CHANGES IN CARDIAC AUTONOMIC MODULATION IN CHILDREN FOLLOWING 4 AND 8 WEEKS OF SUPERVISED SUMMER ACTIVITY

A Thesis
by
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FOREWORD

The research detailed in this thesis will be submitted to the journal *Clinical Autonomic Research,* a peer-reviewed scientific and medical journal of the American Autonomic Society, Clinical Autonomic Research Society, and European Federation of Autonomic Research Societies, LLC. The thesis has been prepared in the American Psychological Association (6th edition) format according to the guidelines set forth by the Graduate School at Appalachian State University.

ABSTRACT

CHANGES IN CARDIAC AUTONOMIC MODULATION IN CHILDREN FOLLOWING 4 AND 8 WEEKS OF SUPERVISED SUMMER ACTIVTY, (December 2011)

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Background: Pediatric obesity is associated with lower physical activity levels and a decrease in cardiac autonomic modulation. Physical activity contributes cardiovascular improvements via increases in heart rate variability. However involvement in regular physical activity decreases during summer vacation for adolescent children. The **purpose** of this study was to examine the effectiveness of 4 weeks (4 wk) and 8 weeks (8 wk) of supervised summer play-based activity versus eight weeks of unsupervised activity in adolescent children during summer vacation on resting blood pressure (RBP), heart rate variability (HRV), and maximal oxygen consumption (VO_{2max}). **Methods:** Twenty-two 8 to 12 year-old children were divided into 4 wk and 8 wk activity or control groups (4 wk *n=6*, 8 wk *n=6,* and control *n=10*). 4 wk and 8 wk treatment groups met 5 days per week, took part in play-based activities for 6 hours each day, and were given nutritional counseling at lunch time. Control subjects were instructed to maintain their regular summer break plans with no intervention by the study team. **Results:** Total power (TP) increased at rest and with tilt following 8 weeks of activity (resting pre 7479.759 ± 2326.283 to post 12007 ± 3392.293 and tilt pre 2183.125 ± 850.642 to post 2938.125 ±1121.615). Normalized low frequency

(nLF) showed significant decreases at rest for 8 weeks of activity (pre 0.488 ± 0.065 to post 0.470 ± 0.062) and increases for the control group (pre 0.052 ± 0.075 to post 0.644 ± 0.072). Normalized high frequency (nHF) increased after 8 weeks training (pre 0.489 ± 0.062 to post 0.51 ± 0.062) and decreased following the control period (pre 0.394 ± 0.072 to post 0.336 ± 0.71). The low frequency to high frequency ratio (LF: HF) was better preserved in the 8 week activity group (pre 115.2 ± 60.347 to post 115.262 ± 78.235) versus the control group (pre 263.550 ± 69.682 to post 199.250 ± 90.338). In **Conclusion** 8 wk of play based activity increased TP while also increasing vagal tone, which favorably changed the sympathovagal balance. Upright tilt revealed less vagal withdrawal and overall increased TP. The significant differences between the 8 wk activity group and the control group supported the idea that routine play-based activity can increase heart rate variability positively and enhance sympathovagal balance in children over summer vacation.

ACKNOWLEDGMENTS

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Introduction

Exercise is an important factor in the prevention and treatment of cardiovascular diseases (CVD) through all stages of growth and development. CVD risk factors can emerge in childhood and progress into adulthood (Strong et al., 2005). Pediatric obesity and sedentary lifestyle have been associated with lowered cardiac autonomic modulation (CAM), suggesting that these individuals are at greater risk for developing CVD. The autonomic nervous system controls the heart rate through two efferent divisions, the sympathetic and the parasympathetic. CAM continually changes outflow to these nervous divisions, which in turn controls the variation in intrinsic heart rate. These variations can be detected by recording sinus rhythms (van Ravenswaaij-Arts, Kollee, Hopman, Stoelinga, & van Geijn, 1993). Heart rate variability (HRV) is the fluctuation of heart rate over time, which is useful to quantify the variability in the heart rate, which is ultimately influenced by autonomic input (Task Force, 1996). Higher HRV shows predominance in parasympathetic input versus sympathetic and lower HRV shows predominance in sympathetic input versus parasympathetic. Lower HRV can be used as a clinical tool to predict cardiac morbidity and mortality (Task Force, 1996). It had been demonstrated that a reduction in HRV is indicative of reduced autonomic modulation of the heart (Colhoun, Francis, Rubens, Underwood, & Fuller, 2001). Reduced CAM can be seen in a variety of conditions that do and do not pertain to the cardiovascular system (Task Force, 1996) such as myocardial infarction, myocardial transplant, diabetic neuropathy, and tetraplegia. A sympathovagal imbalance has been shown to exist within an obese pediatric population at greater risk for CVD (Zahorska-Markiewicz, Kuagowska, Kucio, & Klin, 1993).

