Does the Advanced BioStructural Correction technique have a physiological effect on endurance trained cyclists?

By

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A thesis prepared by Lukus Klawitter

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Abstract

The Advanced BioStructural Correction (ABC) chiropractic technique has been shown in practice and case studies to bring an individual back into their normal posture and open up their respiratory system enabling them to breathe more efficiently. There have been no other studies to date on the ABC technique on any type of athlete, specifically endurance trained cyclists. **Purpose:** The purpose of the study was to determine whether a series of releases called the ABC chiropractic technique, would have a physiological effect on an endurance cyclist. Specifically, this study investigated whether the ABC technique led to an increase in VE threshold, decrease in breathing frequency (RR), and decrease in heart rate (HR) at sub-max exercise, decrease in heart rate at rest, and increase in VO_2, VE, and tidal volume (TV) at max, and improved forward head tilt and hyperkyphosis if present in cyclists. **Methods:** Eleven male and female collegiate or recreationally training endurance cyclists were randomly assigned to a six week, six days per week, training protocol. The experimental group received ABC releases three times a week for the six week protocol, while the control group received no releases. Pre and post metabolic tests were conducted measuring VE, TV, RR, HR, and VO_2. PostureViewer and goniometer measurements were also taken. **Results:** There were no significant differences in the control group for any of the variables over the six week period. The experimental group showed a significant increase in RR sub-max, and a decrease in HR rest, from pre to post trials. There were no significant differences in the amount of change between the experimental and control groups. In a practical sense, some dependent variables did improve. VE threshold (L/min) trended toward a significant increase in the experimental group. The % of VE threshold increased in the experimental group from pre to post trials. TV at max also trended towards a significant decrease in the experimental group. **Conclusion:** A six week endurance cycling protocol with three sessions a week of ABC technique may not be an effective treatment for showing improvement at the physiological level. There was a non-significant but practical increase in VE threshold, and a significant decrease in HR rest in the experimental group. More studies with a larger sample size are necessary to determine if there are any functional benefits to the ABC technique.

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Chapter 1

Introduction

Injuries in sports take place every day, and studies of sports injuries date back to the early 1900's. There are many forms of sports related injuries and many different procedures that can be done to recover from and prevent the injuries from happening in the first place. One of the last forms of sports treatment to come to life has been sports chiropractic. It wasn't until 1974 when chiropractic licensing laws got passed in every state in the U.S. (Bennett & Peck, 2010). As the knowledge of chiropractic becomes more known to athletes and coaches, the potential to increase the performance of athletes today can improve greatly. Because chiropractic in sports is becoming more acceptable and used in sports today, the benefits are becoming more known to athletes. Miners (2010a) discusses the importance of chiropractic, and how it has the potential to augment an athlete's sport performance, including strength, speed, balance, increased reaction and/or recovery times. More and more athletes are requesting the need for chiropractors for their everyday treatment to get back to their sport as fast as possible, and some chiropractors believe they can enhance an athlete's performance.

Over time as injuries take place, the body compensates or attempts to correct itself, potentially putting more stress on the spine. If the body cannot fix itself, it compensates for the stress, by shifting the pressure to a part of the body that can take it, but the injured component never fully heals (Jutkowitz, 2009). Over time the vertebra shift forward, causing the weight of the body to shift forward into a flexion position closing the airways due to the forward compression (Jutkowitz, 2009). The Advanced BioStructural Correction, "ABC Technique", consists of a process of spinal releases that over time unwind the spine back to its original state (Jutkowitz, 2009). Decreasing forward head tilt in cyclists should enhance breathing function.

Bones go out of place in different directions that the body cannot self-correct on its own, because there are no muscles or groups of muscles pulling in the directions to reposition the bones back to place, thus keeping the spine in its normal position (Jutkowitz, 2009). As injuries on the body take place over the lifespan, the spine adjusts to compensate for the injury (Jutkowitz, 2009). Dr. Jutokowitz (2009) discusses the five axioms which were created to describe the importance of the Advanced BioStructural Correction. Axiom 1 discusses how the body is not a totally self-correcting machine, but can self-correct many of its mechanical and other pathologies (Jutkowitz, 2009). Axiom 3 suggests that to keep bodies healthy or get bodies healthy, one must make sure that the things the body cannot self-correct are corrected by some outside agency (Jutkowitz, 2009). This is where the ABC technique becomes relevant in athletes; there are positions our bodies cannot correct, but with help from the ABC technique, the body can be repositioned to function at its best maximal performance.

Lennon et al. (1994) discusses how spinal posture affects and influences every physiological function in the body; as simple as breathing, to the more complex hormonal function. Spinal pain, headache, mood, blood pressure, pulse, and lung capacity are the most relevant functions affected by posture (Lennon et al., 1994). The process of ABC includes a series of releases to unwind the spine, so the body is able to take in a greater amount of oxygen and increase the efficiency at which an athlete can take in oxygen (Jutkowitz, 2009). This increases the rate the body can take in oxygen, and should increase the time an athlete is able to train at high intensities.

In recent years, professional and recreational cycling has increased in popularity (Muyor et al., 2011). Cyclists may ride with a "round-back" posture, which results in increased spinal flexion to reach the handlebars (Schulz & Gordon, 2010). A cyclist spends multiple hours per day sitting on the bicycle with the anterior trunk bending and the lumbar spine in a kyphotic posture (Muyor et al., 2012). Kyphotic posture is a curve in the thoracic spine where the spine is bowed backwards (Jutkowitz, 2009). The Medical Advisory Board (1999-2004) refers to kyphosis as "hunchback". Sitting on a bicycle for an extended period of time with the trunk flexed leads to an increased intervertebral stress, as well as thoracic and lumbar intra-discal pressure. Slumped sitting has been related to decreased lung capacity, expiratory flow, tidal volume, and breathing frequency, all of which would reduce oxygen consumption, and potentially decrease aerobic performance (Muyor et al., 2011).

The higher maximal oxygen consumption an endurance cyclist can attain, the better chance he or she will be able to train and compete for a longer period of time at sub-maximal effort, or approximately 60-85% of VO_2 max. Maximal oxygen consumption (VO_2 max) is the highest rate of oxygen consumption that a person can attain during exercise; it is commonly expressed in L/min or the relative units of ml/kg/min (Haff & Dumke, 2012). Maximal oxygen consumption (VO_2 max) is currently the most valid measure of aerobic capacity; measured via expiratory gases during a maximal test (Gonzalez-Parra et al., 2013). Thus, measuring of VO_2 max is important in determining aerobic performance, especially in endurance cyclists. If chiropractors are able to manipulate the body by correcting spinal posture, there may be an increase in oxygen consumption in an endurance cyclist, leading to a higher aerobic capacity, and cyclists may be able to train and compete at a higher level of performance.

Gonzalez-Parra et al. (2013) discuss that triathlon performance can be predicted by maximal oxygen uptake (VO_2 max). Hahn and Gore (2001) suggest that events as short as 4,000 meters still rely on a high VO_2 max for optimal performance. However, many variables can effect VO_2 max such as the altitude at which you are living and training. The location of this study in Alamosa, Colorado sits at 7,544 feet above sea level. Six hundred meters of altitude (1,968ft) has been reported to reduce 5-minute cycle ergometer power output by 5.9% (Hahn & Gore, 2001). Thus, altitude will be taken into consideration when measuring VO_2 max in this study. Performance at submaximal exercise is also affected by altitude; acute altitude exposure increases lactate production in the blood and muscle during submaximal exercise (Hahn & Gore, 2001). Also, muscle glycogen is depleted more rapidly during submaximal exercise at acute exposure to altitude (Hahn & Gore, 2001). However, the participants in the study have all been exposed to and have been living at altitude of 7,544 ft. for at least one year. Therefore, acclimatization to altitude and the potential effect from the Advanced BioStructural Correction technique on submaximal exercise at a constant work rate should be improved due to a lower requirement of oxygen at any given workload after acclimatization (Hahn & Gore, 2001).

Throughout the review in the following chapter, the background of sports chiropractic will be discussed in sport and how it became relevant. The role of sports chiropractic today is very important. Athletes are demanding sports chiropractic to recover from injury, and possibly to help enhance sport performance. Maximum oxygen consumption can play an important role in an endurance cyclist living and competing at altitude, when striving to produce maximum performance in their cycling event. Requiring less oxygen at a constant workload during submaximal exercise should increase cycling performance. Also, improving submaximal exercise VO_2, breathing frequency, tidal volume, ventilation (VE) and ventilatory threshold should also improve cycling performance.

The Advanced BioStructural Correction (ABC) technique can have many positive effects on the human body. A series of releases unwinding the spine back to its normal position will help with standing an athlete back up into his normal posture, to open up his/her rib cage to allow deeper breaths and greater oxygen intake and absorption to the body. This should lead to a greater maximal oxygen consumption and enhanced sport performance. There have been no other studies to date that have researched the effects of the ABC releases on VO_2, VE, breathing frequency and heart rate at sub-max exercise, ventilatory threshold, or tidal volume and VO_2 at max. Also, ABC manipulations have not previously been used to correct forward head tilt and kyphosis in cyclists.

Purpose of the Study

The purpose of the study was to determine whether a series of releases called the Advanced BioStructural Correction (ABC) chiropractic technique, would have a physiological effect on an endurance cyclist. Specifically, this study investigated whether the ABC technique led to an increase in VE threshold, decrease in breathing frequency, and decrease in heart rate at sub-maximal exercise, decrease in heart rate at rest, and increase in VO_2, VE, and tidal volume at maximal exercise, and improve forward head tilt and hyperkyphosis, if present, in cyclists.

Research Questions

Q1: Does the Advanced BioStructural Correction (ABC) technique have a physiological effect on endurance cyclists, specifically increasing VO_2, VE, and tidal volume at max, with releases performed three days a week over a span of six weeks?

Q2: Does the Advanced BioStructural Correction (ABC) have a physiological effect in endurance cyclists, specifically, decreasing breathing frequency, heart rate, and increasing ventilatory threshold during sub-max exercise and heart rate at rest, with releases performed three days a week over a span of six weeks?

Q3: Would the Advanced BioStructural Correction (ABC) technique decrease forward head tilt and hyperkyphosis, if present, with releases performed three days a week over a span of six weeks?

Delimitations

The study had a few delimitations. First, due to the time of year, the weather conditions in Alamosa, Colorado were harsh, cold conditions with snow and ice. The training protocol for the participants took place on an indoor hydraulic cycle trainer to best mimic natural riding at an altitude of 7,544ft. Conducting the training protocol on the outdoor roads could have a different effect on the participants while performing the training protocol, due to weather conditions, traffic, and change in grade. The study was delimited to men and women endurance cyclists training 10-20 hours per week in the San Luis Valley. The subjects were a mixture of collegiate cyclists and recreational cyclists who were not as heavily trained. The study was also delimited to the training protocol created by a collegiate level cycling coach, Marshal Hartley, with a professional racing history. The ABC technique was the only chiropractic release being used for the study. Lastly, the measurements including the VO_2, VE, breathing frequency, and heart rate at sub-max exercise, ventilatory threshold, and tidal volume, VE and VO_2 at max, and forward head tilt, were the focus of the study.

Limitations

Throughout the six week, four to six days a week training protocol, the participants were encouraged to stay on top of their training and perform each workout at the best of their ability. The participants primarily did all of their training individually. However, the individual effort relied on the individuals themselves and their motivation to perform each workout. Second, having everyone training at the same time could influence the effort given by each participant. Third, supervision of training or lack thereof, could have influenced the effort given by each participant. Fourth, the encouragement given to the collegiate cyclists from the cycling team coach could have influenced their motivation compared to the cyclists not training as part of the team. Lastly, having only collegiate level cyclists who are more heavily trained could have had the potential to show a better result on whether the releases influenced the three research questions rather than the training protocol.

Assumptions

It was assumed that the participants involved in the study would respond well to the ABC releases due to the amount of time spent hunched over their handle bars in an unnatural body position. It was assumed the ABC technique is a credible chiropractic technique and would show a decrease in VO_2 at submaximal exercise, an increase in VE threshold, a decrease in breathing frequency, a lower resting heart rate and lower submaximal heart rate, an increase in VO_2 and tidal volume at max, and improve forward head tilt or hyperkyphotic spine in endurance trained cyclists. The population utilized in the protocol involved a group of collegiate cyclists and recreational cyclists who spend a large amount of their daily exercise routines on a bike; so it was assumed that they could benefit from this technique and its proposed effects. It was also assumed that the participants would utilize their training protocol to its fullest potential and try to maximize their fitness level. It was assumed that the participants who receive the ABC releases would perform better on their post protocol test compared to the participants who did not receive ABC releases.

Definition of Terms

ABC- Advanced BioStructural Correction- "A treatment protocol that corrects the out of place bones that the body cannot self-correct, allowing the body to self-correct the ones it can by "unwinding" the compensations until the body runs into another structure that it cannot self-correct. As this process continues and posture improves, patients become more functional because the nerves are being pulled on less and less, and they are able to become more and more active and healthy as the unwinding process unfolds" (Jutkowitz, 2009).

ABC Technique- A stretch and release to the meninges, ABC does not do rotary moves to the cervical or lumbar spine and there is no risk of vertebral artery dissection. Cleavage moves attempts to adjust a vertebrae back into alignment with two other vertebrae (Jutkowitz, 2009).

There are five axioms that form the basis of the ABC technique (Jutkowitz, 2009):

Axiom- "A self-evident or universally recognized truth that is a basic principle" (Jutkowitz, 2009).

Axiom 1-"The body is not a totally self-correcting thing or machine but can self-correct many of its mechanical and other pathologies. Self-evident by observation – things go wrong with bodies that they do self-correct and they do not self-correct. Therefore, bodies are partially self-correcting but not totally self-correcting" (Jutkowitz, 2009).

Axiom 2- "Health of a body is defined as a body working optimally on a mechanical basis even the chemistry comes down to mechanics if you look at it from a small enough viewpoint, shapes of molecules and atoms fitting together" (Jutkowitz, 2009).

Axiom 3- "To keep bodies healthy or get bodies healthy one must make sure that the things the body cannot self-correct are corrected by some outsides agency" (Jutkowitz, 2009).

Axiom 4- "Regarding what the body cannot self-correct: On the grossest scale, what the body cannot self-correct are bones out of optimal mechanical position in a direction the body has no muscle or combination of muscles that can pull in the direction needed to retrieve and replace the bone into its position of optimal mechanical advantage for the body" (Jutkowitz, 2009).

Axiom 5- "Regarding the treatment of a body: Doctors should only correct things that the body cannot self-correct. Example of bone out of place that the body cannot self-correct because there are no muscles pulling in the direction needed" (Jutkowitz, 2009).

Breathing Frequency (f)- The number of breaths taken per minute of gas ventilated (Powers & Howley, 2012).

Chiropractic- Is a popular complementary and alternative therapy defined as: the diagnosis, treatment and prevention of mechanical disorders of the musculoskeletal system and the effects of these disorders on the function of the nervous system and general health. There is an emphasis on the manual treatments, including spinal manipulation or adjustment (Ernst & Posadzki, 2012).

Forward Head Tilt- When the ear is located in front of the shoulder, rather than being directly over it (Jutkowitz, 2009).

Hyperkyphotic Posture- "Large and locked curve forward in the spine resulting in bent forward posture" (Jutkowitz, 2009).

Maximal Oxygen Consumption (VO_2 max)-"The greatest rate of oxygen uptake by the body measured during severe dynamic exercise and measured in L/min" (Powers & Howley, 2012).

Meninges- "The three membranes that surround the brain and spinal cord. These three membranes are the Dura mater, Arachnoid, and Pia matter. The function of the meninges was said to be protection of the central nervous system however they has been demonstrated to be an elastic stabilizer of the spinal column" (Jutkowitz, 2009).

Meningeal Release- A stretch to pull meningeal adhesions apart (Jutkowitz, 2009).

Primary Biomechanical Pathology (PBP)- "A structure that normally acts to lever the body into a normal upright posture which is out of optimal mechanical position and no longer supports the body via that leverage effect and that the body cannot retrieve or fully reposition on its own" (Jutkowitz, 2009).

Rating of Perceived Exertion (RPE)- Used to indicate subjective effort during exercise, and to provide a quantitative way to track progress throughout an exercise test or training session (Powers & Howley, 2012).

Sub-max Exercise- Sub-max exercise for this study was classified as % of ventilatory threshold (VT) because it is below 85% maximal effort (Powers & Howley, 2012).

Tidal Volume (TV)- Volume of air inhaled or exhaled in a single breath (L/min) (Powers & Howley, 2012).

Unwinding- "This is how the person improves. Bodies' mechanical pathologies are layered sets of twists in three dimensions. The layers consist of PBP=compensation patterns, one on top of another. You cannot get a person well by pushing things into place because the fixed counterbalancing patterns will not allow it. What you do as a practitioner is improve the body's mechanics by correcting PBP as they present themselves" (Jutkowitz, 2009).

Ventilation (VE)-The movement of air into or out of the lungs, or external respiration, measured in L/min (Powers & Howley, 2012).

Chapter 2

Review of Literature

Chiropractic Role in Sports: The Beginning

Since the beginning of chiropractic, well over a century ago, chiropractic has played an important role with athletes from recreational sports to international competition (Uchacz, 2010). Parker (2009) proposed that the earliest chiropractic treatment of a professional athlete was most likely Hall-of-Fame pitcher Mordecai "Three-Finger" Brown in 1911. Mr. Brown suffered with muscular rheumatism in his shoulder (Bennett & Peck 2010). Prior to chiropractic treatment Mr. Brown had massage done from experts in Chicago, but after spinal adjustments Mr. Brown was cured. Chiropractors have worked hard to get their foot in the door in the treatment of athletes at high level competitions. Many people believed chiropractic work did not belong at the same level as orthopedics, physicians, and therapists. Physicians thought of the western science chiropractic as quackery (Day, 2010).

The rise of chiropractic in elite level athletes in the Olympic Games began in the late 1970's (Day, 2010). Dr. Leroy Perry had been called many nicknames by the athletes he treated, including: "a magic doctor," "Magic Fingers," and "The Good Hands Doctor". The summer Olympic Games in 1976 were held in Montreal, Canada, where Dr. Leroy Perry was the chiropractor for Team Antigua. Previous to Montreal, Dr. Perry was the team chiropractor for Panama in the Pan-American Games in 1975. The word of Dr. Perry got out and during the 1980 Olympic Games in Moscow, Olympic committees of Japan, Jamaica, Cuba, Trinidad, and Venezuela wanted Dr. Perry to be their team chiropractor. Dr. Perry was rejected every year by the U.S. Olympic Committee due to the number of orthodox or everyday physicians on the Sports Medicine Council (Day, 2010).

Eventually the demands for the work of chiropractors at the international level rose. Many athletes Dr. Perry treated won gold, and some believed they would not have won without the aid of chiropractic and "The Good Hands Doctor" (Day, 2010). "The efforts of Dr. Perry and the chiropractors who followed after him have played an integral part in the success of America's Olympic athletes, helping the U.S. win more than 750 medals since 1980, 314 of them gold" (Day, 2010). The demand for chiropractic continued to grow and the first year a chiropractor was "officially" on the Summer Olympic Games staff for the U.S. was in 1984, but not until 2002 for the Winter Olympics (Day, 2010).

In the Professional sports world, Dr. Harry Williams, a Canadian chiropractor, worked in the 1950's with the Toronto Maple Leafs professional hockey team, providing years of professional service (Uchacz, 2010). Dr. Williams gained a renowned reputation for enhancing athlete performance and reducing time loss from injury (Uchacz, 2010). Since 1900, interest in both chiropractic and professional American sports has grown exponentially. American professional sports have become a billion dollar industry and are a major facet in the American lifestyle (Bennett & Peck, 2010). Because the salary structure and income in professional sports has risen so greatly, Parker (2009) states it is only logical, considering the highly competitive level of professional athletics, that its participants would seek treatment for any injury which would impact their ability to maintain a livelihood.

