2016

Cardiovascular Strain in Overweight 5k Runners

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CARDIOVASCULAR STRAIN IN OVERWEIGHT 5K RUNNERS

A MASTER'S THESIS

SUBMITTED TO THE GRADUATE FACULTY

GRADUATE SCHOOL

BETHEL UNIVERSITY

BY

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IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER'S OF PHYSICIAN ASSISTANT

AUGUST 2016

Abstract

Previous research is vast and varied regarding how exercise affects the physiology of the cardiac system. Many studies have found adverse effects to the heart in ultra-endurance athletes, but fewer studies have focused on overweight populations. Hamer and Boutcher (2006) observed abnormal post exercise cardiovascular changes in obese individuals when compared to individuals of normal body mass index (BMI) but, were unable to draw any definitive conclusions from the results. With Americans facing an obesity epidemic and healthcare providers increasingly prescribing regular exercise routines to combat it, definitive conclusions regarding the topic of healthy long-term exercise in overweight and obese individuals become important. The hypothesis of this study is if an individual 20-60 years old with BMI > 25 participates in a 5k race, then there will be evidence of a significant increase in cardiovascular strain compared to 20-60 year olds with BMI < 25. The purpose of the study is to determine if there is a correlation between high BMI and cardiovascular strain in individuals who participate in a 5k race. The study question is: what effect, if any, does distance running have on heart rate, blood pressure, and cardiovascular load of individuals with BMI ≥ 25 compared to individuals with BMI <25? Men and women ages 20-60 who have trained at least 5 hours per week for 4 weeks prior to the race will be studied. A pre- and post-race blood pressure and pulse was collected, cardiovascular load (CVL) was calculated, and data analyzed comparing those with BMI over and under 25. The results showed that there was no significant difference between the overweight and normal weight 5k runners. The conclusion of the study is that BMI is an inadequate differentiating factor. Body habitus, effort, training and timing of data collection all influence the final result. Further study is needed to evaluate differences in cardiovascular strain between groups.

BETHEL UNIVERSITY

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May 2016

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	Overweight group		Normal group	
Sex	10 females	14 males	13 females	8 males
Age Range	23-61	27-68	21-58	24-70
Average Age	38.4	45.7	37.9	35.4

Table 2.0 Overweight Group Collection Data Page 32

	Hendel and Geier Cardiovascular Strain Data Collection											
	M/F	Age	Wt	Ht (in)	BMI	Pre-HR	Pre-BP	Post-HR	Post-BP	%CVL	Score	220-age
1	F	31	143	64	25.13672	70	122/74	130	142/82	31.74603	1	189
2	M	40	140	63	25.39683	70	124/88	94	122/80	13.33333	0	180
3	M	48	185	72	25.69444	70	120/80	92	130/70	12.7907	0	172
4	M	28	170	69	25.70888	80	120/78	84	124/90	2.083333	0	192
5	M	32	187	72	25.97222	60	130/70	95	146/78	18.61702	0	188
6	F	59	172	69	26.01134	56	116/70	96	130/80	24.84472	0	161
7	F	46	140	62	26.22268	76	118/76	104	135/90	16.09195	0	174
8	M	61	195	73	26.34641	68	140/70	150	170/68	51.57233	1	159
9	M	68	190	72	26.38889	100	140/98	104	150/92	2.631579	0	152
10	M	50	180	70	26.44898	80	138/90	144	162/88	37.64706	1	170
11	M	28	165	67	26.46469	68	130/85	108	160/90	20.83333	0	192
12	F	55	150	63	27.21088	60	120/78	90	140/88	18.18182	0	165
13	M	54	196	72	27.22222	70	126/80	170	130/90	60.24096	2	166
14	F	28	188	70	27.62449	72	130/90	124	146/92	27.08333	0	192
15	M	54	199	72	27.63889	70	126/80	130	162/88	36.14458	1	166
16	M	50	222	76	27.67313	90	118/90	102	118/100	7.058824	0	170
17	M	55	203	72	28.19444	60	126/80	168	140/90	65.45455	2	165
18	F	23	190	69	28.73346	72	120/70	90	138/78	9.137056	0	197
19	F	26	180	66	29.75207	90	136/76	100	130/84	5.154639	0	194
20	F	27	145	59	29.99138	75	118/82	116	130/70	21.24352	0	193
21	M	27	185	65	31.52663	76	110/75	136	148/90	31.08808	1	193
22	F	61	180	63	32.65306	60	142/88	84	110/90	15.09434	0	159
23	F	28	210	66	34.71074	70	110/70	120	128/88	26.04167	0	192
24	M	45	194	61	37.5383	70	148/80	104	140/70	19.42857	0	175

Table 3.0 Normal weight Group Collection Data Page 33

	Hendel and Geier Cardiovascular Strain Data Collection											
	M/F	Age	Wt	Ht (in)	BMI	Pre-HR	Pre-BP	Post-HR	Post-BP	%CVL	Score	220-age
1	F	37	100	62	18.7305	100	116/62	130	130/68	16.393	0	183
2	F	28	118	65	20.1089	80	122/82	140	138/90	31.25	0	192
3	F	45	140	70	20.5714	76	118/70	70	102/72	-3.429	0	175
4	F	21	112	62	20.9781	90	116/64	110	127/70	10.05	0	199
5	F	23	120	64	21.0938	80	120/84	120	138/80	20.305	0	197
6	F	33	137	67	21.9737	70	132/72	140	140/80	37.433	0	187
7	M	24	153	70	22.4816	70	128/90	130	150/60	30.612	1	196
8	F	27	125	63	22.6757	80	104/60	120	122/68	20.725	0	193
9	F	28	150	69	22.6843	60	118/60	176	134/90	60.417	2	192
10	M	26	150	69	22.6843	58	110/60	120	120/70	31.959	1	194
11	M	40	145	67	23.2569	70	130/80	160	144/80	50	1	180
12	F	27	142	66	23.4711	80	130/88	130	138/88	25.907	0	193
13	F	48	160	70	23.5102	70	110/68	84	122/88	8.1395	0	172
14	M	39	160	70	23.5102	80	115/70	120	130/61	22.099	0	181
15	F	33	130	63	23.5828	120	130/80	140	122/78	10.695	0	187
16	M	24	155	68	24.1349	50	120/70	120	130/61	35.714	1	196
17	F	58	134	63	24.3084	52	118/78	88	128/76	22.222	0	162
18	M	30	173	71	24.7094	60	100/80	170	110/90	57.895	1	190
19	M	70	175	71	24.995	64	152/92	82	122/68	12	0	150
20	F	30	105	62	19.667	80	100/78	104	112/80	12.632	0	190
21	M	30	175	71	24.995	60	110/78	120	108/90	31.579	1	190

Table 4.0 Statistical Analysis Page 34

	Results of the CVL		Results of the BMI raw data points	
	Normal Weight	Overweight	Normal Weight	Overweight
Mean	0.381	0.375	22.6	28.2
Variance	0.3476	0.4185	0.3911	0.6391
Stand. Dev.	0.5896	0.6469	1.7924	3.1307
n	21	24	21	24
T	**0.0397**		**7.2199**	

CHAPTER ONE: INTRODUCTION

Background

Throughout the medical field, healthcare providers are educating patients on the importance of exercise to combat and prevent various forms of cardiovascular disease. Research evidence suggests that physical activity can help reduce hypertension, atherosclerosis, and other cardiovascular risk (Thompson, et al., 2003). Specifically, an episode of activity can allow an 11-12 hour reduction in blood pressure. A decrease in blood pressure following exercise is called post exercise hypotension (PEH) (Hamer & Boutcher, 2006). A study of college athletes demonstrated that over the course of a 90-day competitive season of endurance rowers and strength athletes, heart structure changed. Bilateral expansion of the ventricles was shown in the endurance athletes while the strength athletes' left ventricle muscle thickened. In this aforementioned study of college athletes, function alteration was also demonstrated with an increase in relaxation of heart muscle in between beats of the endurance athletes and a decrease in said variable in the strength athletes (Wood, 2008).