While exercise intervention has been successful in increasing CAM and decreasing obesity status in adults, minute amounts of data have demonstrated the role of exercise intervention on autonomic function in children (Winsley, 2002). There is a growing body of literature suggesting that CAM is greater in aerobically fit individuals compared to sedentary ones (Boutcher, Cotton, Nurhayati, Craig, & McLaren, 1997). Studies have also demonstrated decreases in autonomic function in obese children and adolescents (Kaufman, Kaiser, Steinberger, Kelly, & Dengel, 2007; Tonhajzerova et al., 2008) suggesting that these individuals are at a greater risk for developing CVD. While moderate intensity aerobic exercise has been demonstrated to be effective in increasing autonomic modulation and decreasing obesity status in adults, there are few studies documenting the effects of exercise intervention on autonomic function in children (Winsley, 2002). Sports and regular physical activity may lead to enhanced autonomic nervous system (ANS) function in lean and obese children; whereas reduced ANS activity found in the obese children increases the risk of future cardiovascular and metabolic disorders (Nagai & Moritani, 2004).

The purpose of this study is to examine the effectiveness of supervised play based activity on autonomic and cardiovascular variables during the summer using 4 and 8 week activity groups and an unsupervised age matched cohort. We hypothesized that; (a) Eight weeks of unsupervised activity would present no change in HRV; (b) Four weeks of supervised activity would show gains in vagal tone via increases in sympatholysing, while eight weeks of supervised activity would show further improvements following continued supervised activity.

Methodology

Subjects

Twenty-two male and female adolescent subjects, ages 8-12 years old, were recruited from the local community. There was an 8 week supervised play based activity group (8 wk) *n=6*, a 4 week supervised play based activity group (4 wk) *n=6*, and an unsupervised age matched control group (control) *n=10*. During the initial screening, cardiovascular risk and history were assessed and exclusion criteria included previous CVD, renal disease, diabetes, or any use of medications. Procedures were approved by the university's Institutional Review Board. All subjects and parents read and signed informed consent (Appendix A) and assent forms (Appendix B) to show their understanding and willingness to participate in the study.

Experimental Design

Subjects were required to report to the laboratory on two separate occasions between 6:30 a.m. and 8:00 a.m. following a 12 hour fast. All subject visits took place at the same time of day to reduce the possibility of diurnal influences on the dependent variables. During the first visit, body composition was assessed using a Tanita (TBF-300A) foot to foot Bioelectrical Impedance Analysis System (Tanita; Arlington Heights, IL, USA). Peak height velocity was established by attaining seated height to assess maturational development (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002), followed by seated manual blood pressure after 5 minutes of seated rest. Electrocardiogram recordings (Biopac Systems, Santa Barbara, CA, USA) were collected for a period of 10 minutes supine and 10 minutes tilted head-up at 80°. Lastly, subjects underwent a maximal aerobic capacity test on a treadmill based on a modified Balke protocol at a comfortable jogging speed attained followed by incremental

increases in grade every 2 minutes. Following the lab visit, each subject was signed up for either 4 wk or 8 wk of supervised activity or 8 wk control period of unsupervised activity. Following their 4 wk or 8 wk of activity, subjects were asked to report back to the laboratory between 24 and 48 hours after of their last day for post measurements, which repeated all pre intervention measurements of the initial visit. Data was recorded by the study team (Appendix C).

Anthropometric and Body Composition Assessment

Weight was assessed using a calibrated beam scale and mass was recorded in kilograms (kg), and height was measured using a stadiometer and was recorded within 0.5 cm. Body mass index (BMI) is calculated as: weight (kg) divided by height (m) squared. Body fat was assessed using the estimate given from the bioelectrical impedance analysis (BIA; Tanita TBF-300A, Arlington Heights, IL, USA). Peak height velocity was attained by measuring seated height.

Maximal Aerobic Capacity

Peak oxygen consumption (VO_{2peak}) was assessed using a progressive exercise test performed to fatigue on a motor driven treadmill (True 8200, Reebok, Memphis, TN, USA) using a modified Balke protocol. Subjects began at a comfortable walking pace at which point the intensity was increased via incline increases of 2% every two minutes until the subject reached volitional exhaustion or three of the following termination criteria were met: (a) a resting energy requirement (RER) of 1.15 or higher; (b) a plateau in heart rate despite an increasing work load; (c) a final rating of perceived exertion (RPE) score of 8 or higher on the OMNI-RPE scale; and or (d) a plateau in oxygen uptake despite increasing work load. Heart rate was measured using a Polar Heart Rate Monitor (Polar Electro, Inc., Woodbury,

NY, USA) and was recorded at the end of each stage, along with RPE. Expired air was measured using a True One 2400 Metabolic Cart (Parvo Medics, Sandy, UT, USA).

