Winter 12-2015

The Relationship Between Fitness, Body Composition and Calf Venous Compliance in Adolescents

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THE RELATIONSHIP BETWEEN FITNESS, BODY COMPOSITION AND CALF VENOUS COMPLIANCE IN ADOLESCENTS

by

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B.S., Southern Illinois University, 2012

A Research Paper

Submitted in Partial Fulfillment of the Requirements for the

Masters of Science.

Department of Kinesiology

in the Graduate School

Southern Illinois University Carbondale

December 2014

RESEARCH PAPER APPROVAL

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Southern Illinois University Carbondale

August 1st, 2014

AN ABSTRACT OF THE RESEARCH PAPER OF

MICHELLE WILLIAMS, for the Masters of Science degree in EXERCISE SCIENCE, presented on *AUGUST 1st,2014, at Southern Illinois University Carbondale.

TITLE: THE RELATIONSHIP BETWEEN FITNESS, BODY COMPOSITION AND CALF VENOUS COMPLIANCE IN ADOLESCENTS

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Fitness level can impact venous compliance and this effect can be realized with various exercise forms. The relationship between fitness level and venous compliance has been well established in adults or older participants, there has been minimal focus on children. The primary purpose of this study was to determine the relationship between fitness level, body composition, and venous compliance in children. Twelve participants n=12, 6 males, 6 females were assessed on height, weight, body fat % measurement, venous compliance measurement, and fitness assessment. There were no significant differences in fitness levels and venous compliance when looking at body fat percentage, VO2 peak, and BMI.

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INTRODUCTION

Venous compliance is the change in pressure that accompanies changes in volume in the veins and is a measure of the elasticity of the vessel wall (Zachrisson, Lindenberger, Hallman, Ekman, Neider, & Lanne, 2011). Maintenance of compliance is important due its role in the preservation of blood pressure and consistent cardiac output both at rest and during exercise (allowing for the continuation of consistent blood flow throughout the body). From previous research (Monahan & Ray, 2003; Hernandez & Franke, 2005), we know that venous compliance varies with age (Hernandez & Franke, 2005; Iida, Nakajima, Kurano, Yasuda, Sakamaki, Sato, Yamasoba, & Abe, 2011), and fitness level (Hernandez & Franke, 2005; Iida et al., 2011; Kawano, Tanimoto, Yamamoto, Gando, Sanada, Tabata, Higuchi, & Miyachi, 2010).

As we age, there is a reduction in venous compliance (Hernandez & Franke, 2005; Iida et al., 2011). It is believed that this change is due to structural changes within the veins that cause the venous walls to thicken in response to an increase in the amount of collagen/elastin in the venous walls (Iida et al., 2011). A decline in the sympathetic reflex response also likely plays a role, and contributes to issues with orthostatic intolerance. This relationship to age has led to a number of studies examining the relationship between venous compliance and various fitness variables in older populations that are detailed below.

As stated above, fitness level can impact venous compliance and this effect can be realized with various exercise forms. Improvement has been shown with aerobic exercise in older adults who participated in a six month aerobic training program (Hernandez & Franke, 2005). Kawano and colleagues (2010) looked at venous compliance in the forearm of males who participated in a resistance training program vs. a control group and found that the resistance training program resulted in an improvement in venous compliance (Kawano et al., 2010).

Maintaining an exercise program can help to maintain compliance (Hernandez & Franke, 2005; Iida et al., 2011; Kawano, Tanimoto, Yamamoto, Gando, Sanada, Tabata, Higuchi, & Miyachi, 2010).

In previous research, the relationship between venous compliance, BMI, and body fat percentage has been assessed (Kawano et al., 2010; Iida et al., 2011). Body fat percentage was measured in Kawano et al., 2010, but there was no association with muscle mass and venous compliance in this study. BMI was assessed by Iida el al. in 2011, but there were no significant differences between the exercise and control groups. Neither study explicitly investigated the relationship between body fat percentage or BMI and calf venous compliance.