Generally, it is safe to proclaim the safety of moderation, and exercise is no exception. Based on a study performed by Gerche et al. (2012), researchers in the past have wondered to what extent exercise remains healthy, specifically to the heart in high endurance athletes. Gerche et al. (2012) describes cardiac injury in the form of acute right ventricle impairment a risk of amateur marathon runners. Additionally, highly trained ultra marathon runners may also be at risk for RV arrhythmias and chronic RV remodeling persistent beyond recovery. Furthermore, there is correlation between increased myocardial injury with increases in race duration and increased RV remodeling with increased length of participation in endurance sports (Gerche et al ., 2012).

The question can be raised whether running in overweight or obese patients is healthy given the potentially harmful effects seen in individuals of extreme physical fitness. It is important to answer this question especially with the increasing popularity of running races. According to Hamer and Boutcher (2006), obesity can cause abnormal cardiovascular response to stress. This led Hamer and Boutcher (2006) to believe specifically physical stress in an obese individual may affect PEH differently than in an individual of normal weight and adiposity. Hamer and Boutcher (2006) found that body mass index (BMI) was an independent predictor of post exercise cardiovascular changes: overweight individuals had increased post exercise reductions in stroke volume (SV) and cardiac output (CO) and lower reductions in post-exercise total peripheral resistance (TPR) when compared with subjects of normal weight. It is unclear what implications can be drawn from these results. No matter what the recommendations are, it is important that they are backed up by research. Thus, healthcare professionals should consider if current recommendations for the types and intensity of exercise for overweight and obese patients is beneficial or harmful. The previous study by Hamer and Boutcher (2006) suggests a line may need to be drawn regarding the level of physical fitness any individual may achieve before benefits turn to risk. It is appropriate to also investigate whether that "line" is different for patients of overweight or obese nature.

According to Cote et al. (2014), cardiac fatigue causes reduction in left ventricle systolic and diastolic function. This reduction in heart function can occur after prolonged strenuous exercise. At this time, compromised function appears to be transient only with restoration within 48 hours, but the reduction in magnitude of cardiac fatigue was correlated to higher baseline arterial compliance (Cote et al., 2014). This may be cause for concern in less experienced runners who may be more susceptible to cardiac fatigue (Cote et al., 2014). Physical fitness aside, being overweight or obese is a risk factor for cardiovascular diseases such as coronary heart disease, heart failure, and sudden death (Poirier et al., 2006). Adipose gradually accumulates between heart muscle fibers, which can and most likely will lead to dysfunction (Poirier et al., 2006). Furthermore, Hansen et al. (2014) says, "Guidelines for physical activity in obese adolescents propose that… structured exercise of at least 1h/d should be achieved. In these guidelines, it is implicitly assumed that exercise training would be as feasible and medically safe in obese adolescents as in their lean counterparts" (p. 895). These particular researchers recognized that exercise intensity, volume, and frequency prescriptions and recommendations for obese adolescents may be different based on differing exercise tolerance and cardiopulmonary response to acute exercise (Hansen et al., 2014). Obese adults specifically have been shown to have compromised ventilator mechanics and gas exchange, abnormal hormone regulation, and chronotropic abnormalities (Hansen et al., 2014). Further investigation is necessary to determine whether overweight patients engaging in a new running exercise regimen may be at risk for negative longer lasting cardiovascular effects.

The Problem Statement

The following is a statement of the problem that will be addressed by this study: In the wake of an obesity epidemic individuals may be engaging in unhealthy strenuous exercise. There is a need for clinicians to identify unsafe exercise practices and provide valuable exercise education and counseling for all patients.

Purpose of the Study

The purpose of the study is to determine if there is a correlation between high BMI and cardiovascular strain in individuals who participate in a 5k race. The aim is to evaluate whether cardiovascular strain in individuals age 20-60 years old with BMI < 25, categorized as normal weight, who participated in at least the minimum amount of activity recommended by the Center of Disease Control per week is significantly different after a 5 km race compared to 20-60 year olds with BMI ≥ 25, categorized as over-weight or obese, with similar training after a 5 km race (National Heart, Lung, and Blood Institution [NHLBI], 2001).

Significance of the Study

This study will identify whether or not distance running in individuals with BMI ≥ 25 causes cardiovascular strain. This information is important for clinicians and patients to understand when approaching safe and effective diet and exercise programs. The information in the study may indicate a less aggressive approach to exercise for individuals with BMI ≥ 25.

The Research Question

The following research question will be investigated in this study:

What effect, if any, does distance running have on heart rate, blood pressure and cardiovascular load of individuals with BMI ≥ 25 compared to individuals with BMI < 25?

Objectives:

The following is a list of objectives designed to meet the purpose of the study:

1. Collect height and weight of individuals participating in a 5k race who meet the following criteria:
    a. Age 20-70 years
    b. Trained at least 5 hours per week for 4 weeks prior to the race
    c. Consent to participate in the study
2. Collect pre race blood pressure and pulse
3. Collect post race blood pressure and pulse
4. Determine how many males and how many females
5. Determine age distribution
6. Determine max heart rate (HR)
7. Determine BMI

8. Determine relative cardiovascular load (CVL) based on heart rate: percent CVL = 100 (working heart rate – resting heart rate)/ Maximum Heart rate (Mortazavi et al., 2013)
9. Determine if individuals with BMI ≥ 25 are under cardiovascular strain after a 5k race compared to individuals with BMI<25

Definitions:

The following terms will be used in the study. For this particular study the terms will be defined as follows:

BP: Blood Pressure

BMI: Body Mass Index

CDC: Center for Disease Control and Prevention

CVL: Cardiovascular Load defined as percent cardiovascular load = 100 (working heart rate – resting heart rate)/maximum heart rate (Mortazavi et al., 2013)

HRmax: Maximum heart rate per age (Mortazavi et al., 2013)

Minimum amount of exercise recommended by the CDC:

- 2 hours and 30 minutes (150 mintues) of moderate intensity aerobic activity (i.e., bris walking) every week **and** muscle strengthening activities on 2 or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders, and arms).

