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Effect of Tart Cherry Concentrate on Pain, inflammation, and Strength

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The purpose of this double-blinded, randomized control study was to assess the impact of tart cherry concentrate on pain, inflammation, and strength in resistance-trained males \( (n = 24) \). Specifically, it analyzed the impact of tart cherry supplementation following an eccentric exercise protocol without the use of NSAIDs. Participants received their supplementation of either tart cherry concentrate (TC) or the placebo (PL) to consume over 8 consecutive days. Participants supplemented twice daily with either the TC concentrate (one ounce of concentrate mixed with water) or the placebo. On day 5 of the study, participants completed an eccentric knee extension exercise with their right leg. Blood samples, maximum voluntary contraction (MVC), and pain were assessed at baseline, 48 hours and 72 hours after the eccentric exercise.

Pain was measured using the Visual Analog Scale (VAS). Inflammatory markers included SAA and CRP. Strength was assessed through MVC. The results of this study indicated there were no favorable significant differences in pain, inflammation or strength between groups or over time \( (p > 0.05) \). Future research should target the mechanism of action of tart cherries in order to better understand the potential protective effect on muscle damage.
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EFFECT OF TART CHERRY CONCENTRATE ON PAIN, INFLAMMATION, AND STRENGTH

BY
NATASHA KIRKBRIDE
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A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
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Thesis Director:
Dr. Judith Lukaszuk
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CHAPTER 1

INTRODUCTION

Hundreds of thousands of athletes train vigorously every day, whether competitively, or recreationally. The consistent breakdown of muscle calls for additional nutrients to promote muscle anabolism. A combination of the need to accelerate muscle recovery and increase nutrients to improve muscle recovery prompts the idea of using an antioxidant to assist in muscle recovery. Due to strenuous activity induced by exercise muscle soreness, inflammation and pain occur. Currently, one of the most accepted practices among athletes is NSAID use. However, despite the fact that NSAIDs decrease muscle soreness and inflammation, Mikkelsen et al. (2009) showed that NSAID use negatively affects satellite cell production after eccentric exercise. Satellite cell development is essential in repairing micro-muscle tears following resistance exercise. These findings suggest NSAID use may blunt the muscle’s ability to properly repair DOMS related micro-muscle tears. This, in turn, would negatively affect strength and power training adaptations.

Tart cherry juice has numerous benefits that lend its use to be optimal for assisting in sports performance. It has a high antioxidant potential as measured by laboratory tests and contains a number of compounds that fight free radicals. It has shown to decrease muscle soreness, improve strength following exercise, and decrease inflammatory markers. Not only is there evidence for enhanced sports performance, but it has shown to decrease fat, sugar, and insulin levels in the blood, providing beneficial metabolic effects. The antioxidant property
may also mitigate oxidative stress following exercise in the elderly. The benefits of TC (tart cherries) provide a strong basis for the use in sports nutrition. TC supplementation has been studied in athletics, specifically among runners, non-resistance trained males, water polo players, professional male soccer players and two studies assessed the impact on resistance-trained males. By utilizing an eccentric protocol, the functional recovery of resistance training can be assessed. To our knowledge only two studies have assessed the effects of pain and inflammation in lower extremities (knee extension), but one of the studies did not instruct subjects to restrict NSAIDs for the duration of the study. Since NSAID use blunts muscle strength, resistance-trained individuals are the population of interest. Due to a number of discrepancies, the current tart cherry research is inadequate to demonstrate the effect of on performance in resistance-trained athletes. Therefore, this study aimed to examine a natural alternative to NSAIDs by creating an inflamed environment to evaluate the effect of tart cherries on pain, inflammation, and strength.