The first professional sport to have history of use of chiropractors was baseball. Professional sports in the United States until the 1920's consisted of baseball and prizefighting (Parker, 2009). In 1911 Mr. Brown, nicknamed "champion" of baseball, was dealing with muscular rheumatism in his shoulder and found that work with a chiropractor alleviated all pain when no other treatment was working (Bennett & Peck, 2010). Baseball's wear and tear have led professional players to now look at chiropractic as another method of therapy, as well as treatment, that can keep them healthy and performing on the field (Bennett & Peck, 2010). Bennett and Peck (2010) also state famous baseball players Babe Ruth, Joe DiMaggio, and Lou Gehrig all sought help from chiropractic. Over the past few decades, other sports such as the National Basketball Association (NBA) and National Football League (NFL) also began utilizing chiropractic care but not at the early onset as it did in baseball (Bennett & Peck, 2010). The reasoning may be because the injuries taking place in football and basketball are more contact injuries, while baseball is more wear and tear, leading to a longer time for chiropractic care to catch on in the contact injury sports (Miners, 2010b). This may be due to the belief that contact injuries needed immediate care from physicians; this was before the athletes and owners knew the benefits of chiropractic (Miners, 2010b). Chiropractic became relevant in the NFL when players sought out extra treatment to extend their career, and for faster rehabilitation between games in their long 16-week season (Day, 2010).

Chiropractic Role in Sports: Today

In today's world, it has become normal for nearly all professional sports teams to include the use of chiropractic. Chiropractic care can be used in healing and alleviating pain that could otherwise sideline an athlete (Bennett and Peck, 2010). Only a few studies report chiropractic utilization rates among athletes (Kazemi & Shearer, 2008). The health of athletes is important in many ways. Attendance of fans at sporting events is crucial when trying to increase income for a professional sports organization. The athlete is not the only one concerned about his/her overall health. New York Yankee baseball player Alex Rodriquez's contract calls for $252 million in salary over ten years (Parker, 2009). According to the team chiropractor, Spencer Baron, DC, "there has been a shift in the consciousness of the professional athlete, we are in a place in society that if a multimillion-dollar athlete does not get chiropractic care, he's missing an integral part of fine tuning before an event or rehab" (Parker, 2009). In the NFL 31% of teams have a chiropractor on staff and an additional 12% of athletic trainers refer players to chiropractors (Stump and Redwood, 2002).

Chiropractic now plays an important role in international competition such as the Olympics. A two-week intense process takes place in Colorado Springs, Colorado where the highest rated chiropractors go through an internship to be chosen as members of the United States medical staff of either the Pan Am Games or the Olympics (Day, 2010). The Canadian International team showed similar inclusion of chiropractic on their medical staff. Uchacz (2010) states following the 2010 Winter Olympics, "Chiropractic has now joined with equal footing, all other therapy services (physical therapy, athletic therapy, massage therapy, sport acupuncture) in the delivery of health care".

Vigorous muscular efforts, such as those made in athletic sports, often put severe strains on the spine, as ninety-nine muscles are attached to it (Parker, 2009). "The spine is frequently wrenched, twisted, jerked and jarred, as in driving in golf and polo. The hard movements of tennis or the violent throwing and swinging in baseball; the twisting and swinging in bowling; the jarring, tackling, falling and violent kicking in football; the jarring, twisting and possible falls in horseback riding; a jolt on the jaw in boxing; the straining pulls of hard rowing; the dives and other vigorous moves in swimming; and the other "stunts" in the gymnasium like tumbles and movements performed on the high beams" (Parker, 2009). The body takes a major toll with the everyday stress put on it during the different sports an athlete plays.

In a 2008 study, Kazemi and Shearer investigated two different groups of Taekwondo athletes. Group A included 28 individual male and female Taekwondo athletes at the national level with an age range 16 to 29 years. Group B included 16 male and female Canadian National Taekwondo Team athletes with an equal gender distribution (Kazemi & Shearer, 2008). A twenty one item questionnaire was handed out to the participants. The questionnaire's main goal was to determine which form of health care the Taekwondo athletes used following an injury. Kazemi and Shearer (2008) found 10.7% of group A sought out chiropractic care, and 18% of group B received chiropractic care following their injuries from Taekwondo training and competitions. Taekwondo is an impact sport where the body takes hits while stabilizing and balancing itself against the other opponent. Zemper and Pieter (1989) researched injury rates in taekwondo athletes in the 1988 U.S. Olympic team trials. The researchers found contusions were by far the most common form of injury from body contact, however, musculoskeletal injuries also took place. Kazemi and Shearer (2008) researched how chiropractic care can bring an athlete back from injury and prevent more injuries from taking place. Kazemi and Shearer (2008) stated the treatment of musculoskeletal injuries is a primary form of treatment of sports chiropractic. The researchers concluded that there is a lack of information on chiropractic use in sports, and more studies should be done to determine chiropractic utilization in sports, such as the ABC technique.

Use of Chiropractic in sport

Ernst and Posadzki (2012) defined a sports injury as any physical or medical condition that prevents an individual from participating in regular sporting activities. Since injuries in sport are quite common, it only makes sense to utilize all options possible for returning an athlete back to competition. Miners (2010b) discussed the perceived role of chiropractors in sports health care, and stated that "chiropractic adjustment/manipulation of the spine and extremities comprise the greatest part of most sports chiropractic practices". Depending on the sport, there are different demands on the posture required for the sport, which puts different stresses on the spine and lower back (Muyor et al., 2011). Cycling is one of the most popular recreational sports throughout the world. The incidence of low back pain in cyclists ranges from 32-60% (Van Hoof, Volkaerts, O'Sullivan, Verschueren, & Dankaerts, 2011). Sport chiropractors give consideration to both the hard and soft connective tissues related to the spine; including the muscles, tendons, ligament, and fascia (Pollard et al., 2007). To treat the different hard and soft connective tissues, various manual approaches are utilized including: high velocity low amplitude techniques, massage, stretching techniques, rehabilitation and therapeutic exercises, proprioception exercises, motor pattern correction and sport specific rehabilitation, and non-local biomechanical improvement to improve the kinematic and kinetic chain function (Pollard et al., 2007).

Miners (2010b) conducted a survey on opinions regarding chiropractic care and athletes, and also opinions regarding what constitutes a chiropractic treatment. Current registered Fellows of the College of Chiropractic Sports Sciences received, through mail, a questionnaire with a cover letter describing the investigation's concept and purpose of the study. Thirty-seven of the 54 Fellows who received the questionnaire completed the study. Miners (2010b) also stated for the purpose of the study an athlete was defined as one who is trained to compete in sport or games requiring physical strength, agility, or stamina. All of the participants felt that chiropractic care can be very effective for athletes with musculoskeletal type injuries, meaning maintenance chiropractic care can reduce sport related injuries. Eighty-one percent agreed chiropractic care is important for all athletes, 73% agreed maintenance chiropractic care can reduce sport related injuries, and 81% also agreed chiropractic consultation when an athlete's performance is suffering is also beneficial (Miners, 2010b). Opinions regarding what constitutes a chiropractic treatment included: 100% spinal joint manipulation/mobilization, 100% extremity joint manipulation/mobilization, 100% specific soft tissue therapy, 59% acupuncture, 89% nutritional advice or prescription, 97% exercise prescription, 97% rehab prescription, 86% physical modalities, 97% life counseling, and 100% additional care, health professional referral. The percentages indicate how many of the chiropractors questioned stated above, believed if it is a chiropractic treatment or not (Miners, 2010b).

With all the different options given by sports chiropractors the approach in one on one consultation is very thorough. Pollard et al. (2007) discussed how consultations tend to be longer with athletes compared to the average person. The chiropractors ask questions based on the sports injury and other specific needs that should be taken into consideration. Miners (2010a) also stated sports chiropractors follow a pre-participation examination which corrects all deficiencies that are found in the examination, which can help lead to an improvement in confidence of the athlete. With the role chiropractors play, it is hard to imagine a chiropractor not thinking "if I had the chance to adjust that player just once, he/she would be right back on the field" (Miners, 2010a).

Chiropractic and Sports Enhancement

As chiropractic in sports is gaining more attention, questions arise whether sports chiropractic can improve sport performance. Elite level athletes constantly seek methods to enhance performance (Shrier, Macdonald, &Uchacz, 2006). Shrier et al. (2006) investigated 19 participants involved in sprint sports testing maximum jump height and flying 40-meter sprint time. The participants performed a fifteen minute warm-up then tested maximum jump height and flying 40-meter sprint time. Following the tests, a sport chiropractor evaluated each subject and performed chiropractic manipulations. Following the manipulations the participants rested for an hour and again warmed up for fifteen minutes and performed the same tests. The protocol was again repeated 48 hours later (Shrier et al., 2006). The researchers found improvements in maximum jump height and flying 40-meter sprint time following the test, however, results were not statistically significant because the improvements were not great enough (Shrier et al., 2006).

Bennett and Peck (2010) stated sport owners are requiring all forms of treatment options, such as chiropractic, to assist sports injuries because of the millions of dollars they are paying the players each year. Sandell, Palmgren, and Bjorndahl (2008) stated athletes seek chiropractic care in an effort to get a performance advantage, such as an ergogenic effect. Miners (2010a) stated the role of a chiropractor when treating athletes is to improve the athlete's performance in sport by using spinal manipulation therapy. Jarosz and Ellis (2010) discussed that chiropractic spinal manipulative therapy performed with stretched muscles shows an improvement of golfers' full range of motion swing performance. Miners (2010a) goes on to discuss how the correction of the athlete's spine and all extremity joints restores neurology and biomechanics of the athlete. With correction of all biomechanical faults, this will reduce pain, decrease severity of the injury, and possibly enhance athletic performance. Restoring biomechanical faults in endurance trained cyclists should decrease VO_2 at sub-max exercise, increase VE threshold, decrease breathing frequency, decrease heart rate at rest and sub-max exercise, and increase maximal oxygen consumption and tidal volume at max, as well as correcting a hyperkyphotic spine.

To date there are not any investigations that have been published in any peer reviewed literature to fully back the idea that treatment provided by chiropractors in sport can improve or enhance sport performance (Miners, 2010b). However, when reviewing chiropractic literature it is not uncommon to come across information that states they believe their adjustments or manipulation enhanced the athletic performance of the athlete (Miners, 2010b). Pollard et al. (2007) stated that the philosophy of sports chiropractic by treatment, rehabilitation, and prevention of sports related injuries, can lead to enhanced sports performance. Miners (2010a) discussed how the chiropractor of the University of Tennessee Track and Field team, Dr. Perry, states that the majority of athletes who are adjusted right before they compete generally set personal records, rather than not being adjusted and personal records were not being set. Hall of Fame wide receiver of the San Francisco 49ers Jerry Rice preaches, "chiropractic care has been instrumental in my life, both on and off the field, and I am excited to share this with the American public. I have been blessed with a long and healthy career as a professional athlete, and as I move forward into the next stage of my life, chiropractic care will continue to be an important part of my game plan" (Bennett & Peck, 2010).

A case study conducted by Jarosz and Ellis (2010) researched a 50-year old male elite race walker, who at the time was preparing for the World Masters Athletic Championships. His current personal bests included a state record in the 15k distance and a national record in the 10k distance (Jarosz & Ellis, 2010). The race walker reported lower extremity pain and low back stiffness. After physical examination, the right pelvis was higher than the left side while standing, which led to restriction in range of motion in the sacro-iliac joint and psoas muscle (Jarosz & Ellis, 2010). Through chiropractic treatment using the spinal manipulative therapy, the race walker reported post treatment feeling back to normal with no restriction in range of motion and no pain in the psoas muscle. This led to an improvement of two and a half minutes in his 15k time and he finished with two medals at the World Masters Championships (Jarosz & Ellis, 2010). Jarosz and Ellis (2010), through this research, showed how chiropractic manipulations can enhance sport performance.

High-Velocity Low-Amplitude Treatment

High-velocity, Low-amplitude (HVLA) treatment is a high-velocity, low-amplitude manipulation on the spine or lower extremity joint, depending on the assessment and injury (Shrier et al., 2006). Basic science has suggested HVLA may improve performance because it enhances motor neurons through a full range of motion, and is effective for short-term pain relief (Shrier et al., 2006). Shrier et al. (2006) stated, "Basic science studies suggest that HVLA may improve performance because it facilitates motor neuron pool excitability for 20-60 seconds, which produces a significant increase in surface electromyographically measured on erector spinae during isometric maximum voluntary contraction when performed on the joints of the lumbar spine." The ability to maximize isometric voluntary contraction in muscles will increase sport performance. Shrier et al. (2006) found elite athletes who participate in sprint related sports often perform better in both vertical jump height and flying 40-meter sprint time following HVLA treatment, compared to those who did not receive the HVLA treatment. The authors proposed this improved performance was due to the increase in voluntary muscle isometric contraction. Both vertical jump height and flying 40-meter sprint are used in professional sports to assess player skills.

HVLA might be one of the only chiropractic manipulations researched on enhancing sport performance. Therefore, the current study investigated the ABC technique of using stretch and release of the spine and its possible benefits, and if it could lead to sport enhancement in endurance cyclists, thereby adding to the research on chiropractic use and enhancing sport performance.

A study researched by Sandell et al. (2008) investigated HVLA treatment on hip joint extensibility and running velocity. The researchers divided seventeen male runners, aged seventeen to twenty years old, into two groups: a control group and a treatment group. Prior to the protocol hip extensibility was measured in both groups. The treatment group underwent a series of lower spine and hip HVLA treatments, and the researchers concluded that following treatment, hip extension range of motion increased in the treatment group. Sandell et al. (2008) also concluded there was a 65-millisecond improvement in 30-meter sprint performance in the treatment group compared to the control group. HVLA is one of the only chiropractic treatments currently used to increase sports performance (Miners, 2010b). Therefore, more research should be done to determine whether other chiropractic treatments can enhance sport performance. Like HVLA, the ABC technique is a different approach to chiropractic and has the potential to enhance sport performance by using release and stretching of the meninges of the spine.

Chiropractic and Sports Injury Treatment and Prevention

Ernst and Posadzki (2012) conducted a study on chiropractic care on the prevention of sports injuries. The researchers investigated a sports chiropractic intervention on hamstring and lower limb injuries in the contact sport of Australian football. The researchers found no difference in hamstring and lower limb injuries in the Australian footballers when chiropractic treatment was done. However, the prevalence of lower back injuries was less following play after chiropractic manipulations were done (Ernst & Posadzki, 2012). Ernst and Posadzki (2012) also researched the treatment of sub-acute and chronic grade 1 and grade 2 ankle inversion sprains. The treatment on the ankle sprains included ankle adjustments, which led to greater range of motion and ankle function in the athletes. The type of sport the athletes took place in were not discussed. Another contact sport, ice hockey, results in many contact injuries consisting of muscle, joint, and tendon injuries (Julian, Hoskins, & Vitiello, 2010). Chiropractic treatment was initiated at the onset of acute injuries, where four or less treatments were effectively used to return the player to the ice (Julian et al., 2010). More research needs to be done to determine if chiropractic manipulations can treat and prevent injuries in non-contact sports such as cycling. There has been no research to date on non-contact sport injuries, such as cycling, and chiropractic care.

Posture in Cyclists

Cycling is one of the most popular recreational sports throughout the world. The occurrence of low back pain among cyclists ranges from 32-60% (Van Hoof et al., 2011). Alterations in spinal curvatures have the potential to influence the development of low back pain, which is a common overuse injury in cyclists (Muyor et al., 2011). Cyclists may ride with either a "round-back posture" or "flat-back posture" in order to reach the handle bars while riding; these postures result in a degree of pelvic and spinal flexion (Schulz & Gordon, 2010). Where the hands are placed on the handle bars has a direct influence on spinal flexion (Schulz and Gordon, 2010). Schulz and Gordon (2010) state the best all-around riding position is placing hands on the brake levers for easy access to brakes. This is a more aerodynamic position compared to hands on top of the bars. Having the hands on top of the handle bars is the most comfortable riding position, but this position creates a greater wind resistance. Lastly, the drop position, where the hands are placed on the lowest points on the handle bars reduces wind resistance but increases lumbar lordosis. Burnett, Cornelius, Dankaerts, and Sullivan (2004) stated the aim of a competitive cyclist is to produce maximal power at the pedals to maximize velocity at a given power to move the bike forward, while reducing their aerodynamic drag. A cyclist must bend forward at the hips while at the same time flexing the spine, to an extent in which pelvic and spinal flexion contributes towards reaching the handle bars in a "round-back" or "low-back" posture (Burnett et al., 2004). This increases the tendency of increased flexion in the lumbar spine.

In an article reviewed by the Medical Advisory Board (1999-2004), the authors define hyperkyphosis as, "an excessive curvature of the thoracic spine, also referred to as hunchback. A kyphosis angle over 50 degrees is the standard for hyperkyphosis." Muyor, Lopez-Minarro, Casimiro, and Alacid (2012) state a kyphotic spinal curvature of 20-45 degrees is "neutral" but still can have negative effects, such as compression on airways which will decrease respiratory rate, and decrease lumbar range of motion. Muyor et al. (2012) measured spinal curvatures in Masters 30 level cyclists and Masters 40 level cyclists. Masters 30 and 40 are two age group divisions for Masters cycling. Masters 30 consists of cyclists in the age range of 30-39 years, and Masters 40 consists of cyclists in the age range of 40-49 years. From the time spent on the bike over many years, the researchers wanted to learn if the increased spinal flexion from riding causes hyperkyphosis in sitting and standing posture in the participants. The participants were required to have four years of riding experience riding 2-4 hours per day, 3-5 days per week (Muyor et al., 2012). The researchers discovered a high percentage of thoracic kyphosis in Masters 30, 46.87 ± 8.71 degrees, and in Masters 40, 49.31 ± 10.01 degrees, compared to normal spinal curvatures. Cyclists spend a lot of time, several hours per day on a bicycle with a kyphotic posture on the lumbar spine, and this posture may result in adaptation in spinal curvatures (Muyor et al. 2012). Kyphosis can become worse over time and can lead to hyperkyphosis. Muyor et al. (2012) also stated the Master 40 cyclists who had an average of six years of riding experience, more than Masters 30 who had an average of 4 years, showed a higher percent of kyphosis, mainly because they have spent more time on the bicycle. Lennon et al. (1994) stated the most significant influences posture has on the body are upon respiration and oxygenation. In order for cyclists to perform at their best, they need to have an optimal rate of respiration and oxygen consumption. With limited oxygen consumption and respiration, the body will not be able to send needed oxygen to working muscles while the cyclist is riding.

Jutkowiz (2009) also defines kyphosis as a curve in the spine where the spine is bowed backward (see Figure 1); it can be normal or hyper- (more) or hypo- (less) kyphosis. Kado, Huang, Karlamangla, Barrett-Connor, and Greendale (2004) discussed that hyperkyphosis is associated with restrictive pulmonary disease and poor physical function due to the hunched over posture, and restriction of airways. The most important factor that contributes to airway

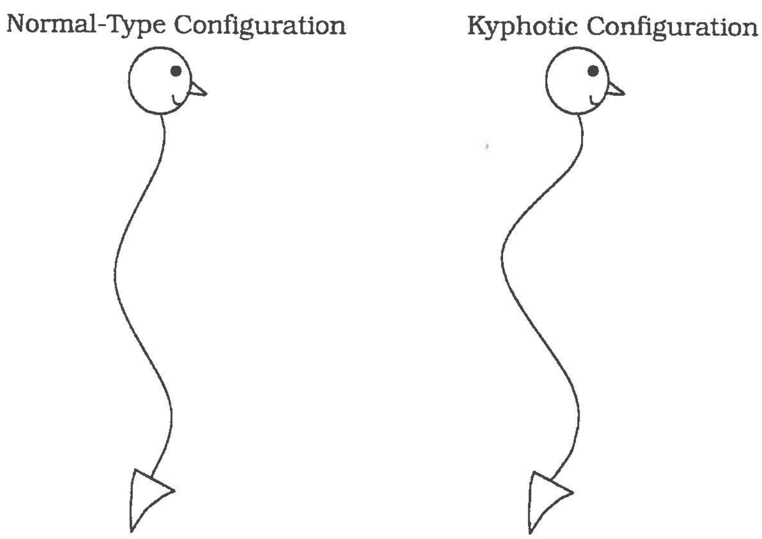

Figure 1. Normal-Type Configuration and Kyphotic Configuration (Jutkowtiz, 2009).

restriction is the diameter of the airway (Powers & Howley, 2012). When the diameter of the airway is reduced, air flow is reduced; then resistance to the flow is increased substantially, which can lead to restrictive pulmonary disease or exercise-induced asthma (Powers & Howley, 2012). This suggests that hyperkyphosis might be associated with other adverse health outcomes. Poor physical function would negatively affect cycling performance. The researchers determined the association between hyperkyphotic posture and rate of mortality and cause-specific mortality in older persons. The researchers found hyperkyphotic posture had a 1.44 greater rate of mortality due to atherosclerosis that develops over time from hyperkyphotic posture (Kado et al., 2004). With the high incidence of kyphosis in cyclists described by Muyor et al. (2012), it is necessary to correct the imbalances in the spine in order to increase performance and better health in general. Postural corrections should be incorporated into the training activities of cyclists to improve spinal posture (Muyor et al., 2012). Figure 2, below, demonstrates the influence kyperkyphosis has on the restriction of airways, heart, and blood vessel compression. ABC technique uses releases hypothesized to correct posture. This will be the first study done on cyclists to determine if hyperkyphotic posture can be corrected.