The studies that looked closely at fitness levels generally excluded individuals who were over a certain BMI. The relationship between BMI and venous compliance with a strength training program was measured in Kawano et al., 2010. There was no association with BMI and venous compliance when comparing a sedentary group to a resistance trained group. They did find that the resistance trained group did experience greater compliance but that was not attributed to the amount of muscle (Kawano et al., 2010). BMI was assessed in Iida et al., 2011 but there were no relationship between BMI and venous compliance. The relationship might not have to do with the decrease in BMI associated with exercise but some other factor. Exercise can decrease your BMI but this does not directly correlate with an increase in venous compliance.

While the relationship between fitness level and venous compliance has been well established in adults or older participants, there has been minimal focus on children. The primary purpose of this study was to determine the relationship between fitness level, body composition, and venous compliance in children. The hypothesis was that children with higher fitness levels will have greater venous compliance. Further, we hypothesized that the children with higher BMI and bodyfat percentage would have lower calf venous compliance at 20mmHg.

METHODS

Participants

Twelve children aged 9-12 years volunteered for this study. All of the parents/guardians signed informed consent approved by the Human Subjects Committee of Southern Illinois University Carbondale. The participants were recruited from local schools and inclusion criteria included absence of cardiac, pulmonary, and metabolic disease, no hospitalization in the last six months, and no current injuries. Resting blood pressure had to be below 140/90 mmHg.

Table 1.

Participant Characteristics

Mean ± Standard Deviation			
	Males n=6	Females n=6	Total
Age	10 years ± 1.04 years	10 years ± 0.81years	10 years ± 0.90years
Mass	42.93 kg ± 14.53kg	42.41 kg ± 9.94kg	42.67 kg ± 11.87kg
Height	142.02 cm ± 16.72cm	150.49 cm ± 4.66cm	146.26 cm ± 12.51cm
BMI	19.42 kg/m2 ± 4.33 kg/m2	18.91 kg/m2 ± 3.19kg/m2	19.17 kg/m2 ± 3.64 kg/m2
% Body fat	29.38% ± 6.80%	30.53% ± 6.55%	29.95% ± 6.39%
VO2 Peak	48.30 L/min ± 21.06 L/min	45.69 L/min ± 9.73 L/Min	47 L/min ± 15.70 L/min
Calf volume	25.12 cm ± 4.14 cm	24.60 cm ± 4.01cm	24.86 cm ± 3.90cm
Systolic Blood Pressure	111.16mmHg± 2.04mmHg	107 mmHg ± 6.78mmHg	109.08 mmHg ± 5.24mmHg
Diastolic Blood Pressure	68.66 mmHg ± 9.77mmHg	88.66 mmHg ± 8.63mmHg	67.75 mmHg ± 8.84mmHg
Heart Rate	79.67 bpm ± 13.47bpm	88.67 bpm ± 13.82bpm	84.16 bpm ± 13.83bpm

Data collection procedures

The participants reported to the laboratory for one hour. In this hour, paperwork and informed consent were completed prior to any testing. The order of the procedures included: informed consent, assessment of height, weight, body fat % measurement, venous compliance measurement, and fitness assessment.

Body composition protocol Body composition was assessed using a bioelectrical impedance analysis. Height and body mass were assessed using a stadiometer and a balance scale.

Venous compliance protocol Calf venous compliance was measured using the technique developed by Halliwill & colleagues (1999). The participants were placed in the supine position with their left leg on the table and the right leg supported at a 45 degree angle from the knee. A Mercury in-silastic strain-gage was placed around the point of maximum circumference of the right calf. A venous collecting cuff connected to an external air source (AF101 Hokanson, Bellevue, WA) was placed on the right thigh. Calf volume was measured using strain gauge plethysmography (ECR5 Hokanson, Bellevue, WA). Prior to measurement, the limb remained in this position for a rest period of 20 minutes. After the rest period of 20 minutes the venous cuff pressure was inflated to 60mmHg for eight minutes (Hernandez & Franke 2005; p. H896). After eight minutes the pressure was reduced manually by 5mmHg/5s over a minute (Hernandez & Franke 2005). Venous compliance was determined using the formula developed by Halliwill & colleagues (1999); compliance=$\beta_1 + 2*\beta_2*20$. The change in volume between the participants was calculated using the following equation developed by Halliwill & colleagues (1999); change in volume = $\beta 0 + \beta 1$- (cuff pressure) + $\beta 2$ (cuff pressure) ^{2}.