OR

-1 hour and 15 minutes (75 minutes) of vigorous intensity aerobic activity (i.e., jogging or running) every week **and** muscle strengthening activities on 2 or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders, and arms).

OR

-An equivalent mix of moderate and vigorous intensity aerobic activity **and** muscle strengthening activities on 2 or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders, and arms) (Center for Disease Control and Prevention, 2014).

Obese: Body Mass Index of ≥35

Overweight: Body Mass Index of 25≥34

PHR: Post-exercise Hypotension

RHR: Resting heart rate (Mortazavi et al., 2013)

RV: Right Ventricular

Significant increase in cardiovascular strain: Evidence of one or more of the following correlated with composite score:

-Post race systolic blood pressure of over 220 mm Hg (+2)

-An increase in Blood Pressure of ≥ 90 mm HG (+2)

-Post race heart rate above maximum heart rate recommended per age group by the American Heart Association (+1)

-Percent cardiovascular load 30-60% (+1)

-Percent cardiovascular load >60% (+2)

(American Heart Association, 2013, New Health Guide, 2014)

WHR: Working heart rate (Mortazavi et al., 2013)

Summary

Healthy diet, weight management and an active lifestyle are important components of patient education. The evidence is clear on the benefits of exercise for cardiovascular health and its ability to reduce hypertension, atherosclerosis, and other cardiovascular risks. Providers are responsible for offering guidance to patients to maintain their aerobic and cardiovascular health (Hamer & Boutcher, 2006, Center for Disease Control and Prevention, 2014). Some bodies of research show evidence of cardiovascular strain associated with extreme fitness regimes in endurance athletes (Gerche et al., 2012). However, little research has been done on the cardiovascular effects of endurance running in overweight individuals. This study will investigate whether cardiovascular function is significantly different in overweight 20-70 year olds following a 5k race compared to 20-70 year olds of normal weight defined as BMI >25. Cardiovascular function will be assessed by measuring blood pressure and pulse pre and post exercise. The CVL will be calculated and compared for individuals with BMI<25, BMI 25>35 and BMI >35. Adequate activity has proven to be essential in maintaining health and fitness (Center for Disease Control and Prevention, 2014), However, aggressive exercise and weight management programs may be doing more harm than good. The information will guide clinical decision making in weight management for overweight patients.

CHAPTER TWO: INTRODUCTION

A vast spectrum of studies were reviewed to gain a background on the topic of exercise related cardiac strain. Past research has been conducted on many different populations under a diverse set of conditions. According to the American Heart Association, an excessively elevated heart rate during exercise is considered strain (2013). The literature explores what level of intensity and what types of people are at risk for cardiac strain as well as the specific cardiac effects and long-term clinical implications of cardiovascular strain.

Overview of available literature

Cardiac studies on athletes

In the article, "How Exercise Changes Structure and Function of Heart" sourced by Massachusetts General Hospital, a study demonstrated that exercise can, and does, induce alterations to cardiac structure and function. Both endurance college athletes from the row team and strength college athletes from the football team were evaluated for a 90 day competitive season. Forty rowers evenly divided into males and females engaged in one to three hours of rowing per endurance session. The training of 35 male football players included skill focused drills, weight lifting, and muscle strength and reaction time improving exercises (Wood, 2008). Expansion was seen in bilateral ventricles in the endurance athletes while isolated left ventricle muscle thickening was seen in the strength athletes. Changes in cardiac muscle relaxation were also observed in both groups of athletes: increased in the rower athletes and decreased in the football athletes. The findings of this study caused the researchers to raise the question what effect, if any, would long-term training have on the heart (Wood, 2008).

Additional types of cardiac changes were seen in other studies of athletes as well. Gerche et al. looked at highly trained athletes in an attempt to clarify the significance of cardiac functional changes and biochemical cardiac abnormalities post-exercise (2011). Gerche et al. uses the term "cardiac fatigue" to explain systolic and diastolic functional changes in the left ventricle (2011). Long-term endurance training and subsequent repeat cardiac fatigue can lead to chronic left ventricle remodeling (Gerche et al., 2011). Since chronic left ventricle remodeling is found to be beneficial, Gerche et al. examined changes to the contralateral right ventricle (2011). Endurance exercise may affect the right side of the heart more significantly. In addition, recovery of the right ventricle post-exercise may be incomplete. This lack of full recovery raises concern for complications of chronic right ventricle remodeling and subsequent right ventricular arrhythmias (Gerche et al., 2011).

Cardiac studies on endurance athletes

Highly trained athletes were used in the 2011 study by Gerche et al. because a correlation exists between highly trained athletes who participate in endurance events longer than a marathon and the aforementioned right ventricle remodeling and arrhythmias. Although acute cardiac remodeling and right ventricular impairment is seen in amateur athletes following a marathon, the changes tend to be more persistent and profound in the highly trained athlete. Another difference with highly trained athletes is that myocardial fibrosis has been seen in long time competitive endurance sport athletes by way of cardiac magnetic resonance imaging versus more novice athletes (Gerche et al., 2011).

Participants for the Gerche et al. study were chosen based on specific criteria. The first 40 individuals who planned to participate in either a marathon, endurance triathlon, alpine cycling race, or an ultra-triathlon and who were well trained, well performed, and had no cardiac symptoms, risk factors or abnormalities in stress echocardiography were selected for participation. "Well trained" is considered greater than 10 hours of intense training per week for this study while well performed is having finished in the top 25% of the field in a previous but recent endurance event. Cardiac magnetic resonance imaging, echocardiography, and biochemistry were performed at baseline and within 1 hour post-race. After a six to 11 day period following the event of very minimal training, these methods were repeated (Gerche et al., 2011).

Results from these endurance athletes show a reduction in all measures of systolic right ventricular function post-race from baseline in all four events. These results were compared to previous studies and demonstrate less significant changes from those marathon competitors with less training (Gerche et al., 2011). The Gerche study results are consistent with previous speculation that post-exercise cardiac injury is associated with novice athletes. Although the difference from post-race to baseline was less in the highly trained athletes, the highly trained athletes of the Gerche et al. 2011 study also showed evidence of myocardial fibrosis within the interventricular septum. Fibrosis and greater right ventricular structural remodeling were correlated to a more significant history of endurance sport competition (2011).

Consistent with previous research, the Gerche study found left ventricular function to be spared. Right ventricular abnormalities seem to be correlated to a longer history of endurance competition. Arrhythmias were not seen in this study but remain a concern as a complication of any right ventricular fibrosis or remodeling (Gerche et al., 2011). The health benefits and concerns regarding extreme endurance exercises have not yet been well defined.

Another slightly newer study by Wilhelm et al. (2012) also looked at non-elite endurance athletes with some conflicting findings from the study performed by Gerche et al. The Wilhelm et al. study was based on previous work showing acute isolated right-sided heart dilation of both the atria and ventricle in non-elite runners post-marathon. Wilhelm et al. also wanted to determine if marathon-induced cardiac remodeling would lead to complications with arrhythmias and also focused on the right side of the heart only (2012). One hundred twenty two participants of the Grand Prix of Bern 10-mile race in Switzerland were analyzed. Participants were at least 30 years old without hypertension or history of cardiovascular conditions. Three groups were formed for the study. The groups consisted of a control group of physically active non-marathon runners, a group of participants who had previously ran one to five marathons and a third group of had previously finished at least six marathons. Over 36 hours after the race, EKG, transthoracic echocardiography, 24-hour holter, and cardiopulmonary exercise testing on a treadmill were performed (2012).

