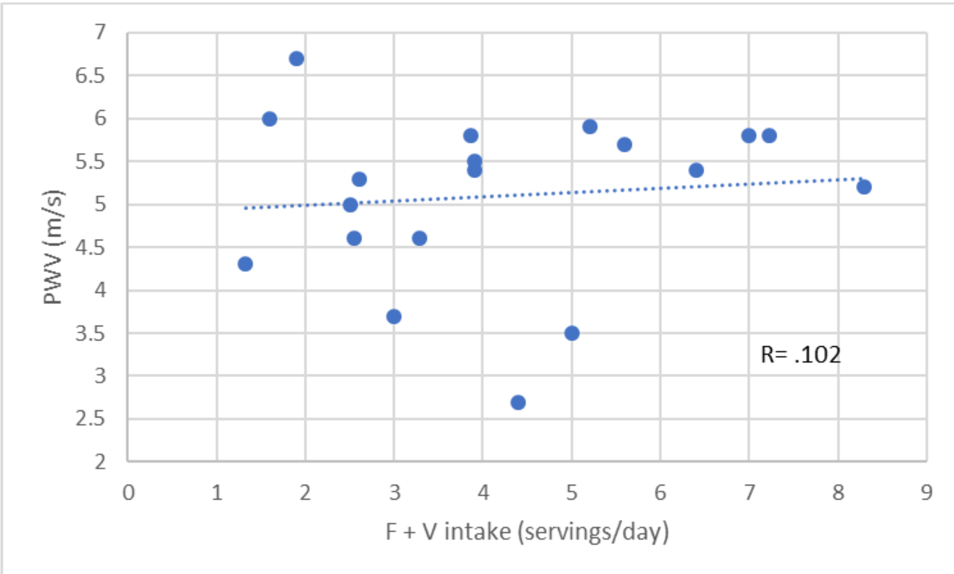
Figure 1. Intake of Fruits and Vegetables vs. Recommendations



serving/day=servings per day

Figure 1 shows the participant intakes of fruits and vegetables compared to the recommended intakes. According to MyPlate and the 2015-2020 DGA, young adults should consume about 2 cups (four ½ cups) of fruits per day and 2.5-3 (five-six ½ cups) cups of vegetables per day (29). The average ½ cup servings per day of fruits and vegetables was 2.1±1.2 and 2.1±1.2, respectively. When looking at total intake of fruits and vegetables, the recommendation is approximately 10 servings per day. When combining fruits and vegetables together in our participants, the average servings per day was 4.2±2.02 (Figure 1). Participants completed the DGAI for an average of 9.1±1.9 days. Participants self-reported an intake of 2.1±1.2 servings of fruit per day and 2.1±1.2 servings of vegetables per day. Participants performed 42.0±17.9 min/day of MVPA as measured via accelerometry. The average resting blood pressure was 126±13/72±9 mmHg and PWV was 5.1±0.99 m/s.

Figure 2. Relationship Fruit &Vegetable Intake with Pulse Wave Velocity



F=fruit, V=vegetable, servings/day=servings per day, m/s=meters per second

Fruit and vegetable consumption were recorded on the DGAI and the total intake of both combined were observed and compared with PWV. Pearson correlation found no significant relationship between total fruit and vegetable servings/day and PWV as shown in figure 2 (r=.102). A multiple regression was run to predict PWV from fruit servings/day, vegetable servings/day, and MVPA/day. There were no significant differences in the three variables combined in predicting PWV (F (3,15)= .893, p=0.467, R=0.389).

Discussion:

The purpose of this study was to examine the impact of fruit and vegetable consumption, and physical activity on PWV in college students. Physical activity was measured via an accelerometer and MVPA was included as a variable for physical activity levels. Fruit and vegetable servings were recorded using ½ cup serving sizes and PWV was measured to analyze arterial stiffness. There was no significant relationship between fruit & vegetable intake and PWV, nor was there a significant relationship between MVPA and PWV.

Despite the fact that fruit & vegetable intake or MVPA was not a predictor of arterial stiffness, our participants were not consuming the recommended servings of fruits and vegetables per day. Our results were not significant, although previous studies looking at fruit and vegetable consumption have shown significant relationships with PWV. When looking at fruit and vegetable consumption across the lifespan, vegetable intake was found to be an independent predictor of PWV in both childhood and adulthood (1). It would be optimal to have high consumption of vegetables throughout the lifetime. In contrast to our study focusing on young adults, in adulthood, both fruit and vegetable consumption were found to be significantly related to PWV (1). High fruit and vegetable intakes were associated with lower PWV, but it was more evident if intake was consistently high from childhood through adulthood compared with consistently low intakes throughout the lifespan (1). This shows that childhood lifestyle factors have an impact on PWV in adulthood and it would be beneficial to consume fruits and vegetables over a long period of time to obtain the optimal lower PWV. The results of this study would lead us to conclude that it is desirable to have healthy dietary habits starting from childhood through adulthood and this would support our hypothesis that increases in fruit and vegetable intake would have positive effects on PWV.