**Statement of the Research Problem**

A large number of athletes from recreational to competitive have a need to decrease pain, inflammation, and strength caused by resistance training. Due to this need, many turn to NSAID consumption. Therefore, there is a need for quality research to evaluate a natural source to attenuate those markers for those athletes who may be interested. Tart cherries have emerged as a means to assist markers of muscle damage. The purpose of this randomized, double-blind, placebo-controlled, experimental design was to determine the effect of 8-day supplementation of TC concentrate on pain, inflammation, and strength. Tart cherry concentrate will significantly attenuate inflammation, pain, and strength in resistance-trained individuals versus a placebo.
The Independent Variable

Identification of the Independent Variable

Tart Cherry Concentrate (TC): 100% tart cherry concentrate – King Orchards©
Placebo (PL): A beverage with similar taste and visual properties- Kool-Aid©

Nominal Definition

The nominal definition for TC supplementation consisted of a treatment group (TC) supplementing twice a day (once in the morning and once in the afternoon) for eight days versus consuming a placebo (PL) using the same supplementation period.

Tart cherry concentrate group (TC): subjects consumed 1 oz TC concentrate of a commercially formulated product mixed with 4 oz of water, twice a day.

Placebo group (PL): subjects consumed 4 oz of a placebo drink with similar visual and taste properties as the TC.

Operational Definition

Subjects were randomly assigned to the TC group or PL group. The placebo consisted of a beverage with similar visual and taste properties. Upon assignment, subjects were given tart cherry juice or placebo and instructed to consume two doses for eight days.
The Dependent Variables

**Dependent Variable: Pain**

The dependent variable of pain was assessed through a Visual Analog Scale (VAS).

*Nominal Definition*

VAS is a reliable measure for acute pain with well-defined threshold. VAS is a continuous scale comprised of a horizontal (HVAS) or vertical (VVAS) line, usually 10 centimeters (100 mm) in length, anchored by two verbal descriptors, one for each symptom extreme. Pain intensity is assessed with “no pain” (score of 0) and “pain as bad as it could be” or “worst imaginable pain” (score of 100 [100-mm scale]). To avoid clustering of scores around a preferred numeric value, numbers or verbal descriptors at intermediate points are not recommended.4,13,14

*Operational Definition*

For the purposes of this study, subjects completed the VAS to assess pain on two separate days (48 hours and 72 hours after the eccentric exercise).

**Dependent Variable: Inflammation**

The dependent variable of inflammation is based on the measurement of CRP and SAA levels.

*Nominal Definition*

Strenuous exercise has shown to dramatically increase the inflammatory response of C-reactive protein (CRP).16 Serum amyloid A (SAA) is a highly conserved acute-phase protein, released in response to inflammation or infection.17
Operational Definition

Both CRP and SAA were based on detection ranges.

Dependent Variable: Strength

Strength was assessed through maximum voluntary contractions (MVC) through the dynamometer.

Nominal Definition

Muscular strength refers to the maximal force (expressed in either Newtons or kg) that can be generated by a specific muscle or muscle group. Static or isometric strength can be measured conveniently using a variety of devices, including cable tensiometers and handgrip dynamometers. In this study the CSMi Humac Norm dynamometer was used. Peak force development in such tests is commonly referred to as maximum voluntary contractions.  

Operational Definition

On day one of the study, subjects completed 3 MVC, separated by 15 second rest. Each MVC was held for 3 seconds. Subjects returned to the laboratory 48 hours and 72 hours post-exercise and completed three leg-extension MVC. The average and peak of all 3 MVC was recorded.
Research Questions and Hypotheses

Research Questions:

1. What is the effect of tart cherry concentrate on pain in resistance-trained individuals completing eccentric muscle contractions?

2. What is the effect of tart cherry concentrate on inflammation in resistance-trained individuals completing eccentric muscle contractions?

3. What is the effect of tart cherry concentrate on strength in resistance-trained individuals completing eccentric muscle contractions?

Hypotheses:

1. Tart cherry concentrate will decrease pain following eccentric muscle contractions in the tart cherry group compared to individuals consuming the placebo.

2. Tart cherry concentrate will decrease inflammatory markers, following eccentric muscle contractions in the tart cherry group compared to individuals consuming the placebo.