Based on the Wilhem et al. study results, marathon participation seemed to be an independent predictor of right atrial remodeling, but not right ventricular remodeling, dysfunction, or complex ventricular arrhythmias. However, right ventricular remodeling leading to arrhythmias in high trained, elite athletes was not ruled out (2012).

Cardiac studies on runners

The newest piece of literature used also studied well-trained amateur marathon runners. Schattke et al. (2014) concluded that marathon running seems to correlate in a beneficial way with regard to cardiac effects. However instead of ventricular remodeling and arrhythmias, Schattke et al. focused on 2D strain and strain rate at rest in this population (2014). Standard transthoracic echocardiography ad 2D strain and strain rate values were analyzed pre- and post- the Berlin Marathon in 84 amateur marathon runners. All 84 participants had previously finished one full marathon (Schattke et al., 2014).

When compared with previously published overall longitudinal myocardial contractility in rest of healthy untrained individuals, there is an increase in this value among the experienced marathon participants of the Schattke et al. study (2014). In addition to an improved myocardial contractility value, the cohort of Berline marathoners demonstrated better values for diastolic function when compared to previous published values in untrained individuals. Shattke et al. did consider comparison to controls in separate studies a limitation of the study (2014).

While Schattke et al., Wilhelm et al., and Gerche et al. all focus on marathon runners, Cote et al. studied 34 ultra-marathoners (2014). Thirteen women and 21 men ages 28-56 were initially evaluated with measurements of baseline baroreceptor sensitivity, heart rate variability, and arterial compliance. Pre- and post- race echocardiographic evaluated left ventricular dimensions, volumes, Doppler flow velocities, tissue velocities, strain, and strain rate. Of the 34, 17 men and eight women finished the Fat Dog 100 Ultramarathon Trail Race (Cote et al., 2014).

Ultra-endurance exercise resulted in a significant decrease in fractional shortening diastolic filling, septal and lateral tissue velocities, and longitudinal strain (Cote et al., 2014). Cote et al. aimed to find different post-exercise cardiac responses between sexes. Although evident differences in post-ultramarathon responses between men and women were absent, there were other significant findings. Instead it was demonstrated that exercise-induced cardiac fatigue was associated with a lower baseline arterial compliance and with the level of training and experience (2014).

Cardiac studies on the overweight population

For this review literature, which studied the population of overweight and obese individuals, was also consulted. Hamer and Boutcher researched how body mass index (BMI) was related to post-exercise hemodynamic responses (2006).

Participants for the study consisted of 16 males ages around the age of 20 who had no known cardiovascular function abnormalities at rest. On both a control day and on a separate day following a session of moderate exercise, forearm blood flow, blood pressure, and cardiac output were measured. Higher BMI correlated with greater reductions in cardiac output and stroke volume with simultaneous lowered reductions in total peripheral resistance (Hamer & Boutcher, 2006).

A more recent meta-analysis study by Hansen et al. evaluated body fat composition and response to exercise (2013). Exercise tolerance of obese adolescents was compared to exercise tolerance of lean adolescents with the concern that healthcare providers prescribe medically safe exercise routines for obese adolescents needing to lose weight (Hansen et al., 2013). Nine previously published articles were selected to analyze peak vital oxygen (VO2 peak), peak cycling power output, and peak heart rate. These nine articles included 333 obese and 145 lean individuals. There was a decrease in VO2 peak in the obese adolescents. Hansen et al. were unable to make a definitive conclusion about the cardiopulmonary responses during maximal exercise between the two groups (Hansen et al., 2013).

Gaps in the existing research

The following section discusses current knowledge and gaps in the literature regarding cardiovascular health studies in overweight and obese populations.

Cardiovascular health is a widely studied topic however, there are still gaps in our knowledge of the effects of exercise on cardiovascular function and cardiovascular strain. Target maximum heart rate is a guideline recommended by the American Heart Association and frequently used to monitor training (American Heart Association, 2013). Target heart rate is also of clinical importance when testing for cardiovascular disease and testing cardiac function (Kolata, 2001). A widely accepted formula that is currently advocated by the American Heart Association for maximum heart rate is HRmax=220-age (2013). Target heart rates are a general metric based on age that do not take into account the physical fitness level or overall health of the patient. Currently, recommendations for target heart rate are the same for individuals regardless of body mass index (BMI) or fitness level. The advised ranges from the American Heart Association offer guidance for people to work with their individual capabilities, but a review of the literature reveals little scientific guidance for specific populations (2013). Lack of standardization in this area may confound cardiovascular studies in populations of varying fitness and cardiovascular health.

Research on the origin of the HRmax=220-age formula reveals that the formula was created using methods that would not be acceptable today (Kolata, G, 2001 and Rogers, R. and Landwehr R, 2002). The information that the maximum heart rate formula was based on was not representative of the general population revealing a significant methodological issue with the development of the formula. The American Heart Association does advice individuals to stay between 50% and 85% of their target heart rate (2013). A range is better suited for the needs of the general population, but there is still a gap in the research regarding HRmax=220-age and its validity as a calculation for maximal heart rate for all populations.

Blood pressure is a metric that is well known and widely used to assess cardiovascular health. Blood pressure has been used in research to measure cardiovascular effects of exercise, but relevant data on the benefits of measuring blood pressure versus heart rate during routine exercise is not expansive. The importance for individuals to track their heart rate during physical activity cannot be understated, but heart rate does not directly link to blood pressure (American Heart Association, 2014, New Health Guide, 2014). Information on target resting and active blood pressure is readily available however, it is still unclear if tracking blood pressure during routine exercise is indicated for overweight and obese athletes. Further research will need to be done in order to determine if blood pressure tracking during routine exercise for overweight and obese athletes offers a better picture of cardiovascular strain.

The Center for Disease Control (CDC) recommends that individuals stay active to maintain health (2014). The CDC has published guidelines for levels of activity deemed necessary for a healthy lifestyle (2014). The amounts of activity the CDC recommends is the minimum amount to maintain a healthy life style. The recommendations do not address the amount of activity that is still considered safe and effective for all populations, including overweight and obese individuals. Many people engage in activity that far exceeds the minimum recommendations by the CDC. We know that healthy people who engage in endurance running such as marathons, have evidence of cardiovascular strain (Cote et al., 2014, Gerche et al., 2012, Wood, 2008, Schattke et al., 2014, and Wilhelm et al, 2012). Though evidence of negative cardiac effects in endurance athletes exists, there is limited research-based medicine on cardiac strain in overweight and obese endurance athletes. The lack of information creates a gap for providers when counseling overweight or obese individuals who choose to engage in endurance activities.