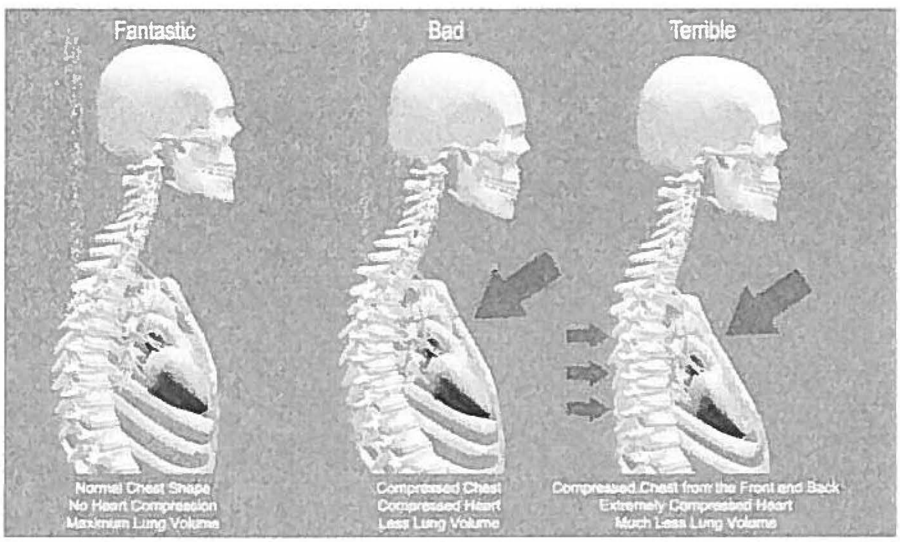

Figure 2. Bad and terrible kyphotic posture and how compression of the heart and lungs affects lung volume (Aberlechiropractic.com, 2014)

Advanced BioStructural Correction (ABC)

The Advanced BioStructural Correction (ABC) is an approach to structural health care developed by Dr. Jesse Jutkowitz. Pascoe (2009) discussed how Dr. Jutkowitz discovered how some bones go out of place in a certain direction where there are not any muscles to pull them back into place. The body tries to correct the out of place bones and compensates, which creates new misalignments and can cause issues such as arthritis or independent vertebral fractures (Kado, Lui, Ensrud, Fink, Karlamangla, & Cummings, 2009). As time goes on, more bones can misalign, causing even further compensations, and a complex layering of misalignments and compensations causing severe symptoms to occur one after another (Pascoe, 2009). Dr. Jutkowitz describes the first step is finding the Primary Biomechanical Pathology (PBP), which is the pathology and compensation pattern the body has twisted into to counterbalance the effects of the PBP (Jutokowitz, 2009). An example of a PBP would be the forward head tilt or a kyphotic posture. The chiropractor would perform a first rib maneuver which takes the stretch off the spinal cord and nerve roots so they are not dragged forward (Jutkowitz, 2009). Taking this pressure off the spinal cord and nerve roots could increase breathing efficiency because it will open up the airways from the better posture, which could increase oxygen consumption and as a result, improved cycling performance.

In a case study conducted by Jutkowitz (2009), a patient came in with a pain in the knee with a "sticking" feeling. The chiropractor followed the list of steps for the ABC technique manipulating the PBP. After the initial treatment the patient returned saying the pain in the knee has lessened but was feeling different pain on the other side of his body. That is the process of unwinding. First the imbalance is corrected, but this often results in pain shifted to another position, as the body tries to correct the imbalance, as the weight is shifting from the first treatment correction. After a series of visits, 12-25, the number of which depends on the individual, the body unwinds and eventually ends up in its normal position. Jutkowitz (2009) quotes "the point is the process". Bones in the vertebrae hurt and are tender only if twisted, and bones are twisted as part of a compensation pattern; bones can and do go out of place in directions the body cannot self-correct because it has no muscle pulling in the direction needed. When you can test which direction the PBP is, by pushing on it and noting the response, this means you have to observe the entire body and note the overall response, not just the local response (Jutkowitz, 2009).

Another case study presented by Jutkowitz (2009), stated how it is "essential" to correct people with hyperkyphosis because people with hyperkyphosis have a greater risk of developing heart disease and dying at a greater rate than people without hyperkyphosis, most likely from years of having poor posture. Kado et al. (2009) conducted an on-going study examining mortality rate on 610 women aged 67-93 years old who presented with hyperkyphotic posture. The researchers concluded that hyperkyphosis is strongly related with independent vertebral fractures, which are often undetected. Kado et al. (2009) stated hyperkyphosis is a risk factor for osteoporosis, which results in independent vertebral fractures and increased mortality in older women. Kado et al. (2009) also stated that those with vertebral fractures were likely to die from pulmonary causes because the vertebral fracture induced changes on the spine could also affect respiratory function (see Figure 2).

Hyperkyphosis, also known as the "dowager's hump" (Kado et al. 2004), or "hunchback" (Medical Advisory Board 1999-2004), is commonly present with restrictive pulmonary disease and poor physical function, and potentially other adverse health outcomes (Kado et al., 2004). Lennon et al. (1994) stated the most significant influences posture has on the body are upon respiration and oxygenation. Correcting hyperkyphotic posture in cyclists or correcting any imbalances in cyclists, using the ABC technique, may lead to enhanced performance because it may offset the negative influence hyperkyphotic posture has on respiration rate and oxygen consumption. The case study patient came in with the upper body curving dramatically forward significantly around the shoulders, with a caved in chest, which had a large effect on her breathing because the hunched posture restricted her ability to breathe (Jutkowitz, 2009). After the first initial treatment releasing the meninges at the point of the kyphosis, the patient already stated the relief she felt; the chiropractor saw her head come up, and the patient commented on how her breathing felt more efficient and easier (Jutkowitz, 2009). Improving respiration rate and oxygen consumption will lead to an increase in tidal volume, increase ventilatory threshold, decrease in breathing frequency, decrease in heart rate at sub-max exercise, and decrease in heart rate at rest (Powers & Howley, 2012). The body will require less oxygen during submaximal exercise due to the increase in tidal volume and decrease in breathing frequency which means deeper more efficient breathing (Powers & Howley, 2012). Therefore, improving the rate oxygen can be consumed by correcting the compression on the chest, lungs, and heart in endurance cyclists by using the ABC technique, should improve performance.

Another case study presented by Jutkowitz (2009), is a great example on how the body can stand back up after treating a severe hyperkyphotic spine. The patient presented himself with severe hyperkyphosis, and could hardly sleep at night without holding himself up with pillows underneath him; he had severe sleep apnea from his hyperkyphosis (Jutkowitz, 2009). After one treatment, the patient noticed he was talking to people at a different angle, and observers were shocked by the height he gained in just the first treatment (Jutkowitz, 2009). The hyperkyphosis curvature causes the body to lean forward and present the ear in front of the shoulders. The patient was shocked from the height he gained because the ABC technique allowed his spine to release into its normal curvature allowing the head to come back up over the shoulders (Jutkowitz, 2009). Figure 3 demonstrates a before and after picture of a male and female who received their first ABC treatment. The male and female both showed the ear lining up more over the shoulder and a slight increase in height from before the treatment took place to after.

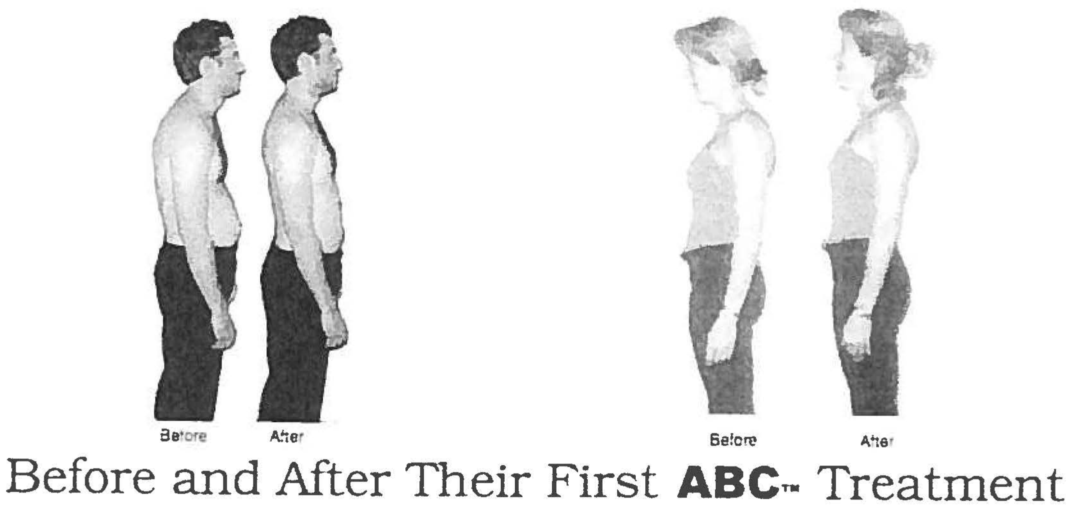

Figure 3. Before and after ABC treatment forward head tilt (Jutkowitz, 2009).

Dr. Jesse Jutkowtiz quotes "you will consistently and predictably get the results we are promising with Advanced BioStructural Correction, as long as you follow the directions exactly and do not do what appears to be following the directions but is actually not, on the case you are working on at that particular time" (Jutkowitz, 2009). As long as the directions of the Advanced BioStrucutral technique are followed there will be positive results. The number of releases necessary for improvement however, will depend on the severity of the patient's symptoms (Jutkowtiz, 2009). Jutkowitz (2009) states on average the patient will need two to three releases a week for up to six weeks.

There have not been any studies focusing on physiological changes specifically, such as an increase in VE threshold, decreased breathing frequency, and decrease in heart rate at sub-max exercise and rest, and increase VO_2 max and VE, and TV in endurance cyclists. Therefore, this study on endurance trained cyclists will determine if the ABC technique has a physiological effect on the variables stated above, and whether that, in turn, enhances cycling performance.

Altitude's Effect on VO_2 max and sub-max exercise responses in cyclists

Alamosa, Colorado sits at approximately 7,500 ft in altitude. The effects of training at moderate altitude and performance at altitude became relevant during the lead up to the 1968 Mexico City Olympic Games, which was located at 7,545ft (Saunders, Pyne, & Gore, 2009). Other examples of major sporting events, specifically cycling, taking place between 6,500ft and 11,500ft include the different stages of Le Tour de France, Vuelta Espana, and Giro d'Italia cycling races (Saunders et al., 2009). Maximal oxygen uptake (VO_2 max) is currently the most used measure of aerobic capacity (Gonzalez-Parra, 2013). Cyclists normally train at different percentages of their VO_2 max depending on their training schedule (Noordhof, Schoots, Hoekert, & Koning, 2013). For example, an easy long ride of two or more hours might be at 50% of the cyclist's VO_2 max, while a harder ride at a higher % of VO_2 max, with more intensity at altitude has an effect on overall VO_2 max due to decreased oxygen uptake at altitude, making it harder to perform the task (Hahn & Gore, 2001).

When an endurance athlete trains at altitude, the muscle's capacity to receive and consume oxygen is limited due to the decreased partial pressure of oxygen in the air. This affects the ability of the pulmonary system to intake sufficient oxygen and the cardiovascular system to transport oxygen to working muscles; a major consequence from this is a decrease in aerobic performance (Saunders et al., 2009). Acute exposure to cycling at altitude on flat terrain for short durations is likely to enhance performance due to less air density which means less aerodynamic drag (Hahn & Gore, 2001). Bob Beamon shattered the world record in the long jump, which is an anaerobic sport, at the 1968 Olympic Games in Mexico City because of the decreased air density at Mexico City's 7,545ft (Powers & Howley, 2012). As one climbs higher in altitude weight of the air is decreased because each liter of air contains fewer molecules of gas (Powers & Howley, 2012). However, riding on a hilly course, or on a stationary trainer, performance will be reduced due to the hypoxic effect from altitude because the cyclist is not getting the effect from less air density (Hahn & Gore, 2001). From acute exposure to altitude whole body VO_2 is reduced due to the decreased oxygen pressure at altitude, which will increase ventilation during exercise in an attempt to increase VO_2 to required levels (Green, Roy, Hughson, Burnett, Otto, Pipe, McKenzie, & Johnson, 2000).

Improving submaximal exercise performance allows a cyclist to require less oxygen and therefore expend less energy at any given speed below 85% of VO_2 max or below the ventilatory threshold (Powers &Howley, 2012). If a cyclist can improve sub-max work effort, less oxygen is required in the working muscle, and this leads to decreased energy expenditure (Powers & Howley, 2012). Increasing the efficiency a cyclist can ride at sub-max exercise will increase overall cycling performance. Noordhof et al. (2013) researched gross efficiency in cyclists at sub-max exercise intensities of 45%, 55%, and 65% of VO_2 max at altitude and at sea level. Gross efficiency is the ratio of work generated to the metabolic cost, and is assumed to be the best way to determine endurance performance in cyclists (Jobson, Hopker, Korff, &, Passfield, 2012). Noordhof et al. (2013) found there was no difference in gross efficiency in cyclists from altitude to sea level, meaning the metabolic cost during sub-maximal exercise cycling at sea level and altitude are equal in altitude acclimatized cyclists. However, this is the only study found to state the equivalence of cycling at sea level and altitude at sub-maximal effort. Saunders et al. (2009) discussed after two to three weeks of exposure to altitude, performance can improve at sub-max exercise by 20%-60%, because the cyclist became acclimatized. This should lead to improved competition performance due to enhanced ability to take in oxygen. As researched by Sanders et al. (2009), altitude acclimatized cyclists improved VO_2 max, and decreased breathing frequency and heart rate at sub-max exercise, which were the focuses of the current study.

Endurance exercise has many positive benefits on exercise such as lower resting and submaximal exercise heart rate (Achten & Jeukendrup, 2003). However, altitude also affects exercise heart rate; submaximal VO_2 is lower at a given heart rate in sea level activities, compared to the same workload at altitude. Heart rate at submaximal exercise at altitude is increased due to the increased heart rate needed to maintain VO_2 at altitude because of the decreased oxygen partial pressure in the air at altitude (Rusko, Tikkanen, & Peltonen, 2004). Also, as an athlete rises in altitude, the decrease in partial pressure has a direct influence on ventilation, which increases VE and also decreases the ventilatory threshold (Powers & Howley, 2012). The respiratory muscles' main task is to act upon the chest wall to move air in and out of the lungs and promote blood flow to and from the heart (Powers & Howley, 2012). Correcting hyperkyphotic posture with the ABC technique will assist the respiratory muscles taking the pressure or compression off the chest, allowing an increase in ventilation which should combat the effect of increasing altitude, by increasing oxygen availability, and improving performance.

Summary

In conclusion, this literature review has discussed research about how chiropractic has become relevant in sports from the first reported chiropractic use in sport with Mordecai Brown. Also, reviewed was the possible impact chiropractic can have on injury prevention and performance enhancement. It was the purpose of this study to determine whether the Advanced BioStructural Correction technique has on impact on endurance cyclist's performance. This study investigated whether the Advanced BioStructural Correction technique can correct forward head posture and hyperkyphosis in cyclists, while specifically decreasing VO_2, increasing ventilatory threshold, decreasing breathing frequency, decreasing heart rate, all at sub-maximal exercise, decreasing heart rate at rest, and increasing ventilation, tidal volume, and VO_2 at max. It was hypothesized that if the ABC technique results in the above positive physiological changes, then cycling performance will be improved.

Chapter 3

Methods

Setting

The study took place in the San Luis Valley in Colorado, at approximately 7,500ft in altitude, in the homes, dormitories, and living spaces each participant chose to set up their hydraulic trainer. The ABC manipulations took place three days a week in the Adams State University Human Performance lab. The submaximal exercise VO_2, ventilatory threshold, heart rate, breathing frequency, tidal volume, VO_2 max, and forward head tilt, along with hyperkyphotic posture if present, was also measured in the Adams State University Human Performance lab.

Population

The eleven male and female participants in the study included collegiate level cyclists from Adams State University, and recreational cyclists of the San Luis Valley who regularly train on their mountain and road bike on a consistent basis, for an average of 4-6 days and 10-20 hours per week. Collegiate level cyclists were recruited by cycling coach Marshal Hartley, and the recreational cyclists were recruited by word of mouth in the San Luis Valley. All the participants had a knowledge of chiropractic work and some of the benefits it has on the body, but no prior ABC manipulation experience. The participants were aware they would be training and performing the protocol at an altitude of 7,544 ft. All participants had been exposed to altitude for at least one year, so they were considered to be acclimatized.

Instrumentation

Chiropractor: The Chiropractor who performed the ABC releases three times a week. Dr. Terry L. Wiley, Doctor of Chiropractic, Level 2 certified, Advanced BioStructural Correction technique.

Chiropractic Table: Used for the participants to lay on during the releases.

Goniometer: A protractor-like device (Lafayette Instrument Company) was used to assess the degree of forward head tilt in the participants.

Heart Rate Monitor: Used to determine heart rate electronically via telemetry while the subject wore a chest strap (Polar T31), during the maximal oxygen consumption test, to determine submaximal heart rate and maximal heart rate.

Hydraulic Trainer: A device that attaches to the rear wheel of a bicycle which provides resistance via fluid to simulate the demands and effort of riding outdoors during the winter months.

Metabolic Cart: The ParvoMedics TrueOne Metabolic System (OUSW 4.3.3) Gas Analyzer assessed pulmonary ventilation (VE, VT, f), and oxygen consumption during a graded exercise test to max on a cycle ergometer, pre and post-intervention.

Monarch Bicycle: The Monarch Bicycle Ergometer model #828E, is a stationary bicycle that provides resistance via adjusting workloads; it was used during the maximal oxygen consumption test.

Personal Bicycles: Each participant was required to have their own bicycle to complete the training protocol.

PostureViewer: Used to take standing before and after pictures of participants in a lateral view to visually see forward head tilt.

Baseline Testing

Participants were required to sign an informed consent approved by the Institutional Review Board (IRB) committee at Adams State University (see appendix A). Participants were then required to fill out a Par-Q Form asking about their individual health (see Appendix B); if two or more risk factors of disease were present the participant was not allowed to participate. All participants performed a VO_2 max incremental test of three minute stages on a cycle ergometer beginning at a workload of 1.0kp (see Appendix C). The workload increased every three minutes by 0.5kp and continued to increase 0.5kp every three minutes. The test ended when the participant could not continue due to reaching maximal effort. The test measured oxygen consumption, ventilation, breathing frequency, tidal volume, and heart rate on a Monarch Bicycle Ergometer model #828E, on their visit to the Human Performance laboratory. This assessed maximal oxygen consumption, and heart rate, ventilatory threshold, tidal volume, breathing frequency, and oxygen consumption during each sub-maximal stage up to maximal oxygen consumption in the participants. Prior to the metabolic test, to avoid any potential fatigue, participants had standing lateral view pictures taken using PostureViewer to determine forward head tilt and to identify if there was any hyperkyphotic posture. A goniometer was used to measure the degree of forward head tilt. These numbers were used to compare to post test values after the six week training protocol to see the effects of the ABC technique.

Research Design

Following baseline testing, participants were divided randomly into two groups; equal numbers of male and females, and collegiate level trained cyclists were included in each group. The experimental group received ABC manipulations by Dr. Terry Wiley, three days a week for the six-week training protocol, and the control group did not receive ABC releases. Dr. Terry Wiley was the only chiropractor performing the releases, in the ASU Human Performance lab. The releases took up to 10 minutes for each session.