3. Tart cherry concentrate will attenuate strength loss, following eccentric muscle contractions in the tart cherry group compared to individuals consuming the placebo.
Background and Significance

NSAIDS

Research has shown that millions of people, including athletes, use non-steroidal anti-inflammatory drugs (NSAIDs) to help reduce pain and inflammation. The COX enzymes (COX-1 and COX-2) produce prostaglandins that promote inflammation and pain, in response to injury. Inhibition of these enzymes may reduce inflammation (if present) and pain, hence the use of NSAIDs. However, studies have yielded inconsistent results in regards to the efficacy of anti-inflammatory drugs on reducing muscle soreness from intense exercise. One study looked at the effects of saffron versus indomethacin (NSAID) on DOMS post eccentric exercise. The indomethacin experienced pain prior to 72 hours while the saffron group did not. Some studies have shown improvements of muscle recovery and prevention of exercise-induced fatigue, while other studies have displayed opposite results. However, despite the fact that NSAIDs decrease muscle soreness and inflammation, Mikkelsen et al. (2009) showed that NSAID use negatively affects satellite cell production after eccentric exercise. Satellite cell development is essential in repairing micro-muscle tears following resistance exercise. Although NSAID use may attenuate pain, these findings imply NSAID use may prevent the muscle’s ability to properly repair DOMS related micro-muscle tears. This, in turn, would negatively affect strength and power training adaptations.

NSAID Use in Athletes and Side Effects

Studies show that 50% of World Cup Soccer players consumed NSAIDs during World Cup tournaments. Also, during the Atlanta and Sydney Olympic games, NSAIDs use in all athletes was 33% and 38%, respectively. Athletes use NSAIDs and have shown to use them for
providing that the main reason for use was injury treatment and the only known adverse side effect noted by majority of athletes was gastrointestinal complications.\textsuperscript{30} Additionally, research has shown that 29\% of college athletes consume NSAIDS as a preventative measure.\textsuperscript{31} Although athletes use NSAIDs, its side affects involve the gastrointestinal tract, cardiovascular system, kidneys and liver.\textsuperscript{32,33} Specifically, when NSAID doses were taken regularly for one month, the relative risk bleeding in the upper gastrointestinal tract was much higher than in controls.\textsuperscript{32} These findings demonstrate that NSAIDs are not an optimal solution for athletes seeking aid to their soreness and assistance to their performance.

**Tart Cherries**

If athletes consume NSAIDs and supplements as a means to decrease pain and influence performance, assessing an alternate route to assist those markers would be of high interest. Sweet and tart cherries both contain high levels of antioxidants including melatonin, carotenoids, hydroxycinnamates, and several flavonoid groups including anthocyanins, as well as the flavonol quercetin.\textsuperscript{34}

**Anti-Inflammatory and Antioxidant Role**

Tart cherries have anti-inflammatory and antioxidant properties. Anthocyanins are plant pigments found mostly in the skin of plants and provide the color to many fruits and vegetables.\textsuperscript{36} Research has shown that anthocyanin content in cherry juice and reduced cell damage are correlated. One study assessed anthocyanin function of tart cherries in mice. The TC increased the enzyme superoxide dismutase, a free radical scavenger, and glutathione peroxidase, an enzyme important in the removal of hydrogen peroxide.\textsuperscript{2}
Tart cherries’ ability to fight oxidation has been examined by comparing its antioxidant capacity to fruits. Using an ORAC (oxygen radical absorbance capacity) assay, the antioxidant capacity showed a range from 1,145 to 1,916 µmol Trolox equivalents (TE)/100 g in tart cherries. The values found in tart cherries are comparable to those found in some berry fruits, strawberry, and are higher than in apple and kiwis.