Massachusetts General Hospital published a study in 2008 regarding the effects of different types of exercise on heart function. The study revealed that the individuals in the strength-training group presented with thicker cardiac muscle at the end of the study whereas the endurance group presented with increased ventricular chamber volume. The clinical significance of these findings are unknown. While this information expands available data on cardiac remodeling, a knowledge gap exists in how this information can be effectively used to council overweight and obese patients on types of physical fitness and how different types of exercise will affect their long term cardiovascular health.

The long-term benefits of cardiovascular exercise are evident in research (American Heart Association 2013, CDC, 2014, Wood, 2008 and Schattke et al., 2014). Changes in heart wall thickness, compliance and function have been demonstrated in athletes over time (Wood, 2008 and Schattke et al., 2014). The long-term clinical significance of cardiovascular remodeling in exercise in healthy individuals however is still unknown. The gap in knowledge regarding cardiovascular remodeling over time is substantial. The clinical significance is relevant for health care providers when counseling patients and managing their cardiovascular health. Further research needs to be done in order to understand the clinical significance of cardiovascular changes and how it can be applied to improving patient health.

Questions requiring further research

The following section lists questions requiring further research in regards to exercise induced cardiovascular strain in overweight/obese individuals. The questions were derived from the gaps in literature that need further exploration.

1. To what extent is the formula for maximum heart rate (HRmax=220-age) a valid metric for individuals who are overweight and obese?
2. How beneficial is blood pressure monitoring during exercise compared to heart rate monitoring?
3. To what extent are current methods reliable in measuring whether individuals are undergoing cardiovascular strain during exercise?
4. To what extent does physical fitness level alter "target" cardiovascular function?
5. What are the differences in cardiovascular strain between overweight/obese individuals and normal weight individuals?
6. Are the results of this study significant enough to be a consideration for primary care providers when counseling their patients?
7. To what extent should primary care providers be counseling men and women differently when it comes to exercise and cardiovascular health?

8. What is the clinical significance of the effects of different types of exercise effect on the remodeling of the heart?
9. Are the results of that study significant enough for primary care providers to consider when counseling patients?
10. What is the long term clinical significance of cardiovascular remodeling in exercise?

Summary

Literature focused on the topic of cardiac structural and function changes post-exercise are abundant among populations of amateur and elite endurance athletes. Studies question the cardiac benefits and risks of marathon distances and beyond. Some research has also been performed among populations of the overweight and obese but the findings have not been definitive enough to have clinical significance. Knowledge gaps exist in this area of research pertaining to measures of cardiovascular fitness and strain and long-term effects of cardiac remodeling. The validity of HRmax=220-age in calculating maximum target heart rate for all populations remains unknown. Heart rate is a mainstay of physical training. The benefits of blood pressure monitoring during daily exercise have yet to be explored. Further research needs to be conducted on cardiovascular strain in overweight and obese individuals. Current recommendations are not specific to BMI and address the minimum recommended amount of activity. Recommendations do not provide guidance on overtraining or exercises activity that may have negative cardiac effects. Research has been conducted on cardiac remodeling, but the long-term effects and clinical significance of remodeling remains unknown. Though research has been conducted on cardiac effects of exercise, most studies are done with normal weight participants. Information available for clinicians to counsel overweight and obese patients is limited. Since research on cardiovascular strain in overweight and obese individuals during exercise is lacking our study will explore the relationship between BMI, exercise and cardiovascular strain.

CHAPTER THREE: METHODS

Introduction

In order to determine if there is a correlation between high BMI and cardiovascular strain in individuals who participate in a 5k race, we used a specific study method. The following sections will be covered in chapter 3: study design, sample population, and validity and reliability of our study tools, data collection, data analysis, limitations, and de-limitations. With these topics in mind, we evaluated whether cardiovascular strain in individuals age 20-70 years old with BMI <25, categorized as normal weight, who participated in at least the minimum amount of activity recommended by the Center of Disease Control per week is significantly different after a 5 km race compared to 20-60 year olds with BMI≥ 25, categorized as over-weight or obese, with similar training after a 5km race. Our aim was to answer the question: what effect, if any, does distance running have on heart rate, blood pressure, and cardiovascular load of individuals with BMI ≥25 compared to individuals with BMI < 25?

Study Design

This is a pre-experimental design two-group pre-test posttest design. In order to research cardiovascular strain, we conducted testing at the Color Run in St. Louis Park, MN and at the Circle the Lake 5k in Fairbault, MN.

Collecting study participants:

Race coordinators were contacted via email seeking permission to research during that specific event. The email is as follows

> "Hello, We are students at Bethel University conducting research on cardiovascular function in 5k runners and request permission to collect data on a volunteer basis at the ________. Data collection will include asking for volunteers prior to the race and collecting blood pressure and heart rate from participants pre and post race. Please let us know if this is possible and what we need to do to be in compliance with race regulations. Thank you."

For those races in which we have been granted permission to conduct research at, a booth was set up at the pre-race expo where the researchers had an opportunity to be in contact with potential study volunteers. Researchers explained the expectations of volunteers: a resting blood pressure will be taken at the time of the expo one day before the race followed by a second blood pressure reading immediately following the runner's finish. Study participants needed to present at the research booth located at the finish area after completing the 5k within 5 minutes. If race participants were willing and able to be a research participant, researchers screened them to ensure that they fit into the sample population. Only those who fit population criteria were used for study data.

Data was collected on 45 runners. Data on 50 runners would have allowed for a detection of a significant difference at alpha set at .05 with 80% power with a meaningful difference of 1 between group and an assumed standard deviation of 1 for both groups. Sample size estimation was used with MedCalc version 15.2.2.

Performing the study/Procedure

Once research participants were determined based off willingness and meeting set criteria (see below), researchers collected necessary demographics (age, height, and weight) as well as a baseline resting blood pressure. Height and weight were obtained from participants. BMI was calculated using the measured height and weight using the National Institute of Health BMI calculator, which can be accessed with the link http://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmicalc.htm. Blood pressure was measured after allowing the study participant to sit for 2 minutes using a manual sphygomanometer. This data was recorded under an identification number assigned to each participant. Using an identification number rather than the participant's name protected identify. The number was written on the race bib. This data collection occurred prior to the start of the respective race but on the same day.

A booth was set up at the finish area of the 5k, which allowed for final data collection. As soon as a runner presented for post-race data collection, a blood pressure with a manual sphygmomanometer was taken and recorded. There were no participants who presented under distress and in need of medical evaluation. Data was analyzed (see below).

Risk

This study in itself did not pose additional risk to participants. Any risk would already have been assumed from voluntary participation in the race itself.

Monitoring of Potential Adverse Events

Heart rate and blood pressure were the only two measurements taken. Heart rate was obtained by counting the radial pulse frequency in 15 seconds with the use of a stopwatch. This number was multiplied by 4 to standardize the data to beats per minute. With regard to the heart rate data collected, bradycardia and tachycardia were determined based off numbers less than 60 and greater than 100 respectively. No other significant conclusions can be made with this measurement alone with regard to any possible acute cardiac risk. Blood pressure was obtained with the use of a stethoscope and sphygmomanometer. There was no use of EKG in this study, and heart rhythms such as atrial fibrillation, ventricular tachycardia, atrial ventricular blocks, etc. were not detected using these methods. Both measurements are only able to detect the sensation of the pulse and are insensitive to detection of heart sounds such as murmurs or bruits. Heart rate and blood pressure measurements were provided to the participants upon request, but interpretation of the numbers were limited to only if those numbers fell inside or outside the normal ranges. We expected that post-run heart rates be tachycardic and that blood pressure be elevated from the resting state.