ABC Technique Protocol

The ABC technique protocol from Jutkowitz (2009) performed by Dr. Terry Wiley, is as follows:

1) "By Objective Synchronous Testing, check the meninges and release where positive findings occur – find it and fix it, one thing at a time for all corrections.
   a) Anterior
   b) Posterior
   c) Rotate right
   d) Rotate left
2) Check for and release anterior PBPs from C7 to L5.
   a) If you have a C7 or T1 do the first, then C7 or T1
3) Check for and release sacral base posterior PBPs right and left.
4) Check for and release sacral apex PBPs right and left.
5) Check for and release femur head PBPs right – anterior and/or posterior and left anterior and/or posterior.

6) Treat ankles, feet, and fibular heads as needed. (In that order.)
7) Check and release anterior and posterior ribs.
8) Recheck and release L3, L4, L5 anterior PBPs.
9) Recheck C7/T1 and treat it and check for anteriors farther down if their body fold when letting body relax. (C7 will almost always be there after doing L5 since you pull the neck forward doing L5 and other vertebrae might also have been pulled anterior when you did L5 so check with slump test – breathe in, out and let their bodies relax and look for a fold AFTER doing C7/T1.)
10) Check for cranial accelerators at the sphenoid wings and treat accordingly.
11) Recheck and treat from beginning." (Jutkowitz, 2009).

Six Week Cycling Training Protocol

Both groups received a 6 week cycling training protocol created by Marshal Hartley, the Adams State University cycling coach. There were two training protocols, one for the collegiate level cyclists (see appendix D), and one for the recreational level cyclists (see appendix E). The experimental group received ABC releases in the evenings three days a week for six weeks. Participants were required to keep a daily journal, recording completion of workouts, description of how they felt aerobically, description of how they felt physically, such as muscle fatigue, and rating of perceived exertion (RPE) immediately following the ride (see appendix F). The training log was used to monitor compliance to the training program. The participants were not allowed to adjust any of the settings on the bike during the six weeks of the study.

Once the six weeks of training was complete, and ABC releases had been done on the experimental group, all participants performed the same protocol of post-testing as the pre-test (baseline). Like the pre-test, photos were taken using PostureViewer to observe whether there was an improvement on forward head tilt and if the degree of hyperkyphotic curve of the spine had improved in the experimental group (see appendix G). Goniometer measurement angles were used for accurate numbers. Lastly, all participants performed the same protocol as the pre-test VO_2 max test (see appendix C), on the Monarch Bicycle Ergometer model #828E, which assessed maximal oxygen consumption, and heart rate, ventilatory threshold, tidal volume, breathing frequency, and VO_2 throughout the test.

Reliability/Validity

In order to assess whether the ABC releases have a physiological effect on endurance cyclists the researcher used instruments that are deemed reliable and valid to assess the variables of interest. Oxygen consumption (VO_2) is a critical determining factor when related to exercise performance (Haff & Dumke, 2012). Levin, Laursen, and Abiss (2014) agree that the VO_2 max test is a valid graded exercise test in cyclists because cycling ranges in distance and intensity. Powers and Howley (2012) also agree the measurement of VO_2 max is the best choice for measuring aerobic capacity in endurance athletes such as cyclists. The goniometer was used to have accurate measurements of forward head tilt and kyphotic spine. Gajdosik and Bohannon (1987) stated the goniometer instrument is a valid tool to use to measure an angle in degrees on the human body. PostureViewer was an accurate way to measure forward head tilt and used by all chiropractors who perform ABC releases. The training protocol was created by a collegiate level cycling coach, Marshal Hartley, who has years of experience in biking. Therefore, it can be assumed the training protocol he created is valid and reliable for maintaining or improving cycling performance. The ABC releases were done by a certified ABC Chiropractor, Dr. Terry Wiley. There were no prior studies testing ABC releases on any type of athlete.

Statistical Analysis

Data was recorded in Microsoft Excel for accurate recording. Descriptive statistics for all dependent variables are stated as the mean ± standard error. The independent variables include the treatment groups - each individual either received ABC releases (experimental group) or did not receive ABC releases (control group); and the time of measurement - before the intervention (pre) and after the intervention (post). The dependent variables include breathing frequency, tidal volume, VO_2, VE threshold, HR, all at sub-max exercise, TV, VE, and VO_2 at max, and degree of forward head tilt. A paired samples t-test was used for each dependent variable to compare the experimental and control group's pre vs. post trials. Non-parametric Wilcoxon Signed Ranks test was used for HR max because it did not meet the assumptions of normality or homogeneity. Also, an independent samples t-test was used for the comparison between experimental and control groups for change, post – pre trials. However, a non-parametric Mann-Whitney U test was used for HR Rest in the change, post – pre in the experimental and control groups because it also did not meet the assumptions of normality or homogeneity. This statistical test allowed for comparison between groups and time for each of the dependent variables. Data was analyzed in SPSS software, version 22 (2013), and the results were considered statistically significant if $p<0.05$.

Chapter 4

Results

A total of 11 cyclists participated in the study, five were collegiate trained and six were recreationally trained. The experimental group had five males with the following characteristics (mean ± SD): age 26.2 ± 24 years, height 71.32 ± 6 in, weight 158 ± 16.4 lbs, and two females: age 22.5 ± 7 years, height 66.9 ± 5.8 in, weight 136.1 ± 27.8 lbs. The control group had three males: age 25.7 ± 13 years, height 71.61 ± 5 in, weight 152.3 ± 4.6 lbs, and one female: age 19 years, height 66 in, weight 128.4 lbs. Compliance in the experimental group for ABC releases was 83%, 15 of 18 scheduled. Compliance in the training programs for the control group was 96%, and 98% for experimental group.

Figures 4-13 illustrate the mean ± SE for each DV, by group, pre and post-trial. Figures 14-23 show the comparison of post – pre change of scores for the experimental and control groups over the 6 week study period. All variables in the control group showed no significance (Table 1, Figures 4-13). For the experimental group, RR sub-max increased in the experimental and control groups, and it was significantly different only in the experimental group ($t_{1,6}$=-2.817, p=0.030; Table 2). HR Rest (bpm) decreased in the experimental group and increased in the control group. HR Rest (bpm) trended towards significance in the experimental group ($t_{1,6}$=2.352, p=0.057). TV Max (L/min) decreased in both experimental and control groups, which also trended towards significance ($t_{1,6}$=-2.186, p=0.071; Table 2, Figures 4-13). Also, VE threshold increased in the experimental group which trended towards significance ($t_{1,6}$= -1.977, p=0.095).

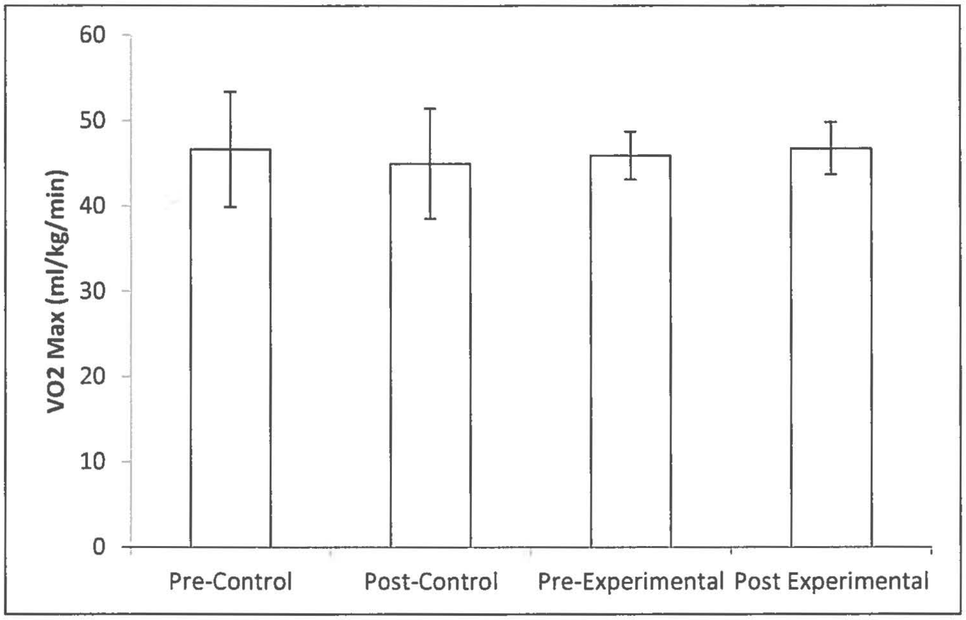

Figure 4. VO_2 Max (ml/kg/min) pre vs. post, experimental vs. control groups.

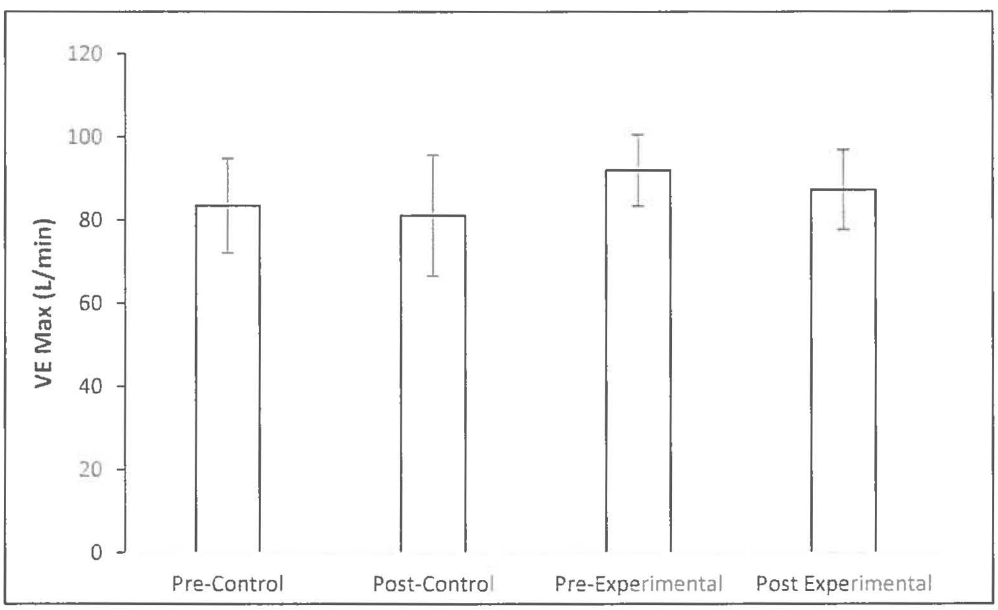

Figure 5. VE Max (L/min) pre vs. post, experimental vs. control groups.

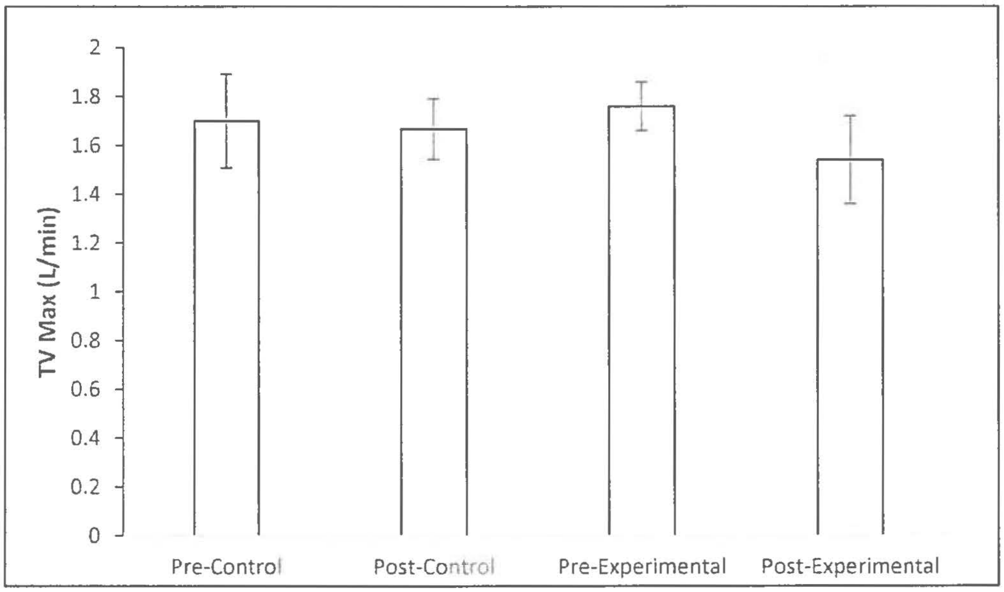

Figure 6. TV Max (L/min) pre vs. post, experimental vs. control groups.

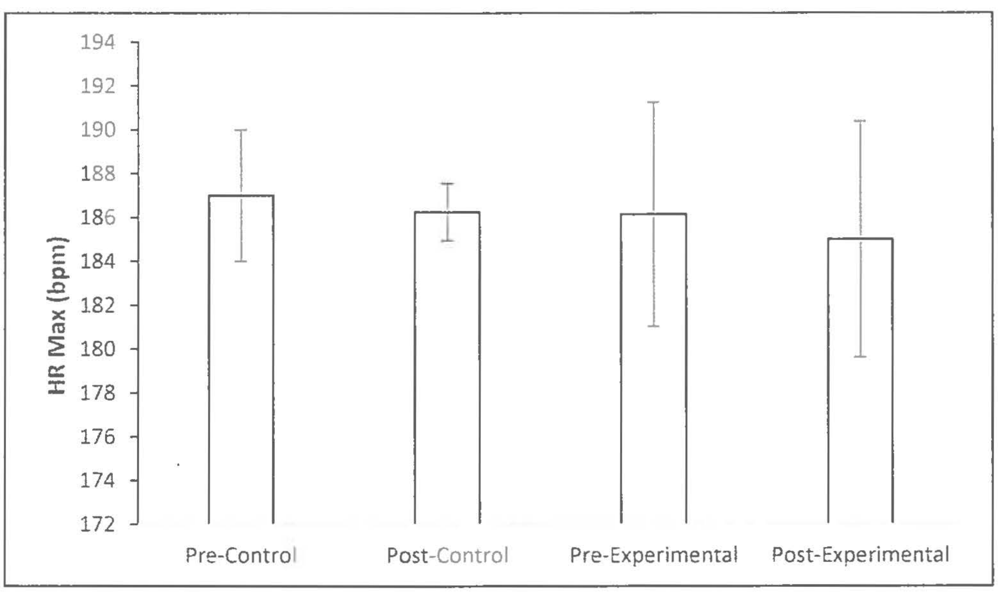

Figure 7. HR Max (bpm) pre vs. post, experimental vs. control groups.

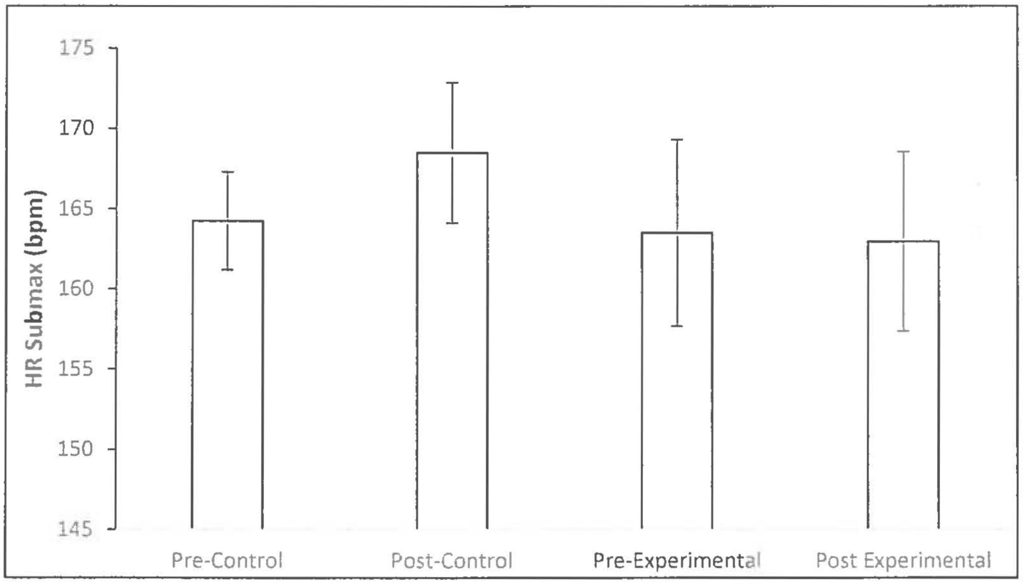

Figure 8. HR Submax (bpm) pre vs. post, experimental vs. control groups.

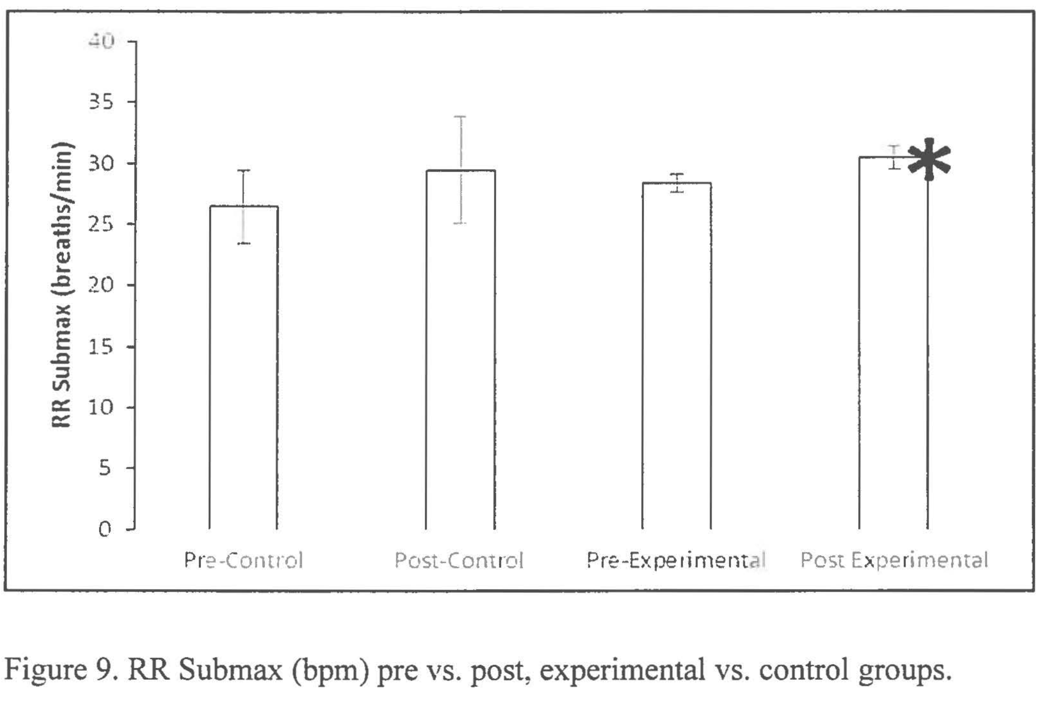

Figure 9. RR Submax (bpm) pre vs. post, experimental vs. control groups.

Asterisk represents significant difference $p<.05$, between pre vs. post experimental group.

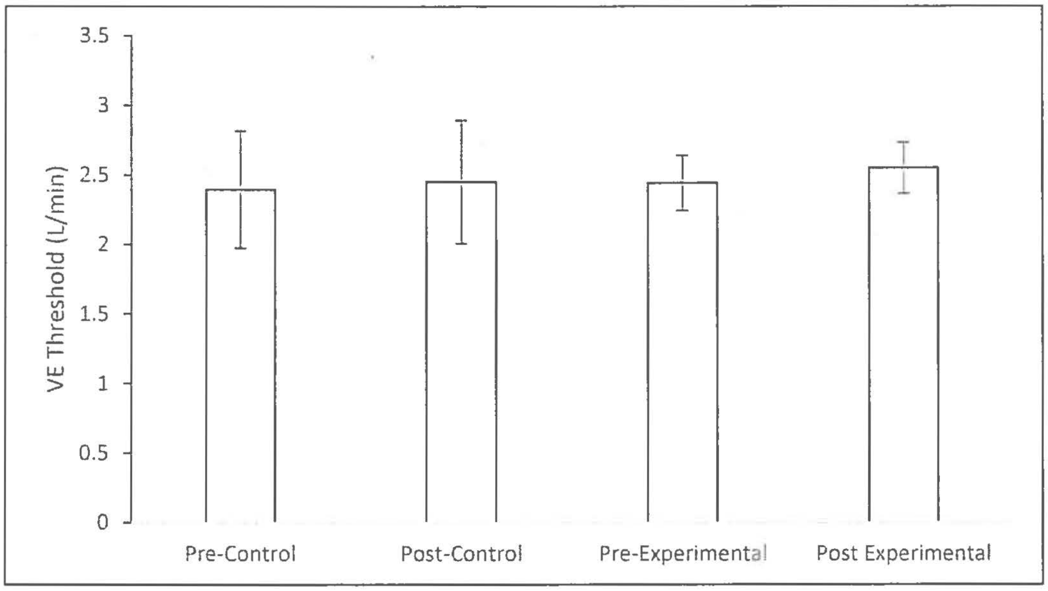

Figure 10. VE Threshold (L/min) pre vs. post, experimental vs. control groups.