Exercise test protocol Resting heart rate and blood pressure were collected upon arrival at the laboratory. Heart rate was measured using a Polar Heart Rate Monitor™. A sub-maximal exercise test was conducted using a treadmill and the Bruce protocol (two minute stages). Heart rate was measured at the end of the first minute of the first stage. Heart rate and blood pressure was measured at the end of the second minute of each stage . Blood pressure was measured manually with the pressure cuff placed on the right arm. Heart rate, blood pressure, speed, and grade was recorded until the participant reached 85% of their heart rate maximum. Following test termination, heart rate, blood pressure, speed, and grade were recorded. The subject walked on the treadmill until their heart rate returned to resting levels.

Analysis

A t-test was conducted to determine sex differences in anthropometric variables. Correlations were conducted (SPSS 22) to determine the relationship between sex, fitness, body fat, BMI, and venous compliance at 20mmHg. Venous compliance at 20 mmHg was chosen as the benchmark because that is the standard that has been established in previous studies (Monahan & Ray, 2004).

RESULTS

We hypothesized that children with higher fitness levels would have greater venous compliance. We used body fat percentage, BMI, and VO2 peak as measures of fitness. There were no significant relationships between body fat, BMI and venous compliance between the participants (Figures 1-3). No significant correlations were found between body fat percentage, VO2 peak and venous compliance at 20mmHg, although there was a tendency for compliance to be higher as body fat % decreased and VO2peak increased (*Figure 1*). Similarly, there was no significant correlation between BMI and calf venous compliance at 20mmHg (*Figure 2*). The results show that there was no significant correlation between VO_2 peak and venous compliance at 20 mmHg in male and female children 9-12 years old (*Figure 3*).

Percent body fat and venous compliance in adolescents

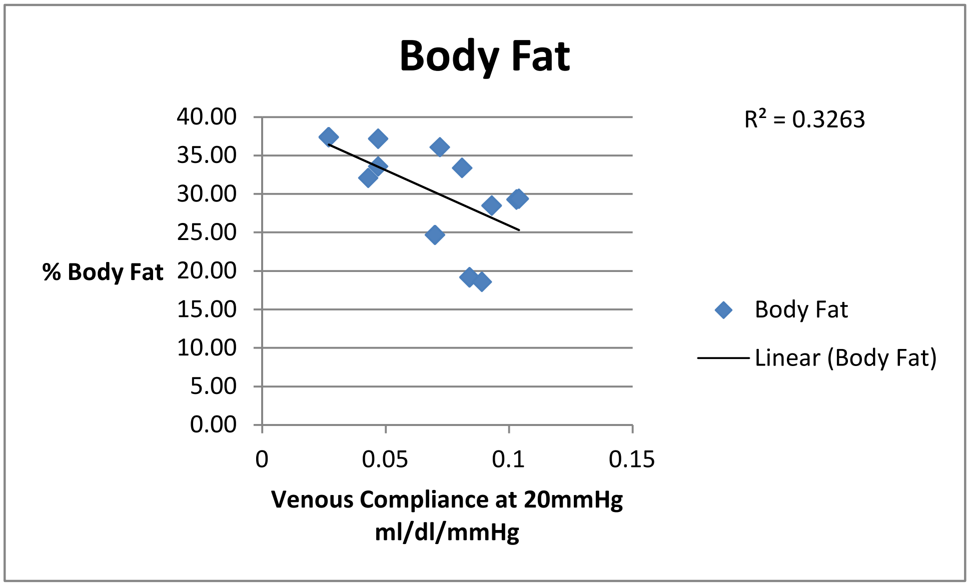

Figure 1.