Signal Acquisition and Analysis

Beat-to-beat heart rate was recorded using a modified, bipolar CM5 electrode configuration using the Biopac. In the CM5 configuration the right arm electrode is placed on the manubrium and the left arm electrode is placed at the 5th intercostal space in the anterior axillary line. The left leg lead acts as a ground electrode and can be placed anywhere. The electrocardiogram was collected at a sampling rate of 1,000 Hz. All files were stored off-line and were analyzed at a later time. Data files were manually inspected for ectopy, arrhythmic events, and noise and each file was linearly interpolated to provide a continuous data stream. The QRS complex is a series of 3 waves on an electrocardiogram; the Q wave, the R wave, and the S wave, that represent ventricular depolarization during a normal heart beat. The Q wave is the first downward deflection. The R wave is an upward deflection and is followed by the S wave which is any downward deflection following the R wave. R waves were detected via an automatic QRS detection algorithm and generated an R-R interval time event series (Kubios HRV Analysis Software, Biosignal Analysis and Medical Imaging Group, University of Eastern Finland, Kuopio, Finland). The R-R interval is the time between the R wave of one QRS complex to the successive R wave of the following QRS complex. The continuous data stream was resampled through a low-pass impulse response filter with a 0.5 Hz cut off frequency.

The power was calculated by measuring the area under the peak of the power spectra density curve. Three peaks were revealed and their corresponding bandwidths are defined as follows: a very low frequency domain (< 0.04 Hz) resulting from non-harmonic fractal

oscillations of unknown origin; a low frequency region (0.04 - 0.15 Hz) related to baroreflex activity and thermoregulatory components that is mediated by both the sympathetic and parasympathetic branches of the ANS; and a high frequency region (0.15 - 0.40 Hz) caused by respiratory sinus arrhythmia that is indicative of parasympathetic modulation of the heart (Task Force, 1996). The very low frequency (VLF) domain was used to calculate the normalized low frequency (nLF) and normalized high frequency (nHF) HRV. The power spectra were calculated in both absolute and normalized units to represent the relative value of high frequency and low frequency as a proportion of total power. Total power (TP) is a value of overall variability and it is used as marker of vagal modulation (Task Force, 1996). The low frequency to high frequency ratio (LF: HF) was used as an indicator of sympathovagal balance. All data acquisition and analysis were conducted in accordance with standards presented by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Task Force, 1996).

Supervised Activity

The 4 wk and 8 wk supervised activity groups were involved in a play based summer program. Children were required to attend camp five days a week, arriving at 8:30 a.m. and departing at 4:00 p.m. Participants were involved in play based activities that focused on skill development and personal fitness achievements including hiking, canoeing, soccer, swimming, running, group sports and games, and resistance-band training. The 8 wk control group was not involved in any type of structured program, but they were encouraged to maintain their normal summer break schedule.

Treatment of the Data

Statistical analysis of the data was completed with SPSS v19 (IBM, Chicago, IL, USA). Group differences were measured using a 2 x 2 x 3 repeated measures analysis of variance (RmANOVA; time [pre versus post] by factor [rest versus tilt] by group [8 wk supervised versus 4 wk supervised versus 8 wk unsupervised control]). A priori significance was set at $\alpha < .05$ and all data are reported as mean ± standard error (SE).

Results

Subjects

Group characteristics are presented in Table 1. Weight, body fat percentage, and peak height velocity did not change from pre to post measures. No significant differences were found between groups in any of these variables.

Heart Rate Variability

Time domain analysis of Root Mean Squared of Successive Differences showed less vagal tone at rest in the 8 wk activity group, while the 4 wk activity group and the control group showed no significant change (Table 2). No significant differences were found with LF power, although decreases were seen during rest and with tilt in the 8 wk activity group (pre 2514.16 ± 1213.57 to post 2013.33 ± 1179.08). Subsequent increases were seen during rest and at tilt in the control group, representing increased sympathetic modulation upon the orthostatic challenge (Table 3). HF showed less vagal withdrawal during tilt for the 8 wk group compared to the 4 wk and control group (Table 4). TP increased at rest and with tilt following the 8 wk activity group (resting pre 7479.759 ± 2326.283 to post 12007.875 ± 3392.293 and tilt pre 2183.125± 850.642 to post 2938.125±1121.62). The 4 week activity group noted significant increases in TP with tilt; however, no changes were noted in resting values (Table 5). The control group decreased TP both at rest and with tilt. The LF and HF

powers were normalized to reflect the relative value of each power in relation to the TP minus the VLF component, emphasizing the balance of the parasympathetic and sympathetic branches of the ANS (Chobanian, 1996). Changes in nLF showed that sympathetic outflow was significantly lower at rest and during tilt in the 8 wk activity group when compared to both the 4 wk and the control group (Table 6). Significant increases were seen in nHF for the 8 wk activity group from pre to post training (pre 0.489 ± 0.062 and post 0.51 ± 0.062) and had significantly greater vagal modulation than the 4 wk and control groups during tilt (Table 7). The LF: HF significantly increased at rest in the 4 wk and control groups and was preserved in the 8 wk activity group. An increased ratio was seen during tilt in the 4 wk and control groups and a decreased ratio was seen in the 8 wk activity group (Table 8).