**Antioxidant Mechanism**

Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are produced in reaction to dietary xenobiotics, normal biochemical reactions in our body, and increased exposure to the environment. The ROS and RNS create oxidative stress in different pathophysiological conditions. The reported chemical evidence suggests that dietary antioxidants help in disease prevention. The antioxidant compounds react in one-electron reactions with free radicals *in vivo*/*in vitro* and prevent oxidative damage. Antioxidant activity can be categorized into enzymatic or non-enzymatic. The breakdown and removal of free radicals into hydrogen peroxide and then water is the progression of an enzymatic antioxidant. This process requires cofactors such as zinc, copper, and iron. A non-enzymatic reaction works by interrupting free radical chain reactions. A few examples of the non-enzymatic antioxidants are vitamin C, vitamin E, plant polyphenol, carotenoids, and glutathione. This antioxidant function of tart cherry juice is related to its anthocyanin content.

**Exercise**

Several studies have assessed the impact of TC from exercise induced soreness, inflammation, oxidative stress, etc. Sports have included resistance-trained exercise.
running, water polo, and soccer players. In order to show the affect of TC on markers of inflammation, pain and strength, a strenuous activity must catalyze the symptoms. Eccentric exercises have been associated to morphological alterations of the muscle, such as myofibrillar disruption, disturbance of the extracellular matrix, and an inflammatory reaction, which results in delayed onset muscle soreness (DOMS) and muscle stiffness.40-42 An eccentric muscle contraction is produced when the force applied to the muscle exceeds the momentary force produced by the muscle and results in a lengthening action (i.e. work is done on the muscle).43 One of the most common results of eccentric exercises, often because it is an unaccustomed activity, is the delayed onset of pain; this is usually accompanied by functional changes/damages to muscle fibers.43 Because this study aimed to utilize a strenuous activity upon participants, an eccentric exercise protocol was used in this study as the means to induce muscle soreness, pain and inflammation.

Inflammatory markers: CRP and SAA

C-reactive protein (CRP) was one of two blood markers assessed in this study to determine inflammation. CRP is an acute-phase reactant. Plasma CRP concentrations increases rapidly and dramatically (100-fold or more) in response to tissue injury or inflammation.44 Previous studies assessing the impact of TC have used hs-CRP and CRP as markers of inflammation following exercise. Howatson et al. used CRP, IL-6 and uric acid, assessing the influence of TC juice on marathon runners. All markers were significantly reduced in the TC juice group.4

Serum amyloid A (SAA) is a highly conserved acute-phase protein, produced by hepatocytes released in response to inflammation or infection. Production of acute-phase SAA
(A-SAA) is stimulated by proinflammatory cytokines, such as interleukin-6 (IL-6), IL-1, tumor necrosis factor (TNF), interferon-γ, and transforming growth factor- (TGF-). The concentration of A-SAA increases dramatically during acute inflammation and injury, reaching within 5-6 hours levels that are 1000-fold greater than normal. To our knowledge only one other study has used SAA as a marker of inflammation in response to TC, however this study assessed TC and its affect on horses, so the current study is the first to assess the attenuation of SAA using TC on human body inflammation post-exercise.

Previous studies which showed supplementation success with tart cherry concentrates and cultivar juice blends, prompted an increase in exercise-based research to prove beneficial effects in mitigating muscle damage, oxidative stress, inflammation, and muscle pain providing motivation to increase performance. This study was conducted to prompt resistance training individuals to gravitate towards pursuing a natural, compound rather than synthetic to assist in inflammation, pain and strength.
CHAPTER II

REVIEW OF LITERATURE

Historically athletes participating in strenuous exercise have taken over the counter drugs such as NSAIDs in order to attenuate their muscle soreness and fatigue. Although NSAIDs are effective in attenuating muscle pain\textsuperscript{22-23} negative side affects associated with taking NSAIDs, include increased rates of acute kidney injury\textsuperscript{33}, GI bleeding,\textsuperscript{32} increase in arterial blood pressure,\textsuperscript{46} increased risk of stroke and cardiovascular death.\textsuperscript{37} Tart cherries, specifically in the form of concentrate have been shown to have effects similar to that of NSAIDs, without detrimental health affects. The anthocyanin content in TC makes it a favorable substitute to NSAID consumption. Anthocyanin is the key ingredient to the antioxidant property of TC. The ROS and RNS, produced in response to normal biochemical reactions in our body and increased exposure to the environment, create oxidative stress in different pathophysiological conditions. The antioxidant role, demonstrated in TC, prevents and mitigates oxidative damage.\textsuperscript{11,46} The means to induce muscle damage in current literature has ranged including cycling,\textsuperscript{56} running,\textsuperscript{4,7} and soccer.\textsuperscript{8} Few studies have been conducted using eccentric exercise to induce muscle damage and to assess TC affect on resistance-trained individuals. This indicates a need to evaluate the effect of TC utilizing an eccentric only exercise protocol and including resistance- trained individuals.