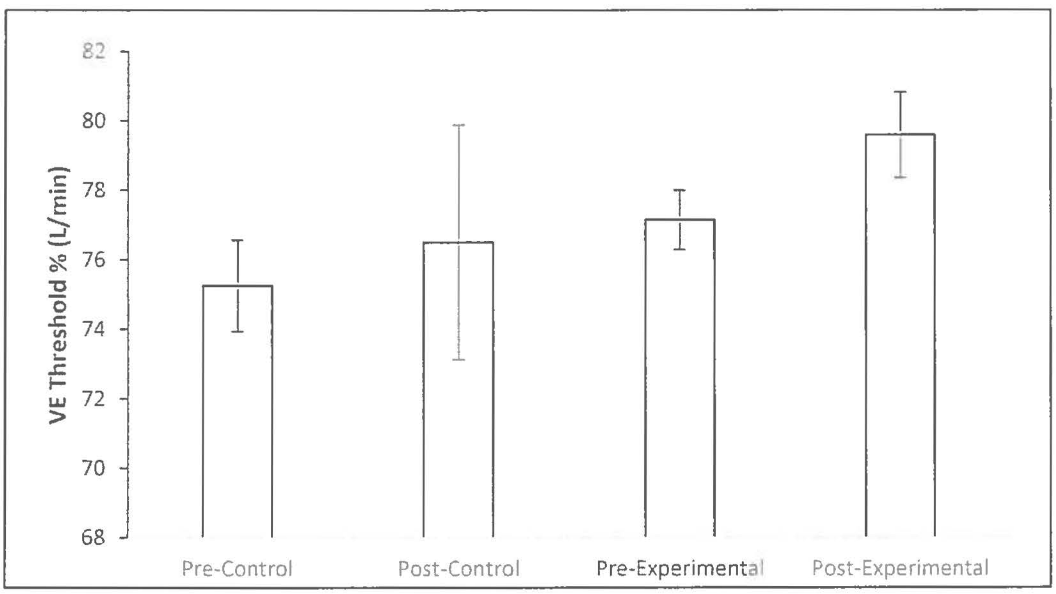

Figure 11. VE Threshold % (L/min) pre vs. post, experimental vs. control groups.

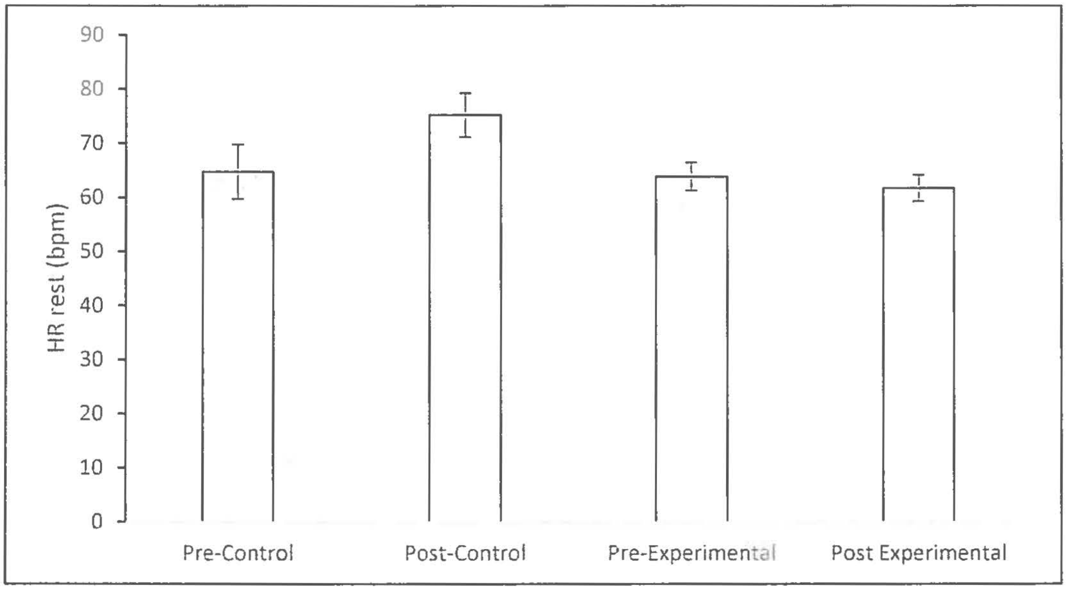

Figure 12. HR Rest (bpm) pre vs. post, experimental vs. control groups.

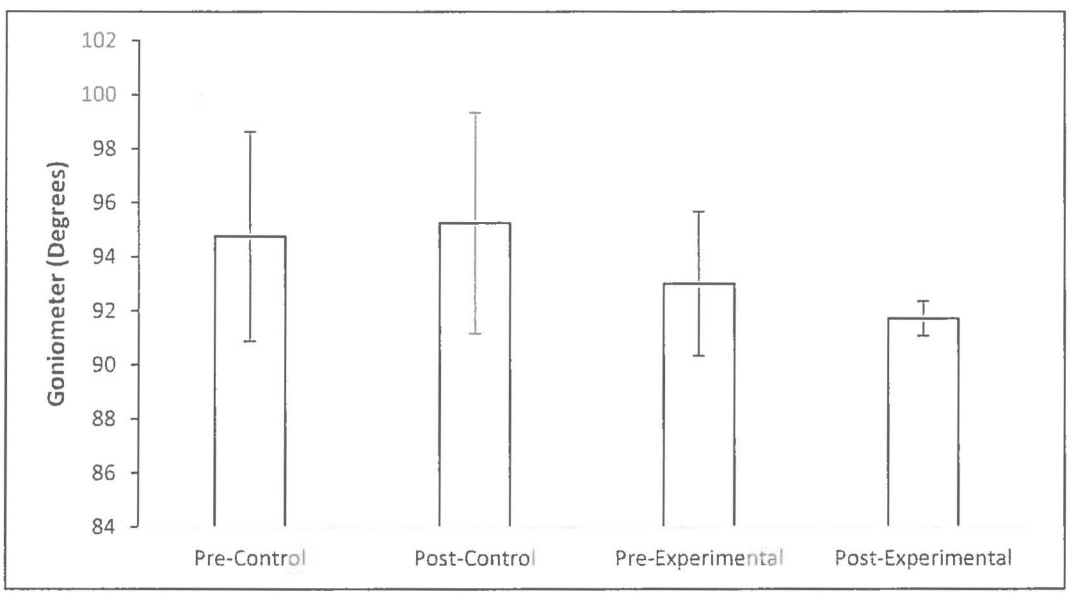

Figure 13. Goniometer (Degrees) pre vs. post, experimental vs. control group.

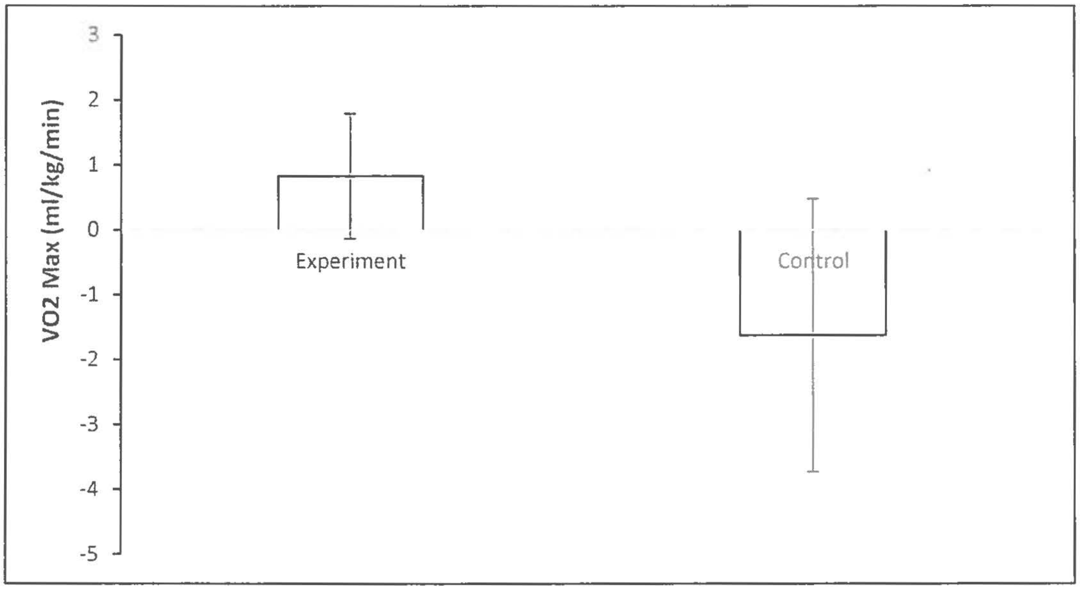

Figure 14. VO_2 Max (ml/kg/min) post-pre, experiment vs. control.

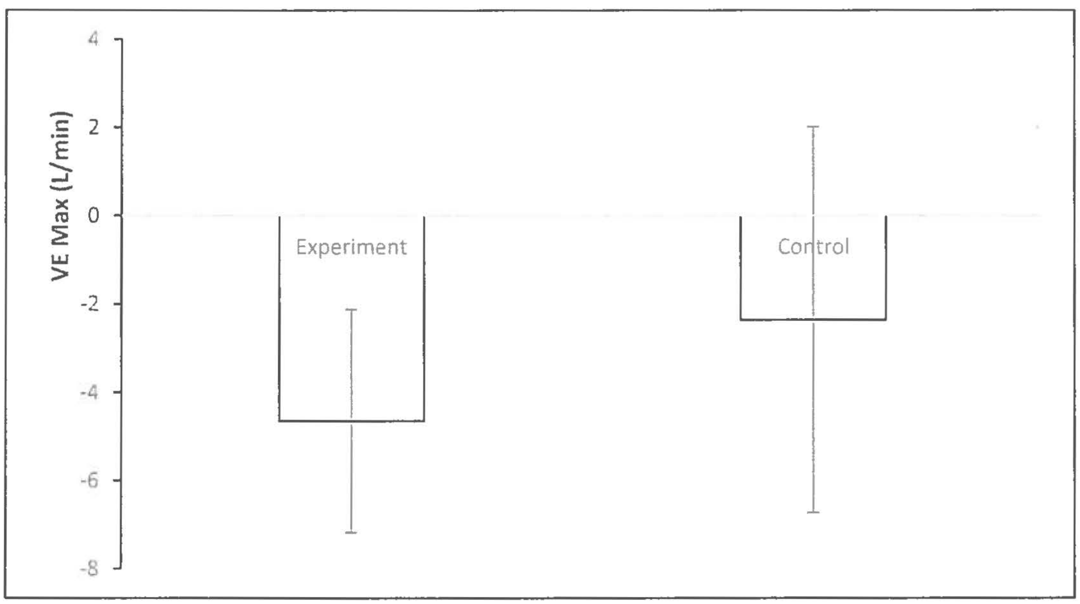

Figure 15. VE Max (L/min) post-pre, experiment vs. control.

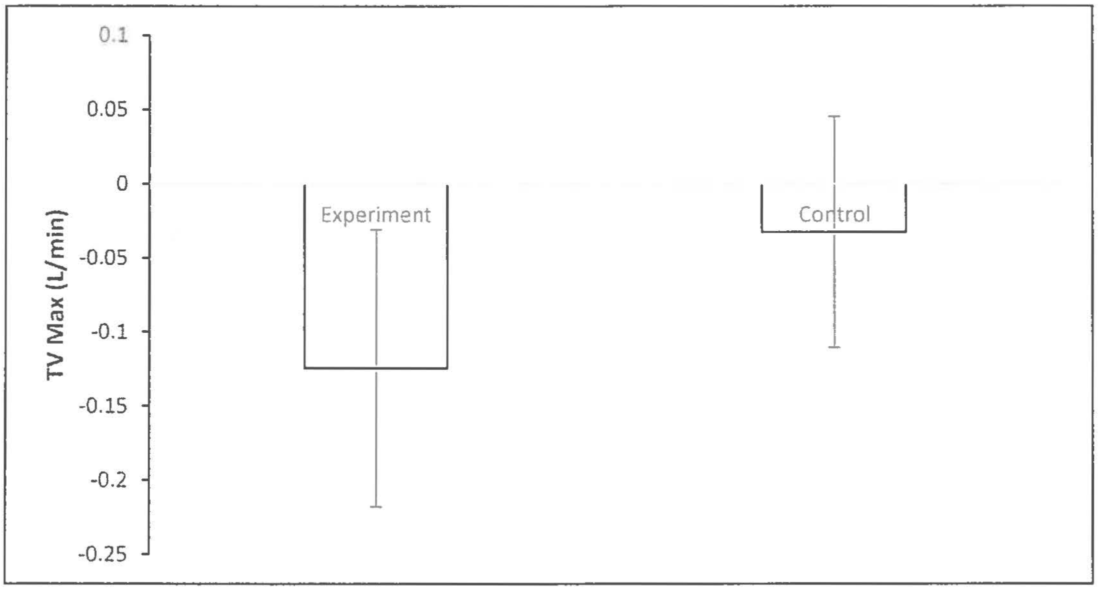

Figure 16. TV Max (L/min) post-pre, experiment vs. control.

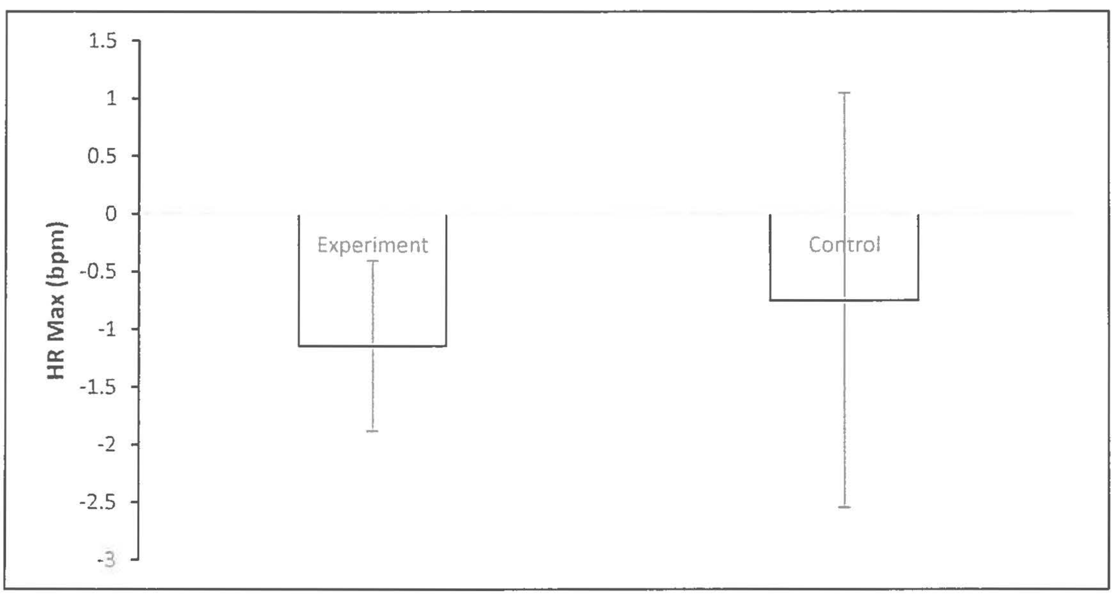

Figure 17. HR Max (bpm) post-pre, experiment vs. control.

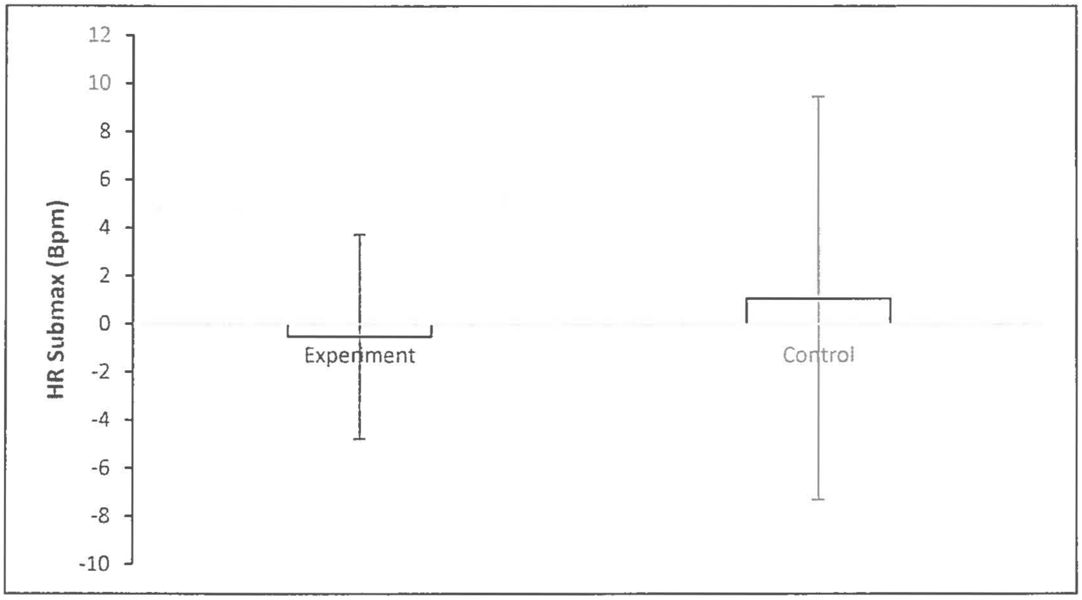

Figure 18. HR Submax (bpm) post-pre, experiment vs. control.

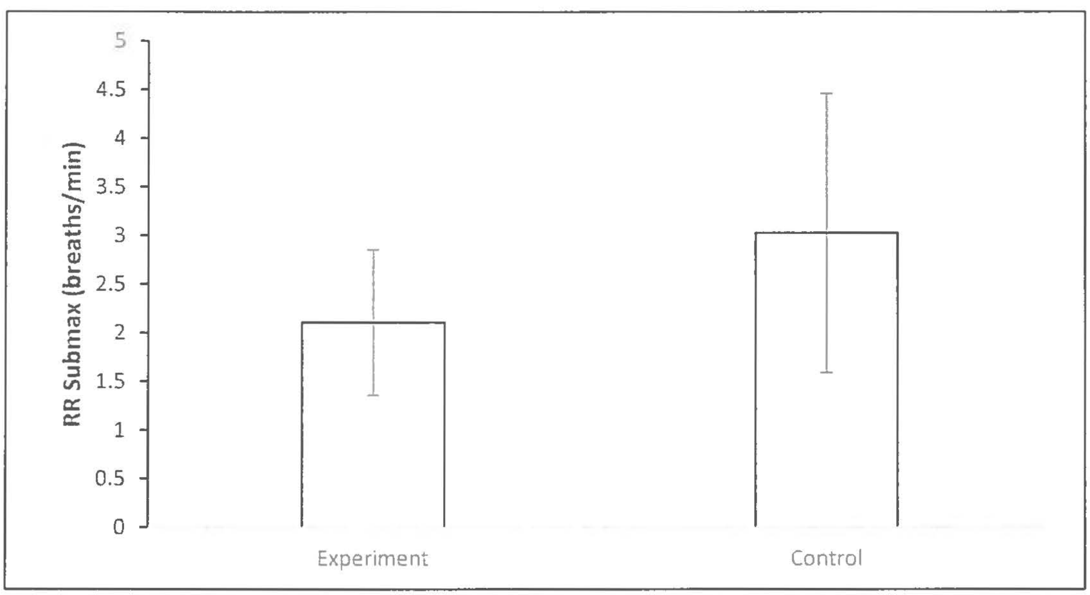

Figure 19. RR Submax (bpm) post-pre, experiment vs. control.