Discussion

The main finding of this study showed that 8 wk of supervised play based activity was enough to elicit changes in CAM towards greater vagal tone and increasing TP. Conversely, the 8 wk control group exhibited decreases total power along with subsequent increases in absolute LF and decreases in absolute HF components. The significant differences between the 8 wk group and the control group support the idea that routine play-based activity can positively change sympathovagal balance, which may exert future cardioprotective benefits.

Consistent with previous literature (Gutin, Barbeau, Litaker, Ferguson, & Owens, 2000), our study shows increases in vagal outflow in adolescents following 8 wk of play based activity. HF power, which is thought to represent efferent vagal activity (Task Force, 1996; Goldsmith, Bigger, Steinman, & Fleiss, 1992), showed a non-significant decrease at rest in the 8 wk activity group. Previous studies pertaining to adults correlated decreased

parasympathetic activity with decreased fitness levels (De Meersman, 1993; Goldmsith, Bigger, Steinman, & Fleiss, 1992). We found nHF increased at rest and tilt for the 8 wk activity group and decreased in 4 wk and control groups suggesting that parasympathetic tone increased after 8 wk of summer activity. The heads-up tilt resulted in increased sympathetic response in the 8 wk activity group. Conversely, decreases were seen in the 4 wk and control groups suggesting that 4 wk of activity is not sufficient to increase baroreflex sensitivity in adolescents (Kochiadakis et al., 1997).

LF is commonly thought to be a marker of sympathetic modulation, particularly when expressed in normalized units (Kamath & Fallen, 1993; Montano et al., 1994), though it is also thought to reflect both sympathetic and parasympathetic modulation (Akselrod et al., 1981; Appel, Berger, Saul, Smith, & Cohen 1989). LF power decreased at rest in the 4 wk and 8 wk activity subjects and increased in control subjects though none of the changes were significant. The normalized portion of LF showed significant decreases in 8 wk; however, other studies have reported no changes in LF or HF when expressed relative to TP (Mandigout et al., 2002). In 16 to 19 year old males and females, similar decreases were found in absolute LF at rest and following tilt after training for competitive cross country skiing (Hedelin, Wiklund, Bjerle, & Henrisksson- Larsen, 2000).

An autonomic imbalance exists within pediatric obesity. A study examining lean and obese, active and non-active children found that the obese, inactive children possessed significantly reduced TP while the lean, active children displayed increased TP, LF, and HF powers (Nagai & Moritani, 2004). Another study found significantly decreased TP in obese children with increased LF power demonstrating sympathetic over activity (Martini et al., 2001). Martini et al. also hypothesized that ANS changes depended on the development of

obesity. Clinical manifestations are usually not present until adulthood. In our study TP increased significantly in the 8 wk activity group and decreased in the 8 wk control group. The control group also shifted towards greater sympathetic tone over the 8 wk period. While adult studies on exercise training and HRV have shown increases in TP, much less literature exists on TP changes with childhood exercise training.

Our findings are consistent with literature showing the positive effects of training on sympathetic and parasympathetic balance in child and adult populations (Gutin, Barbeau, Litaker, Ferguson & Owens, 2000; Seals, 1989). One study found that an LF: HF greater than 2.7 during tilt was a set point that could predict a positive test in 85% of older children (Lippman, Stein, & Lerman, 1995). Later research has not verified the previous finding; however, the LF: HF was able to distinguish between healthy children and children with neurocardiogenic syncope during tilt testing (Longin et al., 2008). In this study the LF: HF was reduced during tilt after 8 wk of activity thus exhibiting less sympathetic excitation and increased vagal modulation as indicated by the nHF and nLF values (Gutin, Owens, Slavens, Riggs, & Treiber, 1997). However, the LF: HF did not change at rest after 8 wk of activity. It has been previously documented that exercise training elicits no changes in the LF: HF (Mandigout et al., 2002), while changes to the LF: HF can be noted due to changes in body composition. Increases in the ratio were noted in obese adults and adolescents (Guizar, Ahuatzin, Amador, Sanchez, & Romer, 2005; Kaufman, Kaiser, Steinberger, Kelly, & Dengel, 2007), while other studies found normal sympathetic activity and reduced parasympathetic activity (Yakinci, Mungen, Karabiber, Tayfun, & Everkioglu, 2000). Many discrepancies in variables are difficult to control for, such as non-modifiable cardiovascular

risk factors including gender, age, and family history, making it difficult to ascertain the cause for changes in the ratio.