Registered dietitians and other health professionals play an important role by keeping up to date with evidence-based research in order to provide accurate and sound recommendations to
individuals seeking treatment or prevention of muscle damage. The natural source of TC in response to vigorous exercise makes it an ideal candidate for registered dietitians and health professionals to consider. However, more research is still needed. Although the exact mechanism of TC is unclear, its effect has been observed in several studies over the past decade. Some studies have used TC juice and some have used TC concentrate. Both have shown beneficial results. Inflammation, shown through some inflammatory markers, has decreased in response to TC consumption. Strength and pain has also shown to improve in several studies as well. The purpose of this literature review is to examine the current research that has evaluated the effect of TC on inflammation, strength and pain, as well as studies that have used eccentric exercise.

**Markers of Inflammation**

Studies that have assessed the effect of cherries on inflammation have used various markers to measure its impact. Howatson et al. used CRP, IL-6 and uric acid, assessing the influence of TC juice on marathon runners. All markers were significantly reduced in the TC juice group. Bowtell et al. used hs-CRP and nitrotyrosine, and found no significant changes over time or between groups for those markers. McCormick et al. found no differences between TC and placebo groups for inflammatory markers IL-6 and CRP. However this study found no significant differences for any of the markers and indicated that TC juice may have minimal to no effect on non-weight bearing sports, such as the water polo participants in the study.

Bell et al. assessed the attenuation of TC concentrate on semi-professional male soccer players. This double blind, placebo-controlled design used the Loughborough Intermittent Shuttle Test. Markers of inflammation were IL-1-β, IL-6, TNF-α, and hs-CRP. There was a
significant main effect for hs-CRP, however no significant group effect. TC significantly attenuated IL-6 and showed significant interaction effects. The discrepancy between IL-6 and hs-CRP suggest that research should further this area to identify the mechanism that solves the difference in findings.\(^8\)

The only study to conduct an assessment on the affect of TC concentrate on high-intensity stochastic cycling included 16 well-trained cyclists. Blood samples were obtained and analysis was conducted on IL-6, TNF-a, IL-8, IL-1-B, and hs-CRP. Significant differences were found for hs-CRP across all time points and IL-6, both lower in the TC group compared to placebo. No other markers showed significant differences.\(^5,6\) The results of hs-CRP agree with previous research,\(^4\) but disagree with others.\(^5,8,9\)

Levers et al. did not find any significant differences in resistance-trained males for any inflammatory markers, using interleukin-1\(\beta\), IL-2, IL-4, IL-5, IL-6, IL-7, IL-8, IL-10, IL-12p70, IL-13, tumor necrosis factor-\(\alpha\), interferon-\(\gamma\), and granulocyte-macrophage colony-stimulating factor GM-CSF.\(^9\)

There are several discrepancies in the results of inflammatory markers, post TC consumption. The current study uses CRP. Out of the two studies that did use hs-CRP, Bowtell et al., did not exclude for NSAID consumption, which may have influenced hs-CRP. Bell et al. used hs-CRP as a marker, but did not find differences between groups. However, the current study will use CRP because it has been shown to be an accurate indicator in strenuous exercise environments.\(^16\) Serum amyloid A (SAA), a total body inflammatory marker, was not used in any of the studies that have assessed the effect of TC on inflammation. Though it has been deemed a sensitive marker of inflammation, this study was the first study to assess SAA in response to eccentric exercise, following TC consumption.
**Strength**