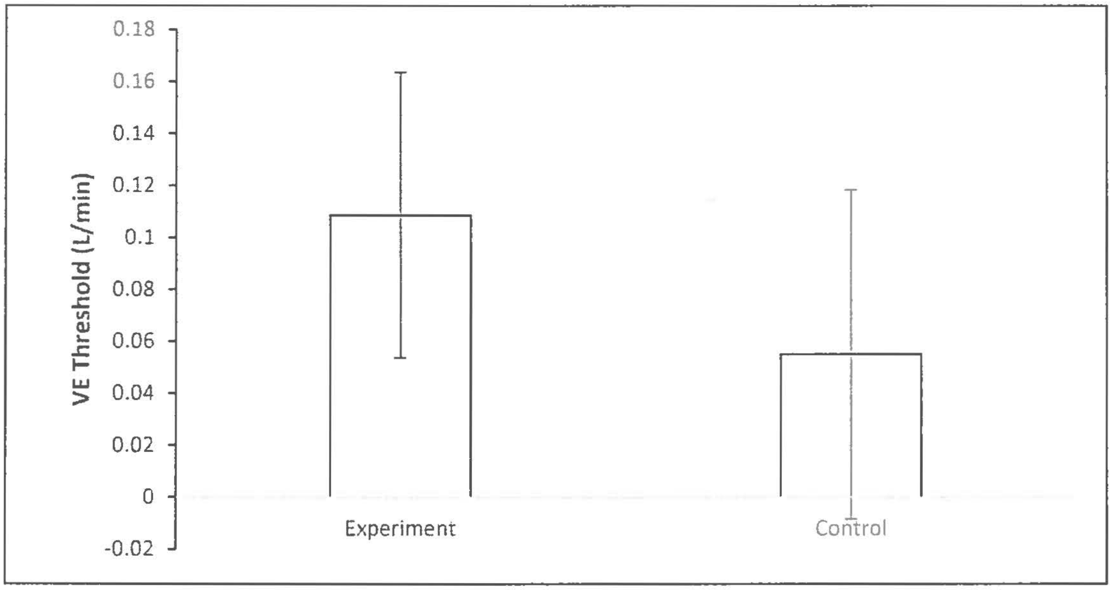

Figure 20. VE Threshold (L/min) post-pre, experiment vs. control.

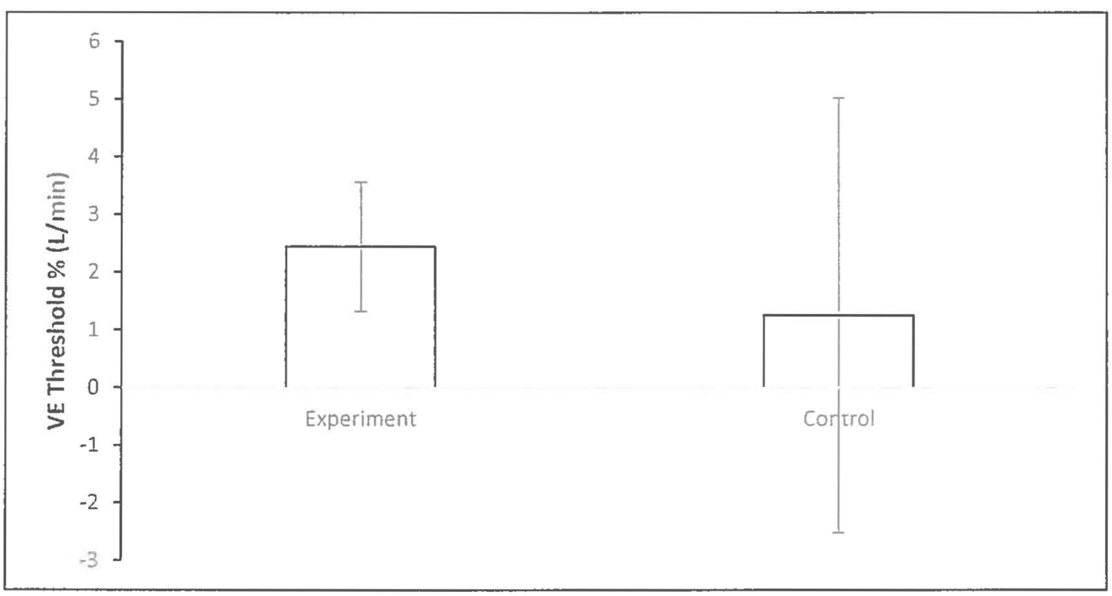

Figure 21. VE Threshold % (L/min) post-pre, experiment vs. control.

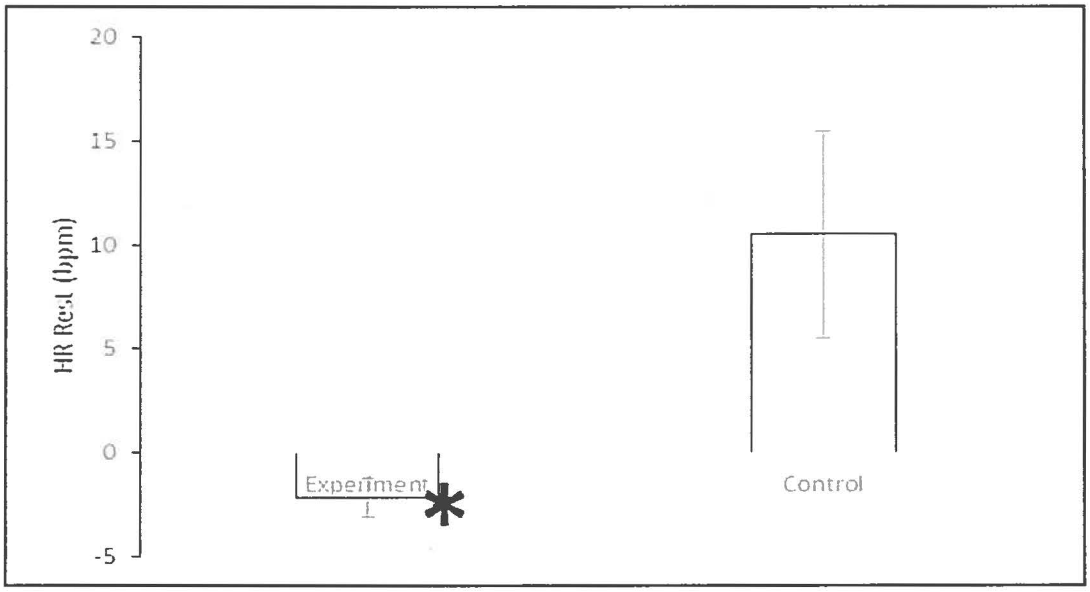

Figure 22. HR Rest (bpm) post-pre, experiment vs. control.

Asterisk represents significant difference p<.05, between experimental and control groups.

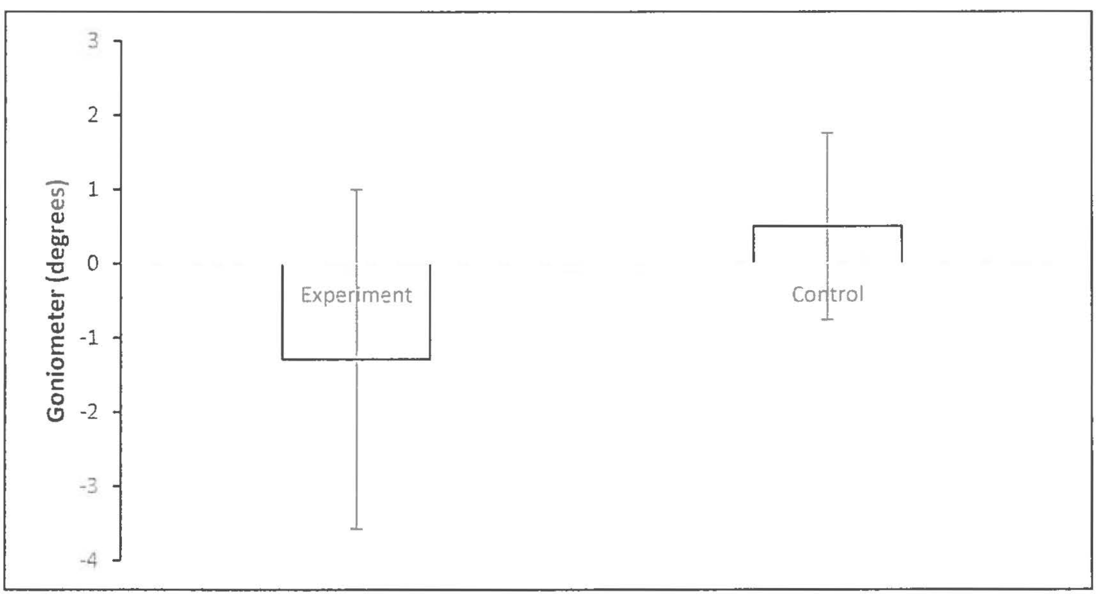

Figure 23. Goniometer (degrees) post-pre, experiment vs. control.

Table 1. Paired samples t-test comparing mean pre and post values for the control group.

Control	**t**	**df**	**p**
VO_2 Max (ml/kg/min)	0.771	1,3	0.497
VE Max (L/min)	0.539	1,3	0.627
HR Max (bpm)	0.417	1,3	0.704
HR Rest (bpm)	-2.104	1,3	0.126
HR Submax (bpm)	-0.507	1,3	0.647
RR Submax	-2.110	1,3	0.125
VE Threshold (L/min)	-0.867	1,3	0.450
VE Threshold % (L/min)	0.417	1,3	0.705
TV Max (L/min)	-0.331	1,3	0.762
Goniometer (Degrees)	-0.397	1,3	0.718

Table 2. Paired samples t-test comparing mean pre and post values for the experimental group.

Experimental	**t**	**d.f.**	**p**
VO_2 Max (ml/kg/min)	-0.861	1,6	0.423
VE Max (L/min)	1.838	1,6	0.116
HR Max (bpm)	1.549	1,6	0.172
HR Rest (bpm)	2.352	1,6	0.057
HR Submax (bpm)	0.501	1,6	0.634
RR Submax* (breaths/min)	-2.817	1,6	0.030
VE Threshold (L/min)	-1.977	1,6	0.095
VE Threshold % (L/min)	1.254	1,6	0.257
TV Max (L/min)	-2.186	1,6	0.071
Goniometer (Degrees)	0.563	1,6	0.594

Variables with an asterisk represent significant difference ($p < 0.05$).

Mann-Whitney U test showed a significant difference in HR Rest in change post minus pre in the experimental group and an increase in control group ($U_{1,9}$=1.0 p=0.012). All other variables showed no significance (Table 3, Figures 14-23). Variables with an asterisk were run non-parametrically and test statistics represent Mann-Whitney U values.

Table 3. Independent samples t-test results comparing mean post minus pre values for the experimental and control groups.

Experimental vs. Control	**t/U**	**d.f.**	**p**
VO_2 Max (ml/kg/min)	1.223	1,10	0.252
VE Max (L/min)	-0.491	1,10	0.635
HR Max (bpm)	-0.240	1,10	0.816
HR Rest* (bpm)	-2.485	1,10	0.012
HR Submax (bpm)	-0.566	1,10	0.610
RR Submax	-0.633	1,10	0.542
VE Threshold (L/min)	0.613	1,10	0.555
VE Threshold % (L/min)	0.382	1,10	0.711
TV Max (L/min)	-0.662	1,10	0.525
Goniometer (Degrees)	-0.554	1,10	0.593

Variables with an asterisk were run non-parametrically and test statistics represent Mann-Whitney U values. HR Rest (bpm) was statistically significant (p <.05).

Chapter 5

Discussion

There has been no other research to this point on the effect the Advanced BioStructural Correction (ABC) technique has on sports in general, specifically endurance cyclists. Data was collected on an experimental group (ABC releases three times a week for six weeks) and a control group (no ABC releases) to determine any significant differences in various physiological variables at rest, submaximal exercise, and maximal exercise. The results discussed for sub-max variables were at a relative workload of % of VE threshold. Generally with training this means that as the workload increases the ventilation increases, so the dependent variables breathing frequency (RR), heart rate, and tidal volume (TV) should also increase or stay the same due to the assumed higher level of fitness. However, it was hypothesized that at these relative workloads, HR at rest should decrease, RR and heart rate should decrease at the sub-maximal workload, VE threshold and % of VE threshold should increase at an equivalent sub-maximal workload, and TV, VE, and VO_2 max should increase at maximal effort, to see if the ABC technique had any effect.

Research Question #1

Does the Advanced BioStructural Correction (ABC) technique have a physiological effect on endurance cyclists, specifically increasing VO_2, VE, and TV at max, with releases performed three days a week over a span of six weeks?

It was hypothesized that the ABC technique would increase VO_2 max following the six week protocol. VO_2 max did increase from an average of 45.91 ml/kg/min to 46.74 ml/kg/min in the experimental group, and decreased from 46.59 ml/kg/min to 44.96 ml/kg/min in the control group, but this pattern was not statistically significant. Mendes, Fonseca, Ramos, Wilke, Cabido, De Barros, and Garcia (2013) researched the effect of a six week aerobic training protocol on cycle ergometer bikes to see if they could improve VO_2 max. The experimental group increased significantly from 44.9 ml/kg/min to 49.8 ml/kg/min, and these numbers are very similar to the experimental group in the current study. Mendes et al. (2013) also had thirteen participants in the experimental group, double that of the current study; the researcher could argue that a larger sample size may have shown a statistical significance towards increasing VO_2 max in the current study. The greatest increase in VO_2 max came from one participant in the experimental group, increasing 3.8 ml/kg/min from 48.3 ml/kg/min to 52.1 ml/kg/min. Five of the seven experimental group participants increased their VO_2 max; statistical significance may have been shown with a larger sample size of experimental participants.

One finding of this study was that the ABC technique did not affect VO_2 max measured in ml/kg/min, as there were no statistically significant differences between the control and experimental groups. The experimental group followed a six week protocol of three ABC releases per week at an altitude of 7,544ft. VO_2 max is currently the most known and used measure of aerobic capacity (Gonzalez-Parra, 2013). As VO_2 max increases the rate at which oxygen is sent to the working muscles becomes more effective, allowing more oxygen to be taken in and delivered to exercising muscles, thus leading to improved aerobic performance (Hahn & Gore, 2001). However, living and training at altitude makes the ability to consume oxygen more difficult due to the decreased partial pressure of oxygen in the air, making it harder to maximize aerobic performance (Saunders et al., 2009). The ABC technique was used to see if it would improve performance at altitude combined with cycling training, compared to cyclists not receiving ABC releases and only training.

Along with VO_2 max, this research found that there were no statistically significant differences in TV (L/min) at max and VE (L/min) at max. However, in this study, TV trended towards significance, decreasing in the experimental group pre vs. post trials. TV was measured at maximal oxygen consumption in pre and post tests for both groups. Maximum TV decreases due to the linear curve of the spike in VE and RR, decreasing TV max (Powers & Howley, 2012). Since VE=TV x RR, if there is a decrease in TV, RR should increase to maintain or increase VE (Powers & Howley, 2012). It was hypothesized that TV would be higher at max during the post trials in the experimental group, because of the improved posture and less compression on the respiratory system and lungs. TV decreased more in the experimental group than the control group. An increase in RR could be compensating for the decrease in TV at max in order to maintain maximal VE, but RR max was not analyzed in the current study. However, because TV decreased in both groups it does not mean ABC did not have an effect on TV at maximal exercise. Rommer, McConnell, and Jones (2002) measured TV at VO_2 max in a pre and post-trial to see if muscle training led to an increase in TV. Sixteen elite male endurance cyclists with a mean VO_2 max of 64 ±2 ml/kg/min (much higher than the current study) were recruited for their study. The participants were divided in half; the experimental group received lower body muscle training along with their cycling protocol. The control group did not receive lower body muscular training with their cycling protocol. The protocol lasted six weeks, which was identical to the current study of six weeks of ABC releases. The researchers found an increase in TV at VO_2 max in the experimental group following six weeks of cycling training and lower body muscular training (Rommer et al., 2012). The study suggests muscular training can be beneficial to increase TV at VO_2 max; this researcher speculates that muscular training combined with the ABC technique could allow the athlete to breathe even more air at VO_2 max.

Research Question #2

Does the Advanced BioStructural Correction (ABC) have a physiological effect in endurance cyclists, specifically, decreasing breathing frequency, heart rate, and increasing ventilatory threshold during sub-max exercise, and heart rate at rest, with releases performed three days a week over a span of six weeks?

Although VO_2 max is the most well-known and used indicator of aerobic performance, some may argue that VE threshold may be a better indicator for improving exercise at sub-max exercise. Amann, Subudhi, and Foster (2006) conducted a study on 15 "well trained" male cyclists to see if VE threshold is a better indicator of aerobic fitness and improving sub-max exercise than Lactate Threshold. The participants had an average VO_2 max of 68 ml/kg/min. The researchers measured threshold with four different methods: three using ventilation, one of them being an estimate method. The researchers indicated the most relevant way to measure VE threshold is VE/VO_2. The current study found VE threshold by plotting VE vs. VO_2 in L/min, in order to determine the spike in VE, where VE increases more rapidly at a certain VO_2. This method is comparable to that used by Amann et al. (2006), who concluded that VE threshold is the best indicator for sub-max performance because a greater percentage of threshold was achieved in the cyclists (Amann et al., 2006). This may be useful for future research to analyze VE Threshold the most efficient way when performing ABC releases on athletes.

Improving submaximal exercise performance allows a cyclist to utilize less oxygen and therefore expend less energy at any given speed below 85% of VO_2 max, under or at the VE threshold (Powers & Howley, 2012). There were no statistically significant differences for pre vs post in the control group in VE threshold (L/min) ($p=0.450$) and % of VE threshold ($p=.705$). There were also no statistically significant differences in the % of VE threshold in the experimental group pre vs. post (p=0.257). However, VE threshold (L/min) trended towards a significant increase in the experimental group, and may have shown a significant increase if there was a larger sample size. The experimental group showed an increase in the % of VE threshold from 77.12% to 79.59% of maximal aerobic capacity and trended towards significance in VE at sub-max exercise from 2.44 L/min to 2.55 L/min (p=0.257). This means the cyclists were able to ride harder at threshold pace of their VO_2 max. The idea is if the cyclist can improve sub-max effort, less oxygen is required in the working muscles, so the cyclist can ride harder with less energy expenditure (Powers & Howley, 2012). Therefore, the ABC technique may have assisted with an increase in percent of VE threshold due to greater ability to take up and utilize oxygen, by taking the pressure or compression off the chest which allowed the respiratory muscles to work more efficiently. It also can be assumed ABC combats the effect altitude had on the body within the experimental group with the reduced oxygen availability in the air by opening up the chest and respiratory system. This is assumed because there was not as large of an increase in VE threshold 75.25% to 76.5% in control individuals who were also exposed to altitude.

Breathing frequency (RR) at sub-max exercise also increased from pre to post trials. However, there was a greater increase in RR for the control group (26.43 breaths/min – 29.45 breaths/min) than in the experimental group (28.37 breaths/min – 30.48 breaths/min). It was hypothesized that RR would decrease at sub-max exercise in the experimental group and stay the same in the control group. RR is the amount of breaths taken per minute and was measured at sub-max exercise at VE threshold (Powers & Howley, 2012). As stated earlier, the ABC technique opens up the chest by taking the compression off the lungs and heart which increases the ability to breathe. However, although there was an increase in ventilatory threshold there was not a decrease in RR, so both groups needed to take more breaths per minute at submaximal exercise. This may be due to the relative workloads the dependent variables were measured at; since VE threshold increases, cyclists were working at a higher workload, which may have necessitated an increase in RR. Almost all studies on breathing frequency are focused on restricted breathing frequency during training (Town & Vanness, 1990). The current study is one of the only studies the researcher could find to see if breathing frequency can be decreased at sub-max exercise.

HR was measured at rest, sub-max exercise at ventilatory threshold, and at maximal exercise. There was no change in the control or experimental groups at max, which is to be expected given a maximal effort (Powers & Howley, 2012). At sub-max the experimental group participants' HR remained the same during the pre and post-trials. HR at sub-max in the control group however increased from pre to post by nearly four bpm. This is a significant change because four bpm could be the difference between two different training zones in cycling (Jeukendrup & Diemen, 1998). Heart rate training is a highly used and very practical method for elite cyclists to monitor changes in workouts or competition. Intensity is hard to monitor, so assessing HR max enables you to make training zones to ride for training different intensities (Jeukendrup & Diemen, 1998). Therefore, if heart rate decreases from pre threshold to post threshold, less work is being done at the given intensity enabling the cyclist to ride at a higher intensity in a given workload. It was hypothesized in the current study, that HR would decrease at sub-max exercise in the experimental group allowing cyclists to increase the performance from new heart rate zones. However sub-max exercise was measured at VE threshold, which increased over the course of the study, so this may have had an effect on HR at sub-max.