HRV is known to be a reliable predictor of sudden cardiac death following an acute myocardial infarction and is used as a clinical marker of evolving diabetic neuropathy (Task Force 1996). Other clinical scenarios in which HRV is being studied as a clinical marker include autonomic neuropathy, heart transplant, congestive heart failure, and MI (Task Force, 1996). Further investigation is necessary to identify markers of autonomic dysfunction at varying ages, body compositions, aerobic fitness, and disease statuses so that HRV can be used as a diagnostic tool in physician practices. Although more research is required, the literature that exists implies that pediatric exercise has similar effects on HRV as adult responses to exercise (Winsley, 2002). Further research is necessary on the effects of exercise training in child and adolescent populations to examine the differences between continuous aerobic exercise, and discontinuous aerobic exercise, and play based activity protocols.

In conclusion, our data show that 8 wk of play based activity increased TP and nHF and decreased LF and nLF at rest. Tilt revealed less sympathetic excitation with less vagal withdrawal and overall increased TP. Control subjects showed overall decreases in TP at rest while increased sympathetic modulation and greater vagal withdrawal was recorded upon tilt. The significant differences between the 8 wk activity group and the control group support the idea that routine play based activity can positively enhance sympathovagal balance and produce cardioprotective benefits in children during summer vacation while 4 wk of activity is not long enough to elicit change.

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Table 1 Subject Characteristics

	4 week *n=6*	8 week *n=6*	Control *n=10*
Age (years)	10.10 ± 1.30	10.60 ± 1.20	10.80 ± 1.30
Height (cm)	145.73 ± 4.41	139.20 ± 5.00	144.04 ± 2.50
Weight (kg)			
Pre	48.14 ± 5.64	43.36 ± 4.87	44.13 ± 2.49
Post	47.65 ± 5.55	46.39 ± 5.28	42.34 ± 3.14
BMI (kg/m^2)	21.44 ± 1.26	22.22 ± 1.79	19.54 ± 1.76
Body Fat (%)			
Pre	27.428 ±3.17	28.540 ± 2.52	26.004 ± 1.94
Post	25.38 ± 2.55	25.56 ± 3.14	23.62 ± 2.26
RHR (bpm)	75.43 ± 4.13	77.20 ± 8.42	76.32 ± 2.79
MAP(mmHg)	78.71 ±2.23	80.80 ± 2.33	80.50 ± 1.44

Note. BMI=Body Mass Index; RHR= Resting Heart Rate; MAP=Mean Arterial Pressure, cm=Centimeters, m^2=meter squared, kg=kilograms, bpm=beats per minute, mmHg=millimeters of mercury. All data are represented as mean ± SE.

There were no significant differences between subject populations.

Table 2 Root Mean Square of Successive Differences

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	95.50 ± 21.26	40.16 ± 9.95	93.00 ± 21.39	38.16 ± 11.77
8 week	71.33 ± 21.26	51.50 ± 9.95	55.66 ± 21.39	37.16 ± 11.77*
Control	90.50 ± 18.38	25.37 ± 8.62	93.12 ± 18.53	42.75 ± 10.19*

Note. All data are represented as mean ± SE.

*Significant interaction, $\alpha < .05$

Table 3 Low Frequency

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	3810.00 ± 1213.57	3173.33 ± 1354.93	3531.50 ± 1179.08	1846.50 ± 581.69
8 week	2514.16 ± 1213.57	1734.16 ± 1354.93	2013.33 ± 1179.08	1332.50 ± 581.69
Control	2520.12 ± 1050.99	847.75 ± 1173.41	2626.00 ± 1021.11	1107.75 ± 503.76

Note. Low Frequency is measured in meters per second squared. All data are represented as mean ± SE.

There were no significant differences.

Table 4 High Frequency

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	3417.17 ± 1117.68	2335.67 ± 1013.13	3417.67 ± 1123.35	645.67 ± 289.36*
8 week	2865.75 ± 967.94	422.25 ± 877.39	2739.13 ± 972.85	743.38 ± 250.59*
Control	1973.00 ± 1117.68	1019.17 ± 1013.13	1022.00 ± 1123.35	448.50 ± 289.36*

Note. High Frequency is measured in meters per second squared. All data are represented as mean ± SE.

*Significant interaction, $\alpha < .05$

Table 5 Total Power

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	9321.50 ± 2686.16	1789.32 ± 982.24	9267.67 ± 3917.08	4642.00 ± 1295.13*
8 week	7479.75 ± 2326.283	2183.13 ± 850.64	12007.88 ± 3392.29	2938.13 ± 1121.62*
Control	6669.50 ± 2686.16	4714.50 ± 982.24	4352.67 ± 3917.08	2814.50 ± 1295.13

Note. Total Power is measured in meters per second squared. All data are represented as mean ± SE.

*Significant interaction, $\alpha < .05$

Table 6 Normalized Low Frequency

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	0.48 ± 0.08	0.64 ± 0.06	0.54 ± 0.07	0.72 ± .08*
8 week	0.49 ± 0.07	0.77 ± 0.05	0.47 ± 0.06	0.64 ± 0.08*
Control	0.59 ± 0.08	0.67 ± 0.06	0.64 ± 0.07	0.71 ± 0.09*

Note. Normalized Low Frequency is measured in normalized units. All data are represented as mean ± SE.