<u>Population</u>

Study Site:

The study site was the location of 5k races in St. Louis Park, MN and Fairbault, MN respectively. Races were selected based off of a general Internet search to identify 5k races as well as given consent to conduct research by race coordinators. Local races were used only as matter of convenience and feasibility, but runners may be from any residence. The 5k races were one of other various distance races within a specific event or day. Study participants were only collected from the 5k distance.

Study Population:

Our study population was divided into two samples for comparison: normal BMI participants and participants determined to be overweight or obese by the Center for Disease Control and Prevention. All study participants needed to be between 20-70 years old, male or female, and will have needed to have trained at least 5 hours per week for 4 weeks prior to the race. Age and prior training hours were based on study participant history. All participants were provided with the opportunity to sign an informed consent. The sample participants were from the Color Run in St. Louis Park, MN and Circle the Lakes 5k in Faribault, MN.

Validity and Reliability

The following section explains the validity of the study, presenting how the study analyzed data and metrics as stated. The following section also discusses the reliably of the study, demonstrating how the study produced consistent results over time.

The purpose of the study is to determine if there is a correlation between high BMI and cardiovascular strain in individuals who participate in a 5k race. In order to insure the validity of the study all participants had the same data collected in the allotted time frames. All data collected were used in determining evidence of cardiovascular strain. No data was collected outside of the parameters discussed in the study and any participant data that does not meet the standard set by the study was not incorporated. Pre and post-race heart rate and blood pressure was collected from all participants in order to calculate percent CVL. The comparison of pre and post-race heart rate and blood pressure provided one metric to evaluate a significant increase in cardiovascular strain (New Health Guide, 2014). Percent CVL calculated from participant data served as a secondary metric of cardiovascular strain (Mortazavi et al, 2013). All evidence of cardiovascular strain in participants was evaluated for significance.

Reliability of data collection was ensured by implementing control measures during the data collection process. All participants had one initial and one verification measurement for each metric. If the participant heart rate or blood pressure had a delta of greater than 10 units, then a third measurement will be taken. If the participant heart rate or blood pressure demonstrated a delta of greater than 10 units on the third measurement then their data was not used in the study. These procedures were used during both pre and post-race data collection to ensure reliability of data collected.

Data Analysis

The following section explains how data collected from participants was analyzed in order to answer the research question.

The study design is quasi experimental. One set of measurements was taken before activity and the same set of measurements was taken after activity. The data was analyzed in two ways; first, the pre-race raw data was compared to the post-race raw data. The goal of this comparison was to identify whether or not there is a trend of significant increase in cardiovascular strain in participants after the 5k race. The data was then used to calculate percent of CVL. The percent CVL demonstrates the severity of strain. Participant CVL was measured against the following standard: <30% CVL: no health risk 30-60% CVL: moderate risk, actions should be taken to reduce strain, >60% CVL: high risk, immediate reduction of strain should be performed (Mortazavi et al, 2013). The significant difference in CVL and WHR trends between the normal weight and overweight groups was analyzed using a t test for dependent samples.

A significant increase in cardiac strain can be assessed from analysis of the raw data points satisfying the purpose of this study. Analysis of CVL in participants will demonstrate the severity of cardiac strain experienced between study groups. Unpaired T tests of mean CVL will demonstrate if study outcomes are significant. The hypothesis is as follows: if an individual 20-70 years old with BMI > 25 participates in a 5k race, then there will be evidence of a significant increase in cardiovascular strain compared to 20-70 year olds with BMI < 25.

Data Storage plan

The following section describes the procedure for data storage in order to maintain security of data collected during the study.

Data was collected in a study leger in the field. Legers were transcribed to digital Excel upon completion of data collection. Legers were shredded and not retained for future use. During data analysis all data was stored on protected personal drives maintained by the researcher. Upon conclusion of the study all data was transferred to a CD and erased from all personal drives. The CD will be maintained at Bethel University with the Research Coordinator.

Limitations and Delimitations

The following section describes possible limitations to the study outside of researcher control. The section also details self-imposed limitations that were implemented as control measures.

The number of viable participants was a limitation to the study. Participants had no incentives to participate in the study and therefore, little motivation to do so. Number of participants may be too low to calculate significant correlations. The study was further limited by qualified participants not completing the post-race portion of the study. Participant total work time was variable depending on participant fitness level, which may have affected data collection. Significant time differences existed in post-race data collection between participants since control over participants was severely limited.

The following are de-limitations placed to standardize participants:

Age: 20-70 years old, males and females

BMI: greater than 25 for the experimental group

BMI: less than 25 for the control group

Trained at least 5 hours per week for 4 weeks prior to running a 5k race.

CHAPTER FOUR: RESULTS

This chapter presents the findings of the study by measuring percent cardiovascular load of 5k runners. Percent cardiovascular load is calculated using working heart rate, resting heart rate and max heart rate. The results collected were correlated with BMI and cardiovascular strain during a 5k race. Participant demographic data and pre/post race data were analyzed. The raw data suggests that there is no significant difference between overweight and normal weight individuals in level of cardiovascular strain during a 5k race.

Data Analysis

Data was collected from various 5k races within the greater metropolitan area. The pre and postrace data collected from the 5k race participants was compiled and analyzed. Below is a discussion of the demographic criteria collected within the study along with a statistical analysis of the data using an unpaired t-test. The following represent the demographic inclusion criteria of the data collection; Age: 20-70 years old and trained at least 5 hours per week for 4 weeks prior to running the 5k race. Participants with a BMI greater than 25 were compared to participants with normal BMI's.

Results

The age, sex, weight, height and BMI of the race participants were recorded below. Individuals were screened for age and amount of training for the 5k prior to data collection. Any individuals who did not fit the age and training requirements were excluded from data collection. Of the total 45 participants, 23 were female from ages 21-61 and 22 were male from ages 24-70. Ten females and 14 males were in the overweight group. The normal weight group had 13 females and 8 males. Table 1.0 illustrates an overview of participant demographics:

	Overweight group		Normal group	
Sex	10 females	14 males	13 females	8 males
Age Range	23-61	27-68	21-58	24-70
Average Age	38.4	45.7	37.9	35.4
BMI	28.2		22.6	

Table 1.0: Participant Demographics

Demographic Data: Overweight group

Total number of individuals in the study totaled 45. There were 23 females and 22 males. Participants were separated into two groups according to BMI. Individuals with BMI over 25 were selected for the overweight group. There were 24 individuals with BMI ≥ 25 that were selected for the overweight group consisting of 53.3% of the participants and average BMI of 28.2. Ten of the individuals in the overweight group were female and 14 individuals were male. All of the participants met the criteria as individuals who did not meet criteria were excluded before data collection. Table 2.0 below details the overweight group data. Of the overweight group 29.2% demonstrated moderate cardiovascular strain and 8.3% demonstrated severe cardiovascular strain. Of the seven participants who demonstrated cardiovascular strain, six of the participants were male.