Correlation between body fat percentage and venous compliance at 20mmHg

BMI and venous compliance in adolescents

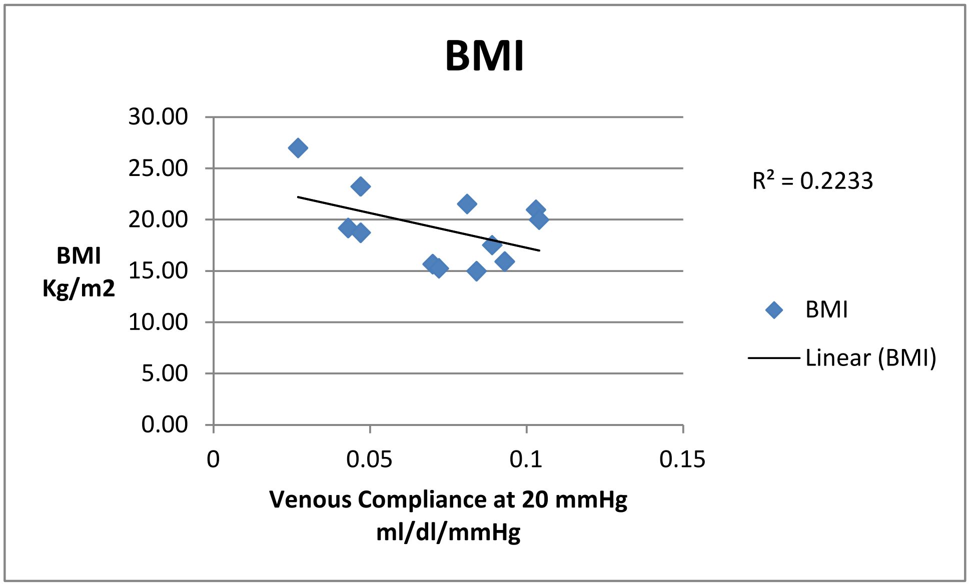

Figure 2.

Correlation between BMI and venous compliance at 20 mmHg

VO_2 peak and venous compliance in adolescents

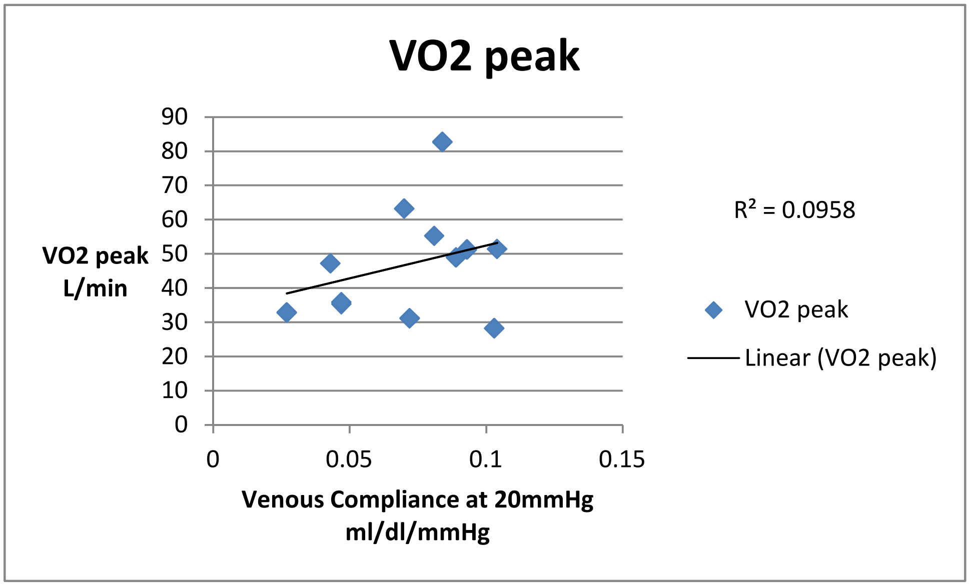

Figure 3.

Correlation between VO_2 peak and venous compliance at 20mmHg

DISCUSSION

Introduction

Our primary hypothesis was that children with higher fitness levels would have greater venous compliance. This study did not find significant relationships between fitness and calf venous compliance in children. There was no correlation between body fat percentage and venous compliance, although compliance tended to be higher as VO2 peak increased and body fat decreased. There was no correlation between BMI and venous compliance.