*Significant interaction, $\alpha < .05$

Table 7 Normalized High Frequency

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	0.50 ± 0.07	0.34 ± 0.06	0.45 ± 0.07	0.27 ± 0.07*
8 week	0.49 ± 0.06	0.22 ± 0.05	0.51 ± 0.06	0.30 ± 0.06*
Control	0.39 ± 0.07	0.31 ± 0.06	0.34 ± 0.07	0.28 ± 0.07

Note. Normalized High Frequency is measured in normalized units. All data are represented as mean ± SE.

*Significant interaction, $\alpha < .05$

Table 8 Low Frequency to High Frequency Ratio

	Pre		Post	
	Rest	Tilt	Rest	Tilt
4 week	124.47 ± 69.68	370.57 ± 151.20	263.25 ± 90.34	647.02 ± 253.93*
8 week	115.20 ± 60.35	524.19 ± 130.94	115.26 ± 78.24	477.04 ± 219.91*
Control	263.55 ± 69.68	253.75 ± 151.20	199.25 ± 90.34	323.88 ± 253.93

Note. Low frequency to high frequency ratio. All data are represented as mean ± SE.

*Significant interaction by factor, $\alpha < .05$

Appendix A

APPALACHIAN STATE UNIVERSITY

Institutional Review Board
Study #: _____

Informed Consent for Participants in

Research Projects Involving Human Subjects

Title of Project: The Effects of Aerobic Exercise on Arterial Dispensability and Cardiac Autonomic Modulation in Young Obese Children.

Investigator(s): Hannah Crawford, BS Dr. Scott Collier, Assistant Professor Carol Jean Cook, MS

You are being asked to participate in a research study because you are a healthy male or female between 8 and 11 years of age, with no diabetes, kidney or heart problems and on no medications. Dr. Scott Collier (Departments of Health, Leisure and Exercise Science at Appalachian State University) is conducting this study.

I. Background/Purpose

It has been shown that children from rural communities are at particular risk for deleterious, long-term complications associated with obesity. A recent poll showed that North Carolina has the fifth highest rate among the worst states in the nation for incidence of overweight and obese children and adolescents 10 – 17 years of age.

Watauga County has a higher proportion of 5 – 11 year-olds at risk than the state as a whole. Currently, there are few interventions that have been shown effective in this cohort. However, activities focused on play and skill development along with nutrition education have proven effective with adequate attendance.

We would like to determine if 8 weeks of a play-based activity camp is effective at improving body composition, blood pressure and heart rate parameters in a group of 8 to 12 year-old adolescents.

II. Study Procedures:

If you choose to participate, you will be asked to:

1. To report to the Institute for Health and Human Services (IHHS) at Appalachian State University (Room 068C, University Hall Rd) on 3 separate occasions for 0.5 to 1.5 hours per visit for paperwork and physiological measures.
2. To participate in one of two groups; a participant in the BLAST program through Watauga Wellness Program for 8 weeks or partake in your normal summer activities for 8 weeks.

At visit 1 (Initial visit)

The morning of your initial visit, you will report to the IHHS, Rm 71, on University Hall Rd.

During this visit, you will be familiarized with the study instruments and procedures in the Research Laboratory and complete the informed consent/assent. You will be asked to answer a medical and exercise history questionnaire. Lastly, you will have your height, weight and blood pressure collected.

Graded exercise test: You will be evaluated for cardio-respiratory fitness using the graded exercise test on a treadmill. In this test, you will start walking on a treadmill at a pace that is comfortable for you and then every 2 minutes the grade will be increased slightly until you get tired. This test is designed to make you tired in about 8 to 12 minutes. You will be wearing a facemask (so that we can collect and analyze your expired air) and a heart rate monitor to measure your heart rate. This test will determine your maximum oxygen consumption (VO2) which is your ability to take oxygen out of the air, to the working muscles. This will help us determine your present level of fitness.

Visits 2-3

At these visits you will be asked to undergo a small battery of cardiovascular fitness tests. Each test will evaluate how healthy your heart and blood vessels are both before and after the 8 week time period. Each test does not hurt and none of the tests have been shown to be harmful to the subjects. A trained exercise physiologist will be administering these tests, which take from 3-20 minutes to administer.

Risks:

The risks and discomforts involved with participating in this study are:

Exercise testing: The risks associated with exercise testing include increased blood pressure and possible heart arrhythmias (abnormal heart beats). There is a very small risk of a heart attack during the exercise testing and training. To minimize this risk, we will have you answer questions regarding your medical history and family history to screen for any significant heart disease that might exist without any symptoms.