Overweight Group

	Hendel and Geier Cardiovascular Strain Data Collection											
	M/F	Age	Wt	Ht (in)	BMI	Pre-HR	Pre-BP	Post-HR	Post-BP	%CVL	Score	220-age
1	F	31	143	64	25.13672	70	122/74	130	142/82	31.74603	1	189
2	M	40	140	63	25.39683	70	124/88	94	122/80	13.33333	0	180
3	M	48	185	72	25.69444	70	120/80	92	130/70	12.7907	0	172
4	M	28	170	69	25.70888	80	120/78	84	124/90	2.083333	0	192
5	M	32	187	72	25.97222	60	130/70	95	146/78	18.61702	0	188
6	F	59	172	69	26.01134	56	116/70	96	130/80	24.84472	0	161
7	F	46	140	62	26.22268	76	118/76	104	135/90	16.09195	0	174
8	M	61	195	73	26.34641	68	140/70	150	170/68	51.57233	1	159
9	M	68	190	72	26.38889	100	140/98	104	150/92	2.631579	0	152
10	M	50	180	70	26.44898	80	138/90	144	162/88	37.64706	1	170
11	M	28	165	67	26.46469	68	130/85	108	160/90	20.83333	0	192
12	F	55	150	63	27.21088	60	120/78	90	140/88	18.18182	0	165
13	M	54	196	72	27.22222	70	126/80	170	130/90	60.24096	2	166
14	F	28	188	70	27.62449	72	130/90	124	146/92	27.08333	0	192
15	M	54	199	72	27.63889	70	126/80	130	162/88	36.14458	1	166
16	M	50	222	76	27.67313	90	118/90	102	118/100	7.058824	0	170
17	M	55	203	72	28.19444	60	126/80	168	140/90	65.45455	2	165
18	F	23	190	69	28.73346	72	120/70	90	138/78	9.137056	0	197
19	F	26	180	66	29.75207	90	136/76	100	130/84	5.154639	0	194
20	F	27	145	59	29.99138	75	118/82	116	130/70	21.24352	0	193
21	M	27	185	65	31.52663	76	110/75	136	148/90	31.08808	1	193
22	F	61	180	63	32.65306	60	142/88	84	110/90	15.09434	0	159
23	F	28	210	66	34.71074	70	110/70	120	128/88	26.04167	0	192
24	M	45	194	61	37.5383	70	148/80	104	140/70	19.42857	0	175

Table 2.0

Demographic Data: Normal weight group

Individuals with BMI < 25 were selected for the Normal Weight group. Twenty one individuals were selected for the normal weight group from the participant pool consisting of 46.7% of participants with an average BMI of 22.6. Thirteen individuals were female and 8 individuals were male. All of the participants met the criteria as individuals who did not meet criteria were excluded. Of the Normal weight group, 7 individuals, or 33.3%, displayed evidence of cardiovascular strain. Of which, 28.6% demonstrated moderate cardiovascular strain and 4.8% demonstrated severe cardiovascular strain. Of the seven participants who demonstrated cardiovascular strain, six of the participants were male. Data for the normal weight group is displayed in table 3.0 below.

Normal Weight Group

	Hendel and Geier Cardiovascular Strain Data Collection											
	M/F	Age	Wt	Ht (in)	BMI	Pre-HR	Pre-BP	Post-HR	Post-BP	%CVL	Score	220-age
1	F	37	100	62	18.7305	100	116/62	130	130/68	16.393	0	183
2	F	28	118	65	20.1089	80	122/82	140	138/90	31.25	0	192
3	F	45	140	70	20.5714	76	118/70	70	102/72	-3.429	0	175
4	F	21	112	62	20.9781	90	116/64	110	127/70	10.05	0	199
5	F	23	120	64	21.0938	80	120/84	120	138/80	20.305	0	197
6	F	33	137	67	21.9737	70	132/72	140	140/80	37.433	0	187
7	M	24	153	70	22.4816	70	128/90	130	150/60	30.612	1	196
8	F	27	125	63	22.6757	80	104/60	120	122/68	20.725	0	193
9	F	28	150	69	22.6843	60	118/60	176	134/90	60.417	2	192
10	M	26	150	69	22.6843	58	110/60	120	120/70	31.959	1	194
11	M	40	145	67	23.2569	70	130/80	160	144/80	50	1	180
12	F	27	142	66	23.4711	80	130/88	130	138/88	25.907	0	193
13	F	48	160	70	23.5102	70	110/68	84	122/88	8.1395	0	172
14	M	39	160	70	23.5102	80	115/70	120	130/61	22.099	0	181
15	F	33	130	63	23.5828	120	130/80	140	122/78	10.695	0	187
16	M	24	155	68	24.1349	50	120/70	120	130/61	35.714	1	196
17	F	58	134	63	24.3084	52	118/78	88	128/76	22.222	0	162
18	M	30	173	71	24.7094	60	100/80	170	110/90	57.895	1	190
19	M	70	175	71	24.995	64	152/92	82	122/68	12	0	150
20	F	30	105	62	19.667	80	100/78	104	112/80	12.632	0	190
21	M	30	175	71	24.995	60	110/78	120	108/90	31.579	1	190

Table 3.0

Statistical Analysis:

Table 4.0 represents the statistical analysis of the data collected. An unpaired t-test using statistical software allowed for a total of 21 normal weight individuals and 24 overweight individuals to be analyzed. The means of the two groups were not significantly different at a p value of 0.97. With 95% confidence, BMI did not have an effect on cardiac strain in the 5k runners we observed. When using the raw data BMI's, t value was 7.2199 with a p value of less than 0.0001. This correlates to extremely significant different average BMI's between the groups (22.6 vs 28.2).

Using the data of pre- and post-race heart rates and blood pressures, we were able to determine significant increases in cardiovascular strain in each individual following a 5k race. This was done on a point system based on the following parameters:

1. Post race systolic BP of over 220 mm Hg (+2)

2. An increase in BP of $\geq$ 90 mm Hg (+2)

3. Post race heart rate above maximum heart rate recommended per age group by the American Heart Association (+1)

4. Percent cardiovascular load 30-60% (+1)

5. Percent cardiovascular load >60% (+2)

The cardiovascular load for parameters 5 and 6 is determined by the equation: percent cardiovascular load (CVL) = 100 X (working heart rate-resting heart rate)/(maximum heart rate). A point of at least 1 is considered cardiovascular strain. Points were averaged in each BMI group and compared.

	Results of the CVL		**Results of the BMI raw data points**	
	Normal Weight	**Overweight**	**Normal Weight**	**Overweight**
Mean	0.381	0.375	22.6	28.2
Variance	0.3476	0.4185	0.3911	0.6391
Stand. Dev.	0.5896	0.6469	1.7924	3.1307
n	21	24	21	24
T	**0.0397**		**7.2199**	

Table 4.0

CHAPTER FIVE: DISCUSSION

Summary

This chapter discusses conclusion drawn from the study. Furthermore, a discussion on implications, limitations, and recommendations for further research and future practice will be provided. We hypothesized that there would be a significant difference in cardiac strain between overweight and normal weight individuals as demonstrated after running a 5k race leading to new recommendations for patients with regard to healthy exercise. Our study, however, showed no such significant difference. There were limitations, which is why further research is needed before our goal knowledge can be achieved.