Fitness and venous compliance

Previous research that looks at venous compliance and exercise shows that participating in an exercise program can improve venous compliance (Hernandez & Franke, 2005; Iida et al., 2011; Kawano et al., 2010). Participating in both a short-term (6 weeks, Iida et al., 2011) or a long-term cardiovascular exercise program (6 months, Hernandez & Franke 2005) can elicit improvements in venous compliance. Participating in a total body strength training program for a minimum of three days a week can also elicit improvements in venous compliance (Kawano et al., 2010). Even though there was no relationship between fitness level and venous compliance in the children measured in this study, it is possible that differences might be seen in children participating in an exercise intervention.

BMI and venous compliance

The studies that looked closely at fitness levels generally excluded individuals who were over a certain BMI. The relationship between BMI and venous compliance with a strength training program was measured in Kawano et al., 2010. There was no association with BMI and venous compliance when comparing a sedentary group to a resistance trained group. They did find that the resistance trained group did experience greater compliance but that was not attributed to the amount of muscle (Kawano et al., 2010). BMI was assessed in Iida et al., 2011 but there were no relationship between BMI and venous compliance. Our study did not find significant relationships between fitness and calf venous compliance in children, when using body fat percentage, BMI, and VO2 peak as measures of fitness. There was no correlation between body fat percentage and venous compliance, although compliance tended to be higher as VO2 peak increased and body fat decreased. There was no correlation between BMI and venous compliance. The relationship might not have to do with the decrease in BMI associated with exercise but some other factor. Exercise can decrease your BMI but this does not cause an increase in venous compliance. There has to be another factor that causes these improvements. These changes might be caused from structural changes within the veins that occur from an exercise program and not the change in body composition (Hernandez & Franke 2005). Being more active can improve venous compliance but changing you BMI does not cause this improvement.

Limitations

There were several limitations with this study. First, this study had a low number of participants. There was a low spread of scores between all of the subjects for body fat and VO_2 peak. Second, fitness levels were based on BMI, percent body fat, and VO_2 peak. There was a good range of scores for BMI but these scores did not show a difference in compliance in relation to fitness levels. VO_2 peak was an estimate; it was based on 85% age predicted heart rate max. A VO2 max test could be conducted in future research to measure differences in fitness levels instead of measuring VO_2 peak.

Conclusion

Future research should look for other adaptations of an exercise program that can cause improvements in venous compliance. In conclusion there were no significant differences in fitness levels and venous compliance when looking at body fat percentage, VO2 peak, and BMI.

REFRENCES

Halliwill JR., Minson CT., & Joyner MJ. (1999). Measurement of limb venous compliance in humans: technical considerations and physiological findings. *Journal of Applied Physiology* 1999;87(4):1555-1563.

Hernandez, J., & Franke,W. (2005). Effects of a 6-mo endurance-training program on venous compliance and maximal lower body negative pressure in older men and women. *Journal of applied physiology, 99(3), 1070-1077.*

Kawano, H., Tanimoto, M., Yamamoto,K., Gando, Y., Sanada, K., Tabata, I., Higuchi, M., & Miyachi, M. (2010). Greater forearm compliance in resistance-trained men. *Journal of Applied Physiology, 110, 769-777.*

Iida, H., Nakajima, T., Kurano, M., Yasuda, T., Sakamaki, M., Sato, Y., Yamasoba, T., & Abe, T. (2011). Effects of walking with blood flow restriction on limb venous compliance in elderly subjects. *Clinical Physiology & Functional Imaging*.

Monahan, K., & Ray, C. (2004). Gender affects calf venous compliance at rest and during baroreceptor unloading in humans. *American Journal of Physiology 286(3) 895-901*

Zachrisson, H., Lindenberger, M., Hallman, D., Ekman, M., Neider, D., & Lanne, T. (2011). Diameter and compliance of the greater saphenous vein- effect of age and nitroglycerine. *Clinical Physiology and Functional Imaging, 31, 300-306.*

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Research Paper

The relationship between fitness, body composition, and calf venous compliance in adolescents

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