Individuals may experience localized fatigue during the exercise testing/ training, and possibly some muscle soreness after the exercise testing/training. This should subside within 24-48 hours after testing. Soreness is rare in normal, healthy individuals. Rest breaks will be incorporated into the training to help minimize possible soreness associated with exercise training. We will also try to minimize this risk by taking you through a series of light stretches after testing is completed.

Blood pressure assessment: There may be slight discomfort due to pressure felt in the upper arm that the cuff is placed on. However, this slight pressure is only felt for about one minute while the measurement is being taken.

Answering Questionnaires should not pose any risk to you.

The investigators involved in this project have extensive experience in exercise testing, which should minimize the above risks.

Benefits:

You will benefit from having a personal fitness assessment. You will receive information about your current aerobic fitness level. Additionally, you will receive information on how well your heart and blood vessels respond to your summer routine.

Monetary Compensation:

In addition to the health related information you will be provided (described above), you will be compensated $100 for participation in this study (i.e., all 3 study days), payable on the last day of the study.

The information learned may also help others in the future.

Voluntary Participation:

Your participation in this study is entirely voluntary and you may refuse to participate or discontinue participation at any time without penalty or loss of benefits to which you would normally be entitled. Your decision about whether or not to participate in the study will not affect your relationship with Appalachian State University.

Alternatives:

You are free to choose not to participate in this study.

Questions:

If you have any questions about the research, or in the event of a research-related injury, please contact Dr. Scott Collier at (828) 262-7145 or Carol Cook at (828) 262.3149. If you

have any questions about your rights as a research subject, please contact Dr. Tim Ludwig at the Appalachian State University Institutional Review Board Office at (828) 262-2692.

In Case Of Injury:

In the event of illness or physical injury resulting from taking part in this research study, medical treatment will be provided at Watauga Medical Hospital. You will be responsible for any costs not paid by your insurance company. No other compensation is offered by Appalachian State University. We have no plans to give you money if you are injured. You have not waived any of your legal rights by signing this form.

Confidentiality of Records and Authorization to Use/Share Protected Health Information for Research:

If you agree to participate in this research, identifiable health information about you will be used and shared with others involved in this research. For you to be in this research we need your permission to collect and share this information. Federal law protects your right to privacy concerning this information.

When you sign this consent form at the end, it means that you have read this section and authorize the use and/or sharing of your protected health information as explained below.

Individually identifiable health information under the federal privacy law is considered to be any information from your medical record, or obtained from this study, that can be associated with you, and relates to your past, present, or future physical or mental health or condition. This is referred to as protected health information.

Your protected health information will be kept confidential. Your identity will not be revealed in any publication or presentation of the results of this research.

Why is it necessary to use/share your protected health information with others?

The main reason to use and share your health information is to conduct the research as described in this consent form. Your information may also be shared with people and organizations that make sure the research is being done correctly, and to report unexpected or bad side affects you may have.

In addition, we may be required by law to release protected health information about you; for example, if a judge requires such release in a lawsuit, or if you tell us of your intent to harm yourself or others.

What protected health information about you will be used or shared with others as part of this research?

We may use and share the results of tests, questionnaires, and interviews. We may also use and share information from your medical and research records. We will only collect information that is needed for the research.

Who will be authorized to use and/or share your protected health information?

The researchers will use your protected health information for this research study. In addition, the Appalachian State Institutional Review Board (IRB) committee responsible for protecting the rights of research subjects who supervise the way the research is done may have access to your protected health information.

The researchers and their staff will determine if your protected health information will be used or shared with others outside of Appalachian State University for purposes directly related to the conduct of the research.

All reasonable efforts will be used to protect the confidentiality of your protected health information. However, not all individuals or groups have to comply with the Federal privacy law. Therefore, once you're protected health information is disclosed (leaves Appalachian State University); the Federal privacy law may not protect it.

For how long will your protected health information be used or shared with others?

There is no scheduled date at which this information will be destroyed or no longer used. This is because information that is collected for research purposes continues to be used and analyzed for many years and it is not possible to determine when this will be complete.

With whom would the protected health information be shared?

Your protected health information may be shared with:

- Federal agencies that supervise the way the research is conducted, such as the Department of Health and Human Services' Office for Human Research Protections, or other governmental offices as required by law.

- If so desired, you can request your information be shared with your primary care physician

All reasonable efforts will be used to protect the confidentiality of your protected health information. However, not all individuals or groups have to comply with the Federal privacy law. Therefore, once you're protected health information is disclosed (leaves Appalachian State University); the Federal privacy law may not protect it.

Can you withdraw your authorization to collect/use/share your protected health information?

You always have the right to withdraw your permission (revoke authorization) for us to use and share your health information, by putting your request in writing to the investigator in charge of the study. This means that no further private health information will be collected.

Even after you withdraw your permission, Appalachian State University may continue to use and share information needed for the integrity of the study; for example, information about an unexpected or bad side effect you experienced related to the study.

Can you have access to your health information?