Study Conclusions

In our pursuit to confirm that overweight individuals demonstrate increased cardiovascular strain than normal weight individuals after running a 5k race, we collected pre- and post-race heart rates and blood pressures, which was data needed to calculate cardiovascular load and subsequently total cardiovascular strain. The strain is scored with points using specific parameters. The points could be totaled and averaged, giving each BMI group a general number to describe them. The overweight group averaged a cardiac strain score of 0.375 while the normal weight group averaged a cardiac strain score of 0.381.

When heart rate and blood pressure data were analyzed and compared between the normal BMI group versus the overweight BMI group, the means weren't significantly different with a t value of 0.0397. With these numbers, we can conclude with a 95% confidence that BMI has no clinical significance on cardiac strain after running a 5k race. Per the literature review, it is likely that cardiac strain would be found in a population of overweight individuals. According to the data analysis within this study, no such pattern was found among BMI, in fact the opposite was proven to be true here. Within this study there were obstacles and limitations encountered. Despite these results, given the existing literature, further research would be useful in gaining a broader and more accurate conclusion regarding this topic.

Limitations

As our study unfolded, factors became evident that may make data less reliable and skew the meaningful results. Although the researchers informed the participants to present for post-race data collection within five minutes of finishing, it is likely some of the participants waited longer. It is even more likely that it was the overweight BMI category runners who did so given the correlation between high BMI and deconditioning. It is this same correlation that is questioned when determining the significance of the cardiac strain score in the overweight group. It is possible, and maybe even probable, that the overweight individuals, although exerting more effort due to any potential deconditioning were unable to push their bodies to the level that any normal weight individual could. As a generalization, a fit runner of normal weight can challenge their body further past a level of discomfort with exertion. This may be evident in our study. In some cases, it was apparent that participants initially forgot about post-race data collection although unclear how long. Some runners came immediately, so the amount of time was inconsistent.

Given limitations in resources to conduct the study, manual sphygmomanometers were used and multiple researchers collected blood pressures and heart rates contributing to user differences in measurement. It was also difficult at times to hear the heart while taking blood pressures due to the loud surrounding environment.

For pre-race data collection, we ideally would have taken blood pressures the day before the event. We noticed that some blood pressures and heart rates were higher before rather than after leading us to believe that pre-race adrenaline or anxiety may account for falsely elevated pre-race readings.

Implications and Recommendations for Further Research

Given the unexpected results, subsequent studies would be useful to verify if in fact there is no significant difference in cardiac strain based on weight. There are many other forms of exercise patients partake in that should also be investigated. Perhaps a 5k would not induce cardiac strain in an overweight individual while an obstacle 5k run would. Our current study was based off research suggesting ultra-marathon running has negative effects on the heart. This should also be studied further to formulate guidelines and recommendations for extreme forms of exercise.

Another implication our results may demonstrate is that BMI is a poor indicator of physical fitness or body composition. BMI takes no consideration to the body composition of an individual. A muscular individual with very little body fat could be classified as an overweight individual with the right height and weight. Further research on this topic of cardiovascular strain should look at fat composition rather than BMI. This becomes important because BMI is already being used as a screening tool in the medical field, corralling individuals into categories that may not pertain to them. It will be important to explore how pertinent or ambiguous this measurement tool actually is.

Conclusion

In conclusion, there was not a significant difference in cardiac strain between normal weight and overweight individuals after running a 5k race despite there being a significant difference in average BMI between the groups (28.2 vs 22.6). In previous literature, there is a correlation between obesity and cardiovascular efficiency as well as obesity and response to stress. The current study showed statistical significance in disagreement of the hypothesis, that overweight or obese individuals would demonstrate more cardiac strain with running than those of normal weight. Although the evidence did not support the hypothesis, there were certain limitations to the study that may have prevented more meaningful results from surfacing. It is important, given the ambiguity of the data and the lack of previous research, that further studies should be performed. Healthy exercise recommendations remain uncertain. Since exercise is an important lifestyle modification that anyone can use to help direct their health, the medical field would benefit greatly from having concrete guidelines to follow.

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APPENDIX A

Data Collection Table

Hendel and Geier Cardiovascular Strain Data Collection											
#	Gender	Age	Weight	BMI	Qualified Y/N	Pre-HR	Pre-BP	Post-HR	Post-BP	%CVL	Score
1											
2											
3											
4											
5											
6											
7											
8											
9											
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Appendix B

Communication Approval with 5K Race directors

Maple Grove 5K Approval

Brian Kuhnley <bkuhnley@charter.net> Feb 19
to me, James, Mary

Polly,
I assume you'll just be coming to the race and meeting people there to ask if they want to participate? That would be OK.
We just can't provide runner contact information to you directly beforehand.
If prior contact is required, we could post something to our facebook page and webpage that would ask prospective volunteers to contact you directly. You might want to set-up a separate dedicated address for this.

Brian Kuhnley
Maple Grove Lions
Race Coordinator
bkuhnley@charter.net
763-639-4072 (M)

St Louis Park Color Dash

Sara Geier Mar 31
to Hamid, me

We are Physician Assistant students! St. Louis Park on July 18th sounds great!

We are finalizing the process of getting full acceptance from our review board at our school to contact potential research participants. I have marked this on our calendar and will be in contact when we have the go ahead from the review board!

Thank you!

On Tue, Mar 31, 2015 at 12:52 PM, Hamid Torabpour <hamid@thecolordash5k.com> wrote:

> Let's plan on doing it the July 18th event in St. Louis park. Are you guys nursing students?

APPENDIX C

Signatures

"I certify that the information furnished concerning the procedures to be taken for the protection of human participants is correct. I will seek and obtain prior approval for any substantive modification in the proposal and will report promptly any unexpected or otherwise significant adverse effects in the course of this study."

Signature____ **Date**__________________

Printed Name____

IRB Approval

BETHEL UNIVERSITY

Institutional Review Board
3900 Bethel Drive
PO2322
St. Paul, MN 55112

June 7, 2015

Sara Geier
Bethel University
St. Paul, MN 55112

Re: Project SP-25-15 Cardiovascular Strain in Overweight 5k Runners

Dear Sara,

On June 7, 2015, the Bethel University Institutional Review Board completed the review of your proposed study and approved the above referenced study.

Please note that this approval is limited to the project as described on the most recent Human Subjects Review Form and supplemental materials. Also, please be reminded that it is the responsibility of the investigator(s) to bring to the attention of the IRB any proposed changes in the project or activity plans, and to report to the IRB any unanticipated problems that may affect the welfare of human subjects. Last, the approval is valid until June 6, 2016.

Sincerely,

Peter Jankowski, Ph.D.
Chairperson Bethel University IRB