There was a trend towards a significant decrease (p=0.057) in resting heart rate in the experimental group and an increase in the control group. The experimental group decreased pre to post from 63.86 bpm to 61.71 bpm. A lower resting heart rate, typically leads to a faster recovery post exercise, and is an indication of improved aerobic fitness (Powers & Howley, 2012). The control group however showed an increase in resting heart rate from pre to post trials from 64.75 bpm to 75.25 bpm, possibly due to nerves in one of the participants. Many studies have shown resting heart rate to be an early predominant factor for cardiovascular diseases (Fox, Borer, Camm, Danchin, Ferrari, Sendon, & Tendera, 2007). The higher the resting heart rate, the greater the chance of having early symptoms of cardiovascular diseases. Therefore, adding the ABC technique to cardiovascular exercise may assist with lowering resting heart rate and should be recommended to decrease the risk of cardiovascular diseases; and an improved heart rate recovery post exercise, could also improve aerobic performance. The ABC technique helps with unwinding the spine back to its normal position; this raised the head back up over the shoulders releasing the compression on the chest. Compression to the chest restricts the respiratory system and heart (Jutkowitz, 2009). It was hypothesized that the experimental group who received the ABC technique would have a lower resting heart rate following the six week protocol, and the data supported this hypothesis.

Research Question #3

Would the Advanced BioStructural Correction (ABC) technique decrease forward head tilt and hyperkyphosis, if present, with releases performed three days a week over a span of six weeks?

The goniometer measurements were measured in degrees with the 0 degree mark starting at the external auditory canal. The vertical arm was used as a reference point and the horizontal arm was measured to the inferior point of the nose. Ninety degrees would be considered an ideal head tilt alignment, with less than ninety degrees tilted up, and greater than ninety degrees tilted down. Often, however, the Postureviewer pre and post pictures are the best way to indicate the change in forward head tilt in the experimental group (see Appendix G). Looking at side view photos, it is easily visual how the ear came up over the shoulders, indicating less forward head tilt. The nose and eyes also present level in the post-trial photos compared to the pre photos.

There was no statistically significant differences between experimental group and the control groups in goniometer angles measured, post to pre ($p=0.594$). Following the six week study the experimental group measured closer to 90 degrees, with a slight improvement. The experimental group's mean measurements pre study were 93 degrees, and post trials they measured at 91.7 degrees. The control group pre trials measured at 94.75 degrees and following post trials were 95.25 degrees. The control group over the span of six weeks went slightly farther away from 90 degrees showing lack of any improvement. Continued cycling in a bent over posture could add to the kyphotic curve and limit respiration rate and oxygen consumption because there is more compression on the lungs and heart leading to a decrease in VO_2 (Muyor et al., 2012). It appears that the ABC technique may have helped reduce this limitation to breathing and improved posture.

Recommendations

Based on the current findings there needs to be a lot more research in this field of study. As previously stated, there have been no other studies on the ABC technique and its potential physiological effects in any sports. The current study researched ten different variables to get a wide range of ideas for future studies. A larger sample size should yield much better results and lean towards a greater significance in the physiological variables researched. It is believed the small sample size did not give the results the researcher was looking for because there was not a sufficient amount of data to analyze. However, the study did show some improvements, specifically in posture, in the experimental group (see Appendix G).

The improved posture in the experimental group appeared to improve some physiological variables at rest (HR), sub-max exercise (RR, VE threshold), and max exercise (TV), although only RR at sub-max exercise was statistically significant. In a practical sense, any improvement in physiological function during exercise should enhance performance.

Recommendations to future researchers would include the following: A detailed food log at least two days prior to each VO_2 max test might give more accurate results, giving more experimental control. This would assist with creating the exact same measurements from the pre to post trials. Caffeine and macro nutrients can affect different variables measured in the study, such as weight and respiratory exchange ratio (RER); these were not measured variables in the current study, but RER is an indicator of a max test and macro nutrient use during exercise (Powers & Howley, 2012). Scheduling the pre and post-tests at the same time of day for each individual participant would be advised in order to minimize any extraneous variables that could change results. On average the participants in the current study completed 15 of the 18 ABC releases over the course of six weeks, and all of the experimental group participants showed improved posture in the Postureviewer photos (see Appendix G). However, a longer study utilizing the ABC technique with training may show a larger improvement in the physiological variables measured, because six weeks may not be enough time to show large improvements in VO_2 max (Powers & Howley, 2012). Future research should try to utilize the ABC technique in endurance athletes over a very long period of time, such as a year, to see how athletes respond to changes over a long period of full training cycles. Elite athletes generally take longer to see physiological changes than the average athlete (Powers & Howley, 2012). Lastly, a study utilizing the ABC technique with muscular training might be very beneficial in many athletes in a wide variety of sports. Muscular training puts a lot of added negative pressure on muscles and joints and could easily influence posture in a negative way (Baechle & Earle 2008). ABC releases may be able to combat this effect; more research into combined therapies is recommended.

Chapter 6

Summary and Conclusions

There has been no other research to this point on the effect the Advanced BioStructural Correction (ABC) technique has on sports in general, specifically endurance cyclists. The results of the study showed there were no statistically significant differences in male and female collegiate and recreational trained endurance cyclists in increasing VO_2 max, VE max, and TV at max, or bringing head posture angle closer to 90 degrees. There were no statistically significant differences in VE Threshold, % of VE Threshold, or HR, all at sub-max exercise. These results did not support the researcher's hypotheses and the researcher failed to reject the null hypotheses. RR at sub-maximal exercise was shown to be statistically significant in the direction opposite of what was hypothesized. RR increased in breaths/min when the researchers were looking for RR to decrease at sub-max exercise. This may be due to the relative workloads the dependent variables were measured at; since VE threshold increases, cyclists were working at a higher workload, which may have necessitated an increase in RR.

However, some of the trends had practical significance, which could benefit performance. HR at rest trended towards significance in the experimental vs. control groups from pre to post trials. VE threshold (L/min) also trended towards significance in increasing ventilation threshold in the experimental group. TV trended towards significance in decreasing TV at max. Lastly, the Postureviewer photos showed positive changes in posture in the experimental group. Thus, there is some support for the researcher's hypotheses. The study did show a decrease in HR at rest from pre to post trials in the experimental group, and a greater decrease compared to the control group, whose HR at rest actually increased. There were increases in VO_2 max in five of the seven experimental group participants and the % of VE threshold increased, implying they can work harder at a higher % of their VO_2 max, allowing them to expend less energy at lower submaximal workloads. The only decrease in the experimental group was VE at max, which means the individuals in the experimental group were not taking in as much air at maximal exercise in the post-trial compared to the pre-trials, even though VO_2 max increased slightly. It is highly possible that the ABC technique can promote beneficial physiological changes in endurance trained cyclists, however there needs to be more research done with larger sample sizes and longer periods of intervention, since elite trained athletes take longer to improve physiologically.

Practical Applications

The ABC technique that was applied to endurance trained cyclists three days a week for six weeks did not lead to statistically significant improvements in VO_2 max, VE, and TV at max. Also, RR, VE threshold, % of VE threshold, and HR did not show a significant change in sub-maximal performance. Lastly, goniometer measurements did not show significant changes in improving head angle to 90 degrees. However, HR rest did significantly decrease at rest, meaning the risk for cardiovascular disease was decreased, and aerobic fitness was improved (Fox et al., 2007).

The ABC technique can be a useful tool for decreasing hyperkyphotic posture (see Appendix G), possibly improving aerobic performance, and decreasing the chance for cardiovascular disease. Improved posture takes pressure off the respiratory system and lungs making the athletes feel like they can breathe more efficiently; manipulating these variables can lead to an improvement in performance. Frequently seeing a chiropractor who is trained in the ABC technique could lead to a healthier and longer life (Jutkowitz, 2009). Decreasing the compression on the respiratory system and lungs allows an individual to breathe with more ease and thus probably complete everyday tasks more easily; this could also increase performance.

The researcher believes applying the ABC technique to different training programs could be highly effective. The results show practical positive increases in VO_2 max, which is the most widely known and accepted way for measuring endurance performance (Gonzalez-Parra, 2013). Applying the ABC technique frequently to a training program with a large sample size, such as a full cycling or running team, may result in finding greater significance in all the variables measured. It could be highly beneficial to have a certified ABC chiropractor in a sports program for athletes to go to seek additional benefits to improve performance.

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Appendix A: Participant Consent Form

RESEARCH PARTICIPANT CONSENT FORM

Does the Advanced BioStructural Technique Have a Physiological Effect on Endurance Trained Cyclists?

Lukus Klawitter
Adams State University
Department of Human and Physical Education

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH

To date, no known research has been conducted using the chiropractic technique, Advanced BioStructural Correction (ABC), to identify if physiological changes or posture correction (if poor posture is present from the start) occurs as a result of this release technique. Cyclists spend many hours on a bicycle in a position where they are hunched over the handle bars with an arched back, which has the potential to induce hyperkyphotic spine posture while also restricting airways and blood flow to the heart due to compression of the chest.

The primary purpose of this study is to investigate whether a series of ABC releases will show physiological improvements and promote good posture in a group of endurance trained collegiate cyclists and recreational cyclists. The variables measured will include: oxygen consumption (VO_2), ventilation (V_E), breathing frequency, tidal volume (TV), heart rate (HR), forward head tilt, and hyperkyphosis. Participants will be asked to adhere to a six (6) week training program, devised by the cycling coach at Adams State University. All test procedures will be administered in the Human Performance Laboratory in the East Campus building in Alamosa, Colorado.

PROCEDURES

Specific Laboratory Tests Include:

1. You will be asked to answer a PAR-Q questionnaire about your health prior to taking part in the study and/or have physician approval to participate in the study. If you have two (2) of more risk factors based on the American College of Sports Medicine (ACSM) risk stratification criteria related to cardiovascular disease, you will be excluded from the study.
2. Anthropometric measurements including height and weight will be taken.

3. You will be asked to have lateral view photographs taken and measurements using a goniometer to determine the degree of forward head tilt and hyperkyphosis present.
4. You will be asked to perform a maximum oxygen uptake test (VO_{2max}) by cycling on a cycle ergometer while the work load of the cycle increases at even time intervals until you cannot continue pedaling at the required work load.
5. Your metabolic response will be measured via an expired gas analysis system at all times during the testing (pre and post) procedures. You will wear a head gear system to collect expired air during the testing procedures. These samples are directed through tubing into an automated metabolic analyzer, which will calculate the measures listed in the above paragraph. You will also wear a heart rate chest strap for electronic heart rate measurements.
6. After the conclusion of baseline testing, participants will be divided randomly into two groups, one of which will receive the ABC release manipulations (experimental group), the other of which will not receive the ABC release manipulations (control group). If you are randomly selected to participate in the group receiving ABC release manipulations, you will be asked to report to the Human Performance Laboratory at Adams State University three (3) times per week throughout the six (6) week study to receive ABC spinal manipulations by Dr. Terry Wiley, DC.
7. During the six (6) weeks of the experiment, you will be asked to participate in a cycling training protocol, handed out by the researcher, created by the cycling coach. The actual daily cycling workouts will take place at freedom of the participant, on their own personal cycling trainer.
8. You will be asked to keep track of your workouts by logging them in a daily journal.
9. After the six (6) week study has concluded, you will be asked to report to the laboratory for post testing, which will consist of the same anthropometric measurements, lateral view photographs, and VO_{2max} test, as taken during the baseline testing.

DURATION OF PARTICIPATION

This study will take place beginning the first week of February and continue for an additional seven (7) weeks (six weeks of cycling training, plus one week of post-testing). Each of the workout rides can range anywhere from one (1) to three and a half (3.5) hours, depending on the training status of the participant prior to the study. The training protocol will entail roughly 5-6 days per week of cycling. Per the group that receives ABC release manipulations, the chiropractic manipulation will last roughly 15 minutes each session.

RISKS AND DISCOMFORTS OR EXCLUSION FROM TESTING

Every effort will be made to conduct the testing procedures in such a way to minimize discomfort and risk. You have been asked to participate in this study because you have fulfilled all criteria as either a collegiate endurance cyclist, or recreational endurance cyclist. The potential risks associated with maximal oxygen uptake ($VO_{2\,max}$) tests include, but are not limited to: episodes of lightheadedness, fainting, dehydration, chest discomfort, leg cramps, and very rarely heart attack, stroke, or sudden death. The working staff is CPR/AED certified, and know how to respond if one of these potential risks were to occur. There is also an AED on hand, in the laboratory. Risks associated with the ABC release technique are very minimal, as ABC is a stretch or release of the meninges, not and adjustment (does not involve spinal manipulation), and also, the chiropractor performing the manipulations has years of experience and certification. The potential risks involved with cycling training include, but are not limited to: knee pain, wrist soreness, foot numbness and tingling, urogenital problems, and neck and back pain. Prior to $VO_{2\,max}$ testing, you will be risk stratified according to the ACSM criteria (as mentioned prior), such that if you have two (2) or more risk factors related to cardiovascular disease, you will be excluded from the study and $VO_{2\,max}$ testing will not be performed. We will provide you with an information sheet explaining our findings and suggest that you discuss our risk stratification results with your physician. On the other hand, if you have one (1) or no risk factors related to cardiovascular disease, according to the ACSM, we will be able to conduct a VO2 max test, if you agree to participate, without a physician present. Notably, this type of risk stratification protocol has been routinely followed in the lab for $VO_{2\,max}$ testing.

BENEFITS

As a participant of this study, you will have the opportunity to learn about your fitness status on a physiologically-based level. Your individual results will be provided and explained to you, which may result in basic knowledge of exercise physiology. After interpreting the results of your individual $VO_{2\,max}$ test and other measures taken in this study, you may be able to establish a baseline for improvement of your fitness. You may have the access to a form of chiropractic care, free of charge, via the ABC technique, provided to you throughout the six (6) weeks of the study by a Doctor of Chiropractic Medicine, Dr. Terry Wiley, if you are randomly selected to be a part of the experimental group. In addition, if you decide to take part in this study, you will be provided with a six (6) week cycling training program devised by a knowledgeable cycling professional, the cycling coach at Adams State University, with years of cycling experience. This in turn can help you if you are a cyclist looking to maintain, improve, or gain motivation to train. Lastly, on conclusion of the study, you may see improvements in posture (hyperkyphosis and forward head tilt), maximal oxygen consumption (VO_{2max}), submaximal oxygen consumption, heart rate, breathing efficiency, and ventilation. The health benefits from the increase in these measurements include, but are not limited to: increases and or maintenance in overall fitness, increases or maintenance in cycling performance, and potentially decreases in mortality rate; this is due to the premise that correction of posture (specifically hyperkyphotic posture) and cardiovascular health have been shown to decrease mortality rate (based on the fact that you will be meeting the CDC's guidelines for physical for Americans).

CONFIDENTIALITY

Participation is voluntary and will be held confidential. You may choose not to answer any question you do not want to answer and/ or you may withdraw from participation at any time without penalty. Names will not be used in the study, participants will be assigned a number and group data will be reported. Data will be locked under a password protected computer for seven years in which the researcher only has the password. Adams State University reserves the right to use the results of this study for future research and/or presentation of results. In such cases, participants will be asked to sign a release form freeing all collected information prior to its use by the institution or researcher. If research is used in a public forum, data will be reported as a group without individual or school identification.

INQUIRIES

Any questions or concerns regarding this study are welcomed. For questions please contact the researcher of the study, graduate student Lukus Klawitter, at klawitterla@grizzlies.adams.edu or by phone at (320) 583-7409, or Dr. Tracey Robinson, chair of thesis committee, at tlrobins@adams.edu, or by phone at (719) 587-7663

PLEASE READ THE FOLLOWING STATEMENTS, AND SIGN IN THE SPACES PROVIDED TO INDICATE YOUR CONSENT:

AUTHORIZATION: I have read the above and understand the discomforts and inconvenience of this study as well as the benefits and risks. I, ________________________________ (printed name of participant) agree to participate in this research. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

______________________________ ______________________

Participant's Signature Date

______________________________ ______________________

Researcher's Signature Date

Appendix A: IRB Form

Adams State College

Request to obtain approval for the use of human participants

Date: November 3, 2014

Name: Lukus Klawitter

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Mailing Address: 2710 1st APT 12 Alamosa CO, 81101

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Chair of Thesis Committee: Tracey Robinson, Ph.D.
Email: tlrobins@adams.edu
Phone: 719-587-7663

Subject: Does the Advanced BioStructural Correction technique have a physiological effect on endurance trained cyclists?

The title of the research: Does the Advanced BioStructural Correction technique have a physiological effect on endurance trained cyclists?

Objectives of the research: Currently, there is no research analyzing the Advanced BioStructural Correction (ABC) chiropractic technique, a stretching technique causing release of the meninges, to see if it may promote physiological and postural changes (kyphotic spinal posture and forward head tilt) in an individual. Specifically for this study, we are interested in whether the technique would promote positive physiologic changes and an improvement in kyphotic posture and forward head tilt in cycling athletes. Because cyclists spend many hours on a bicycle hunched over the handle bars with an arched back posture, it is possible for a cyclist to develop kyphotic spine posture. Additionally, in this position, cyclists are compressing their chest, which restricts airways and blood flow to the heart. The purpose of the study is to determine whether a series of releases called the Advanced BioStructural Correction (ABC) chiropractic technique, will have a physiological effect on an endurance cyclist. Specifically, this study will investigate whether the ABC technique leads to a decrease in oxygen consumption (VO_2) at sub-max exercise, increase in maximal oxygen consumption (VO_2 max), increase in ventilatory threshold (VE), and increase in TV and decreased breathing frequency at sub-max exercise, and improve posture via forward head tilt and hyperkyphosis, if present in cyclists.

Methods of Procedure:

The Setting: The study will take place in the San Luis Valley in Colorado, at approximately 7,500ft in altitude, in the homes, dormitories, and living spaces each participant chooses to set up their hydraulic bicycle trainer. The ABC releases will take place three days a week in the Adams State University Human Performance lab by Dr. Terry Wiley. The submaximal exercise VO_2, ventilatory threshold, heart rate, lactate threshold, breathing frequency, tidal volume, and VO_2

max, and forward head tilt, along with kyphotic posture, will also be measured in the Adams State University Human Performance lab.

The Participants: The twelve to fourteen male and female participants in the study will include collegiate level cyclists from Adams State University, and recreational cyclists of the San Luis Valley who regularly train on their mountain and road bike on a consistent basis, on an average of 4-6 days and 10-20 hours per week. All the participants have some knowledge of chiropractic work and some of the benefits it has on the body, but no prior ABC release experience. The participants are aware they will be training and performing the protocol at an altitude of 7,544 ft. All participants have been exposed to altitude for at least one year, so they are considered acclimatized.

Research Design:

Baseline: Participants will be asked to fill out a questionnaire based on overall health prior to the study (PAR-Q form) and/or have physician approval to be a part of the study. Participants perform a VO_2 max test with oxygen consumption, ventilation, breathing frequency, tidal volume, and heart rate readings on a Monarch Bicycle Ergometer model # 828E. This will assess maximal oxygen consumption and heart rate, tidal volume, breathing frequency, and ventilatory threshold in the participants. Participants will have standing lateral view pictures taken using PostureViewer to determine forward head tilt and if there is any hyperkyphotic posture. A goniometer will be used to measure the degree of forward head tilt. These numbers will be compared to post-test values to see if ABC technique had any effect.

Protocol: Participants will be divided randomly, equal numbers of male and females and collegiate level trained cyclists into two groups. The experimental group will receive ABC releases three days a week for the six-week training protocol by Dr. Terry Wiley, and the control group will not receive ABC releases. The ABC technique protocol, from Jutkowitz (2009), and performed by Dr. Terry Wiley is as follows:

1) "By Objective Synchronous Testing, check the meninges and release where positive findings occur – find it and fix it, one thing at a time for all corrections.
    a) Anterior
    b) Posterior
    c) Rotate right
    d) Rotate left
2) Check for and release anterior PBPs from C7 to L5.
    a) If you have a C7 or T1 do that first, then C7 or T1
3) Check for and release sacral base posterior PBPs right and left.
4) Check for and release sacral apex PBPs right and left.