At the end of the study, you have the right to see and copy health information about you in accordance with the Appalachian State University policies; however, your access may be limited while the study is in progress.

Consent to Participate in Research & Authorization to Use and Share Personal Health Information:

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

_____Date_____

Subject signature

_____ Date _____

Witness (Optional except for certain classes of subjects)

Should I have any questions about this research or its conduct, I may contact:

Scott Collier at 828.262.7145 or email him at colliersr@appstate.edu

Investigators Telephone/e-mail

Or

Tim Ludwig, PhD 828-262-2692 irb@appstate.edu

Administrator, IRB Telephone e-mail

Graduate Studies and Research

Appalachian State University Boone, NC 26608

Appendix B

STUDENT ASSENT FORM

We are asking you to be in a research study. Research is a way to test new ideas. Research helps us learn new things.

Being in research is your choice. You can say Yes or No. Whatever you decide is OK.

Why are we doing this research?

In our research study we want to see … if 8 weeks of a play-based activity camp is effective at improving body composition, hemodynamic, autonomic and vascular parameters in a group of 8 to 12 year-old adolescents. We want to determine if supervised play-based activity will exert favorable changes on the cardiovascular profile more than unsupervised activity. We intend to research the mechanisms responsible for the behavioral, metabolic and physiological changes after 8 weeks of the broad-based activity program and then four weeks of "de-training" We want to identify specific biomarkers that elucidate the mechanisms that led to the above changes.

What will happen in the research?

I am asking your permission to…record a three day diet recall, fill out your health history and physical activity questionnaires, and let me measure your body composition and aerobic capacity. On a second visit we will measure your blood pressure, PWV, blood flow and reactive hyperemia (RH) measures. Tests will be conducted in a randomized order. Following the collection of your preliminary data, subjects will either complete an 8-week exercise program or an unsupervised normal at-home routine or report back to the laboratory

for post-treatment measurements that were performed prior to the intervention. Lastly, all subjects will report back to the laboratory four weeks later for post-study measurements that will be repeated at the same time of day in the postprandial state (> 3 hours) and in the same order as the pre-measurements. All subjects should refrain from caffeinated product consumption for 12 hours prior to testing.

What are the good things that can happen from this research?

What we learn in this research may or may not help you now. When we finish the research we hope we know more about … the effect of supervised play-based activity will exert more favorable changes on the cardiovascular profile than unsupervised activity. The effects on body composition, cardiovascular and skeletal muscle parameters to be greater in a group that participates in supervised activities compared to an age-matched group that was not given any structured activity. Identification of the specific biomarkers that elucidate the mechanisms has yet to be shown in this population and will allow us to change physicians and clinicians attitudes that activity is the greatest single factor in the health of an adolescent.

What are the bad things that can happen from this research?

If ever you feel uncomfortable [sharing in the group] [answering the questions], you can pass and not [answer]. It is ok if you choose to do this.

What else should you know about the research?

Being in the research is your choice. You can say Yes or No. Either way is OK.

If you say Yes and change your mind later that is OK. You can stop being in the research at any time. If you want to stop, please tell me or Dr. Scott Collier.

Take the time you need to make your choice. Ask us any questions you have. You can ask questions any time.

Name and Signature of Researcher Obtaining Assent

Date

Participant's Statement

The researcher has told me about the research study. I had a chance to ask questions. I know I can ask questions or stop at any time. I want to be in the research study.

Name of Research Participant

Signature of Research Participant

Date

Researcher's name and contact information:

Carol Jean Cook, MS **Dr. Scott Collier, PhD**

cookcb@appstate.edu **colliersr@appstate.edu**

1-828-262-7155 **1-828-262-7145**

Copies to: Research Participant and Parent/Legal Guardian

Appendix C

Pediatric Exercise study

Vascular Biology and Autonomic Studies Laboratory

Data Collection Sheet

Name: _____

DOB ___/___/___ Age: _____ Sex: _____ Date: _____

Time of test: _____ ID #: _____ Finometer File #: _____

Weight: _____lbs _____kg Height: _____cm _____in

BMI: _____

Blood Pressure: _____mmHg (Sitting)

Body Fat %: _____ Classification: _____

VO_2 _____$_{ml/kg/min}^{-1}$

BLAST classification 8 weeks 4 weeks Control

Peak height velocity_____

Vita

Hannah Elizabeth Crawford was born in Winston-Salem, NC to John and Holly Crawford. She grew up in Mooresville, NC and graduated from Mooresville Senior High School in 2006. In 2009 Hannah earned a Bachelors of Science in Exercise Science with minors in Biology and Psychology from Appalachian State University. The following semester she continued her education at Appalachian State University seeking a Masters of Science concentrating in Clinical Exercise Physiology. She worked as a graduate assistant in cardiopulmonary rehabilitation and cardiovascular research alongside her mentors Scott R. Collier and Jeffrey T. Soukup. Ms. Crawford completed her Master's degree in December 2011.