Another study looking at a population of postmenopausal women with pre- and stage 1 hypertension found that daily blueberry powder significantly decreases blood pressure and arterial stiffness after 8 weeks (30). Blueberries are known for their antioxidant effect and this reduction in the variables was due to nitric oxide vasodilation (30). This significant reduction in PWV ($P < 0.01$) was found in the blueberry intervention group compared with the control group

(30). While our study did not show significant reduction in PWV with increasing nutrient intake, the participants were not consuming the daily recommendation of fruits and vegetables which would aid in the antioxidant nitric oxide release. The findings of this study show the importance of studying antioxidant foods and it is possible that if our population was consuming more antioxidant rich fruits and vegetables there would be significantly lower PWV.

We know that stiffening of the arteries begins in children and progresses even more rapidly with obese children. Our sample population was generally healthy and only young adults. Therefore, it is possible the health status and age offset the undesirable PWV. In a study looking at both obese and normal weight children, there was an increase in PWV with increased body weight and body fat percentages (7). In addition, only 36% of the overweight and obese individuals participated in 60 min of exercise daily compared with 61% of the normal weight children (7). When looking at the physical activity levels of the children, PWV decreased significantly with increasing moderate physical activity levels. In contrast to these individuals, most of the participants in our small sample were achieving the recommended amounts of MVPA which is could have offset the low intake of fruits and vegetables. Aerobic exercise has also been shown to decrease arterial stiffness in young, healthy individuals which was much of our population (12). However, older individuals have stiffer less compliant arteries due to aging and therefore, are less respondent to exercise (12). Hence, it is important to increase aerobic activity at younger ages to slow to natural stiffening progression.

In addition, the transition to college can be a time in which many lifestyle and behavior habits are formed. When looking at the University Life Study which included college students across 7 semesters, a decrease in fruit and vegetable consumption was seen throughout the years (24). This study found that first semester students consumed fruits and vegetables an average of

2.37 times per day (24). This was also the highest intake and it was seen to decrease each year. According to Alissa and Ferns, fruits and vegetables should be eaten as part of a balanced diet and the goal should be to increase the intake above 5 daily servings (2). Many of the studies done do not show adequate intake of fruits and vegetables yet we know there is a protective effect against CVD and arterial stiffness with increased consumption.

Contrary to our population, the students in the University Life Study over seven semesters were not meeting the recommended amounts of daily physical activity, accumulating only about 26 minutes a day of MVPA (24). This 608-student sample could include students from all different interests and activities, while our 19-student sample consisted of a majority of health related majors who emphasize a lifestyle that incorporates regular physical activity. Physical activity levels were seen to decrease by 6% each semester of college as well as fruit and vegetable consumption decreasing by 14% across the seven semesters (24). The findings of this study can conclude that fruit and vegetable consumption is far below optimal in many college students, so healthy eating and behavior habits should begin to be established starting at young ages and especially going into the college years.

In another study, Berry, et al. looked at potassium intake from fruits and vegetables. Although he was looking specifically looking at potassium, the increase in potassium was coming from fruits and vegetables or supplementation. The study included a control group, which increased their potassium intake from supplements by 40mmol/day, and two groups increasing potassium intake from fruits and vegetables, one by 20mmol/day and one by 40mmol/day (31). There was a 3-week run in period to familiarize the participants and then 6 weeks of intervention and they found no evidence that increased potassium intake from any of the methods significantly reduced blood pressure, arterial stiffness, or endothelial function (31).

These participants were older adults, about 45 years old, but like our study there was still no significant findings. Since many interventions included potassium from fruits and vegetables, we could conclude that increased fruit and vegetable intake has no effect on arterial stiffness in this group. This study did not look at physical activity levels, so it is possible that these individuals were similar to our participants and engaging in adequate amounts of physical activity, so the high fruit and vegetable intake had no further effect on arterial stiffness.

While the current study did not find any significance between fruit and vegetables consumption, and physical activity on PWV, other studies reveal the need for future research on these variables. There are also some limitations to the current investigation, and without them, it may have been possible to show a statistically significant relationship between lifestyle and PWV. The first limitation is the small sample size of 19 students. If there was a larger sample size it is plausible there would have been significant findings. In addition, most of our participants were health related majors that emphasize physical activity and healthy eating as part of their lifestyle. These students do not represent the typical college population due to their high levels of MVPA. There was also a lack of ethnicity in the population in which the majority of our sample was Caucasian.

Due to the young age and most participants achieving the recommended amounts of daily MVPA, it is reasonable to believe that early onset of CVD, determined by PWV, may not be present yet. In the future, it is important to branch out to other areas of the college and recruit a more diverse sample of individuals. Many studies have looked at children and aging populations, so it is important to look at young adults who have not yet shown the presence of disease. PWV is a measure of arterial stiffness which is linked to CVD, so if we continue studying PWV there is potential to predict future risk of CVD. Further research should also look at the impact of addition food groups as well as specific nutrients to determine their impact on PWV. While we know both food and physical activity choices have an impact on CVD, further research could help find proper intervention and counseling of the specific variables.

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