5) Check for and release femur head PBPs right – anterior and/or posterior and left anterior and/or posterior.
6) Treat ankles, feet, and fibular heads as needed. (In that order.)
7) Check and release anterior and posterior ribs.
8) Recheck and release L3, L4, L5 anterior PBPs.
9) Recheck C7/T1 and treat it and check for anteriors farther down if their body fold when letting body relax. (C7 will almost always be there after doing L5 since you pull the neck forward doing L5 and other vertebrae might also have been pulled anterior when you did L5 so check with slump test – breathe in, out and let their bodies relax and look for a fold AFTER doing C7/T1.)
10) Check for cranial accelerators at the sphenoid wings and treat accordingly.
11) Recheck and treat from beginning." (Jutkowitz, 2009).

Both groups will receive a 6 week cycling training protocol created by the Adams State University cycling coach. There will be two training protocols, one for the collegiate level cyclists and one for the recreational level cyclists. The experimental group will receive manipulations in the evenings. Prior to ABC releases taking place, Dr. Terry Wiley will determine whether any hypertension, neck pain or dizziness is presented in the participants. Participants of both groups will be required to keep a daily journal recording completion, description of how they felt aerobically, description of how they felt physically, and rating of perceived exertion (RPE) following the ride.

Post-test: Once the six weeks of training is complete, and ABC releases have been done on the experimental group, all participants will perform the same protocol of post-testing as the pre-test. Like the pre-test, photos will be taken using PostureViewer to observe whether there was an improvement on forward head tilt and if the degree of kyphotic spine has improved in the experimental group. Goniometer measurement angles will be used for accurate numbers. Lastly, all participants will perform VO2 max tests on the Monarch Bicycle Ergometer model # 828E to assess maximal oxygen consumption, and heart rate, ventilatory threshold, tidal volume, breathing frequency, and VO2 throughout the test.

Benefits: There are many benefits included with performing this study; as a volunteer in this study, participants will have the opportunity to learn about their fitness status on a physiologically-based level. Participant's individual results will be provided and explained to them, which may result in basic knowledge of exercise physiology. After interpreting the results of the individual $VO_{2\,max}$ test and other measures taken in this study, participants may be able to establish a baseline for improvement of their fitness. Participants may have the access to chiropractic care, free of charge, via the ABC technique, provided to them throughout the six (6) weeks of the study by a Doctor of Chiropractic Medicine, Dr. Terry Wiley, if they are randomly selected to be a part of the experimental group. In addition, if participants decide to take part in this study, they will be provided with a six (6) week cycling training program devised by a knowledgeable cycling professional, the cycling coach at Adams State University, with years of cycling experience. This in turn can help the participant if they are a cyclist looking to maintain, improve, or gain motivation to train. Lastly, per the conclusion of the study, participants may see improvements in posture (hyperkyphosis and forward head tilt), maximal oxygen consumption (VO_{2max}), submaximal oxygen consumption, heart rate, breathing efficiency, and ventilation. The health benefits from the increase in these measurements include, but are not limited to: increases and or maintenance in overall fitness, increases or maintenance in cycling performance, and decreases in mortality rate; this is due to the premise that correction of posture (specifically hyperkyphotic posture) and cardiovascular health have been shown to decrease mortality rate. Also, meeting activity guidelines by the CDC may also decrease the chance of cardiovascular disease.

Risks: Every effort will be made to conduct the testing procedures in such a way to minimize discomfort and risk. The potential risks associated with maximal oxygen uptake ($VO_{2\,max}$) tests include, but are not limited to: episodes of lightheadedness, fainting, dehydration, chest discomfort, leg cramps, and very rarely heart attack, stroke, or sudden death. The working staff is CPR/AED certified, and know how to respond if one of these potential risks were to occur. There is also an AED on hand, in the laboratory. Risks associated with the ABC release technique are very minimal, as ABC is a stretch or release of the meninges, not an adjustment (does not involve spinal manipulation), and also, the chiropractor performing the manipulations has years of experience and certification. The potential risks involved with cycling training include, but are not limited to: knee pain, wrist soreness, foot numbness and tingling, urogenital problems, and neck and back pain. Prior to $VO_{2\,max}$ testing, you will be risk stratified according to the ACSM criteria (as mentioned prior), such that if you have two (2) or more risk factors related to cardiovascular disease, you will be excluded from the study and $VO_{2\,max}$ testing will not be performed. We will provide you with an information sheet explaining our findings and suggest that you discuss our risk stratification results with your physician. On the other hand, if you have one (1) or no risk factors related to cardiovascular disease, according to the ACSM, we will be able to conduct a VO2 max test, if you agree to participate, without a physician present. Notably, this type of risk stratification protocol has been routinely followed in the lab for $VO_{2\,max}$ testing. It has been set as a precedent in the ASU Human Performance Laboratory that VO2 max testing can be viewed as expedited if the ACSM risk stratification are implemented as described prior.

Protection Measures: All participants will be fully informed of all study procedures, and may withdraw at any time. All physiological/laboratory testing will be completed in the HPPE Department's Human Performance Lab, supervised by the leading researcher, Lukus Klawitter, and one of the assisting researchers (Dr. Robinson) who is ACSM certified (American College of Sports Medicine). Participants will also be asked to fill out PAR-Q questionnaire regarding their health status prior to any testing, and if necessary, have a physician clearance before participating in the study. Results of the study will be reported as group data, without any individual subject identifying information. Data will be locked under a password protected computer for five years in which the researcher only has the password. Adams State University reserves the right to use the results of this study for future research and/or presentation of results. In such cases, participants will be asked to sign a release form freeing all collected information prior to its use by the institution or researcher.

Changes: If any changes are made to the research I will contact the IRB immediately and fill out the needed paperwork.

Consent: Participants will be asked to read over and sign the consent form before any testing commences. The informed consent is attached separately.

Tracey L. Robinson 2-4-2015

Name of Department Chair or Appropriate Person Date

Robert Benavides 2-1-15

Name and Signature of IRB Chair Date

Appendix B: Par-Q Form

PAR-Q & YOU

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want – as long as you start slowly and build up gradually. Or you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of a temporary illness such as a cold or fever – wait until you feel better; or
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you answer yes to any of the questions, you must let the trainer know.

Informed Use of the PAR-Q: The trainers assume no liability for persons who undertake physical activity with a pre-existing injury or illness. If in doubt after completing this questionnaire consult your doctor prior to physical activity.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME.. DATE..

SIGNATURE...TRAINER..

Note: This physical activity clearance becomes invalid if your condition changes so that you would answer YES to any of the seven questions. If this occurs please seek GP advice prior to exercising.

(Invitein.org, PAR-Q template, 2015)

Appendix C: VO_2 max Protocol

Subject Characteristics:

Subject#

Gender:

Age:

Height (in):

Weight (lbs):

Seat Height:

Predicted Maximal Heart Rate:

Resting Values: HR:_______

Stage	**Time(min)**	**Workload**	**HR**	**RPE**
1	0-3	1.0kp		
2	3-6	1.5kp		
3	6-9	2.0kp		
4	9-12	2.5kp		
5	12-15	3.0kp		
5	15-18	3.5kp		
6	18-21	4.0kp		
7	21-24	4.5kp		
8	24-27	5.0kp		
TBD				

Max Values: HR:______ RPE:______

Finish Time:______

Recovery:

Time(min)	**HR**
3	
6	

VT:_________________

Appendix D: Collegiate Trained Cycling Protoco

Week #	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total Hours
1	Off-Easy spin	2hrs Endurance	1.5 hrs Endurance	1.5hrs with 30min Tempo	1hr High Cadence	3hrs Endurance	2hrs with 30 min Tempo	10 hours
2	Off-Easy spin	2hrs endurance	2hrs with 45 min Tempo	2.5hrs Endurance	2hrs with 45min Tempo	3hrs Endurance	2hrs Endurance	13.5 hours
3	Off-Easy spin	1hr Easy spin, High Cadence	1.5hr Endurance	1.5hr Endurance with 30 min Over geared	Off	3hrs Endurance	1hr with 30 min Tempo	8 hours
4	Off-Easy spin	1.5 hrs with 60 min Tempo	2hrs Endurance with 30min Over geared	2hrs with Cruise intervals	1hr Easy spin High Cadence	3hrs Endurance	2hrs Endurance	10.5 hours
5	Off-Easy spin	1.5hrs with 60min Tempo	2hrs Endurance with 30min Over geared	1.5hrs with Cruise intervals	2hr Endurance	3hrs Endurance	4hrs Endurance	14 hours
6	Off-Easy spin	1.5hrs with Cruise intervals	Off	3hrs Endurance	2hrs Endurance	4hrs Endurance	4hrs moderate effort	14.5 hours

Endurance: used for aerobic maintenance and endurance training.

Tempo: Ride continuously hard effort with no breaks.

Threshold: Ride at an effort you can hold for 20 minutes without breaks.

Pyramid: Hard intervals 1 min, 2 min, 3 min, 4, min, 5 min, 4 min, 3 min, 2 min, 1 min with 1 min rest.

Spin ups: Random surges at random times during the ride, no longer than 30 seconds.

Appendix E: Recreational Trained Cycling Protocol

Week #	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total Hours
1	OFF	1hr endurance	1:15hr easy	1.5hr with 30 min Tempo	1hr easy	2hr endurance	1:15hr endurance	7.8 hours
2	Off	1.5hr with 45min Tempo	1.5hr endurance	2hr with 45min Tempo	1hr easy	2hr endurance	1.5hr endurance	9.5 hours
3	Off	2hr with cruise intervals	2hr endurance	2hr with 45min Tempo	1hr easy	2.5hr endurance	1.5hr endurance	11 hours
4	Off	2hr with cruise intervals	2hr endurance	2hr with cruise intervals	1hr easy	1.5hr endurance	1.5hr with pyramid intervals	10hours
5	Off	1.5hr with Threshold	1hr endurance	1.5hr with pyramid intervals	1hr easy	1.5hr endurance	1.5hr with threshold	7hours
6	Off	1.5hr with pyramid intervals	1hr endurance	Off	1hr easy	1hr with spin ups	1hr with spin ups	5.5 hours

Endurance: Used for aerobic maintenance and endurance training.

Tempo: Ride continuously hard effort with no breaks.

Threshold: Ride at an effort you can hold for 20 minutes without breaks.

Pyramid: Hard intervals 1 min, 2 min, 3 min, 4, min, 5 min, 4 min, 3 min, 2 min, 1 min with 1 min rest.

Spin ups: Random surges at random times during ride, no longer than 30 seconds.

Appendix F: Training Log Requirements

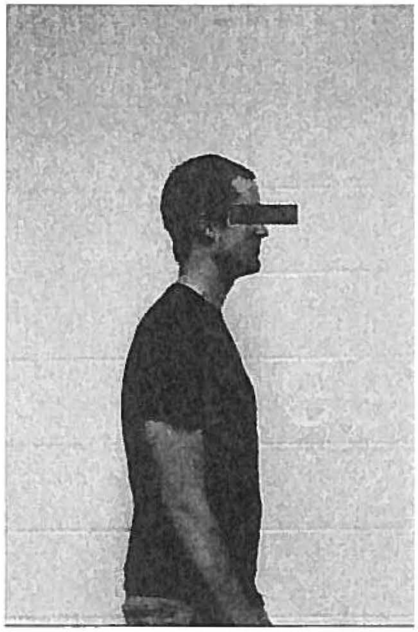
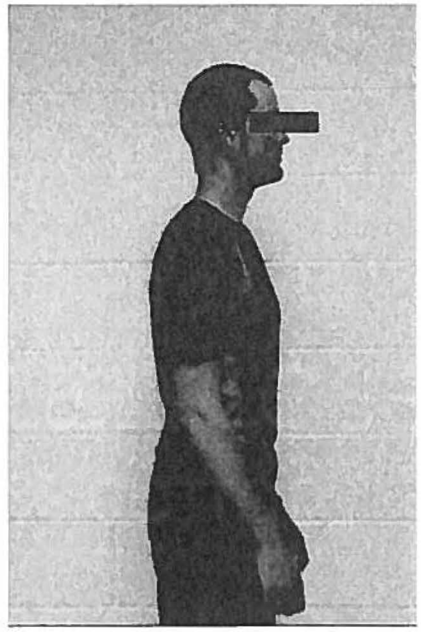
Week #	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:
2	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:
3	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:

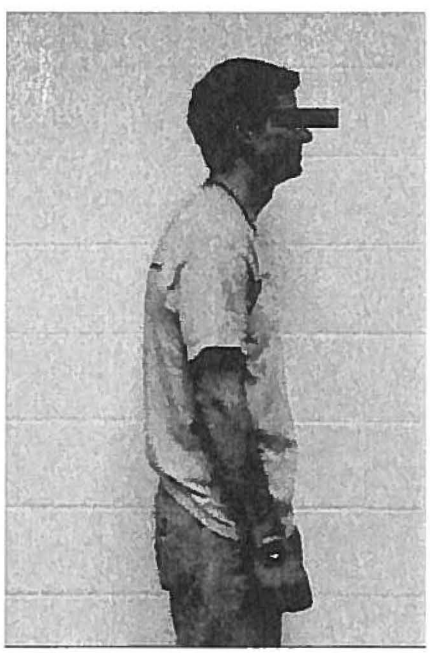
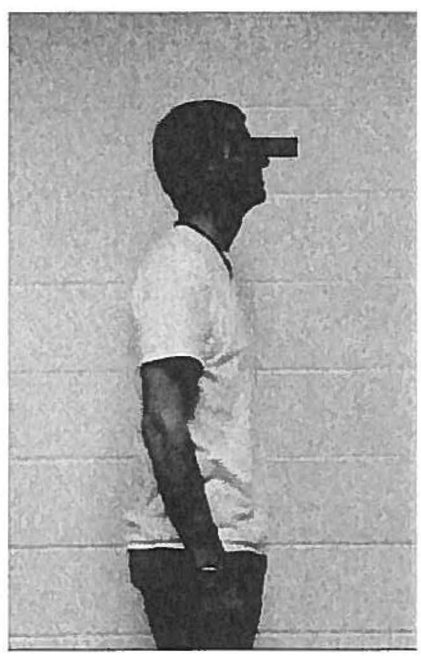
4	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:
5	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:
6	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:	Date of Completion: Aerobic: Physically: RPE:

Participants are required to hand write a daily log about details of every single of their rides throughout the six week training protocol. Requirements are as follows:

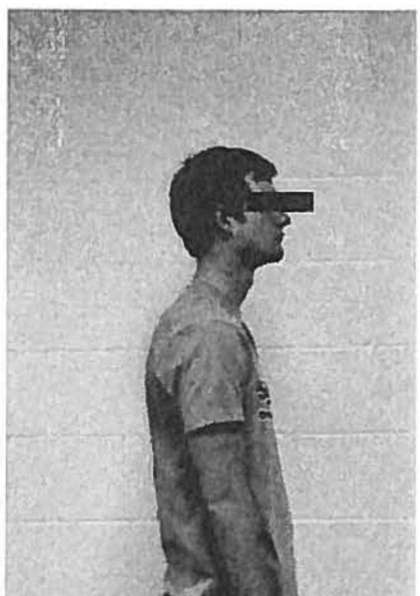
- Completion
- Description of how you felt aerobically (breathing, heart rate)
- Description of how you felt physically (muscle soreness)
- Rating of Perceived Exertion (RPE) immediately following the training session

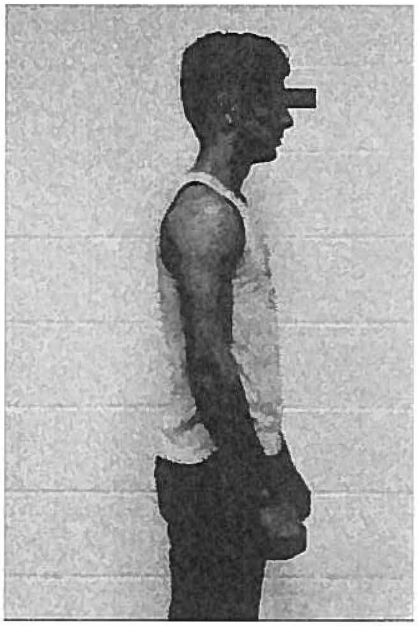
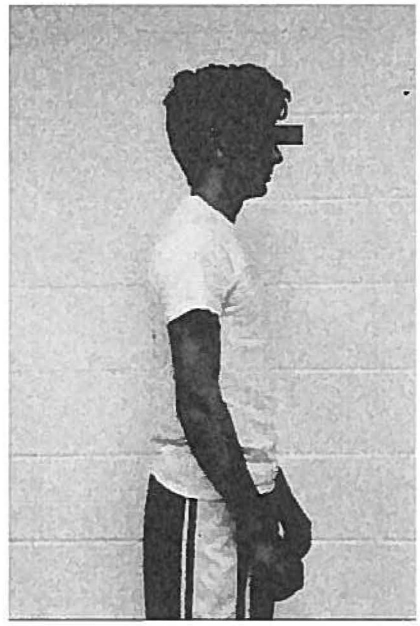
Appendix G: Pre and Post Posture Photos

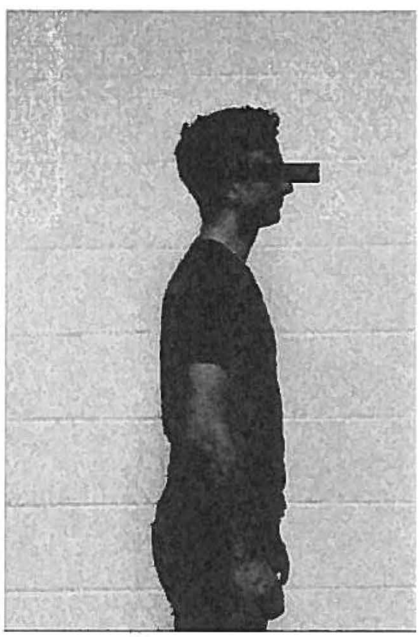
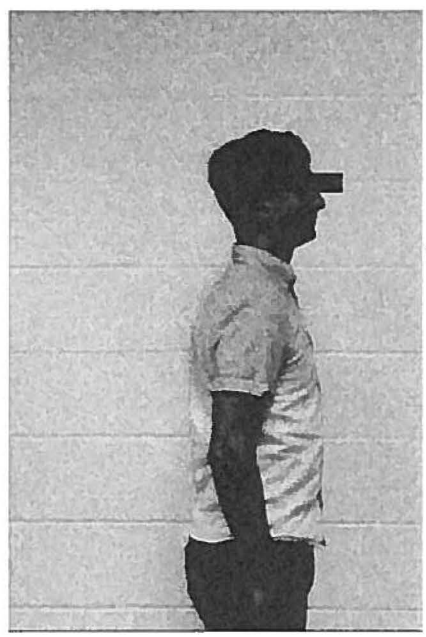



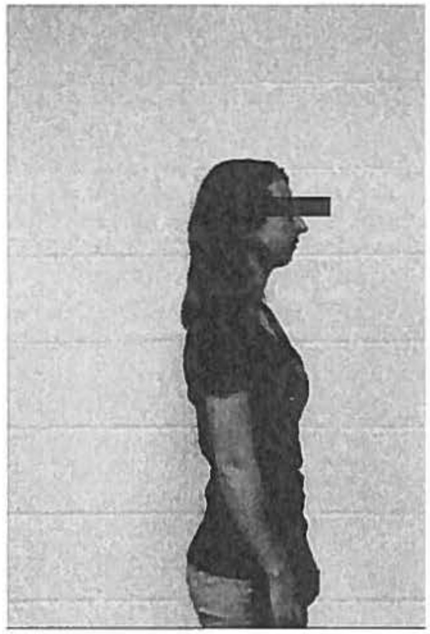







Copyright Consent

Dr. Jesse Jutkowitz gave full permission to use photos and information from his ABC manual (Jutkowtiz, 2009).

"You can use anything. Let me know if you need them in higher resolution or want them sent digitally.

Call Linda at 203.366.2746 to get the digital ones. I am teaching in the U.K. until Monday.

Make sure you check MeningealRelease.com too.

Interested to see your stuff but I can wait. Please send me a copy when you are done.

Jesse. From my phone pardon typos"

All participants gave their consent for photos to be used in this Thesis.