To assess the attenuation of TC concentrate on strength, measurements were taken both before and after the TC supplementation period. In Connolly et al., following three days of TC juice supplementation, a bout of eccentric elbow flexion contractions was performed on the fourth day of supplementation. Isometric elbow flexion strength, pain, muscle tenderness, and relaxed elbow angle were recorded before and for four consecutive days after the eccentric exercise. Connolly et al. showed isometric elbow flexion strength loss was significantly greater in the placebo trial than the cherry juice trial. Howatson et al. showed similar results, following TC juice consumption, isometric strength recovered significantly faster in the TC group than placebo.

Bowtell et al. showed that MVC force recovery was significantly faster after cherry juice consumption than placebo consumption as well. However, it is important to note that this study did not exclude for NSAID consumption. MVC was also superior 72 h post-exercise in the TC group compared to placebo in the study assessing male soccer players.

**Pain**

In addition to the variables of inflammation and strength, pain was assessed as well. Research has shown the development of pain in the elbow flexors after eccentric exercise is significantly different in the placebo and cherry juice trials. Bowtell et al., measured pain pressure threshold to assess pain. There was a significant reduction in pain pressure threshold after 24 and 48 hours of recovery from the exercise protocol, however there was no significant difference between groups. Two studies assessing runners used the VAS (Visual Analog Scale) to assess pain. Kuehl et al. included runners following a relay race and showed that the increase
in pain was significantly smaller in the cherry juice group compared with the placebo group.\textsuperscript{7} Conversely, no differences were found for DOMS, in marathon runners.\textsuperscript{4} A VAS was used to assess pain in the current study.

\textbf{Resistance Trained Individuals}

Resistance training is a common means of exercise to increase muscle mass, to improve sports performance, and for rehabilitation. To our knowledge, only three studies have assessed the effect of TC on resistance-trained individuals.\textsuperscript{5,6,9} Connolly assessed the impact of TC juice using a randomized, placebo controlled, crossover design focusing on upper extremities. Participants included fourteen male college students, who had no upper extremity resistance training over the past 3 months. Isometric elbow flexion strength, pain, muscle tenderness, and relaxed elbow angle were recorded before and for four days (baseline, 24, 48, 72, and 96 hours) after the eccentric exercise. Results showed strength loss and development of pain was significantly greater in the placebo group than the cherry juice group.

These findings reveal there is a significant effect on strength loss and pain when individuals with limited upper body strength consume tart cherry juice. Furthermore, this indicates tart cherry juice has a protective effect by preserving muscle. Limitations of this study include a small sample size. In addition, this study was completed on individuals who had “no upper extremity strength training for the past 3 months”, which does not account for ADL that may assist in arm strength (e.g. type of job, house hold chores, etc). One of the main strengths in the study was that it instructed participants to not consume NSAIDs nor to seek any other treatment for any symptoms of muscle damage, and not to exercise their upper extremities during the study.\textsuperscript{6}
Connolly aimed to focus on individuals who had no upper extremity training within the past three months to help eliminate upper extremity resistance-trained individuals. The current study included resistance-trained individuals, who have been training for at least 6 months. Although Connolly et al. provided information in regards to pain, strength, and muscle soreness, no blood samples were taken, so markers of inflammation were not assessed.⁶

Levers et al. conducted a randomized, double-blind, placebo-controlled study with a total of 23 participants. Inclusion criteria comprised of participants involved in a resistance-training program with regular squat exercise for at least six months prior to study recruitment. The placebo and treatment group were matched based on back squat strength, age, body weight, and fat free mass. This study utilized powdered tart cherries as the supplement form (480 g), equivalent to 10.5 oz of TC juice, consumed once a day at breakfast. Participants supplemented for 10 days up to 48 hours post-exercise. The exercise used to induce muscle damage was ten sets of ten repetitions (non-eccentric) of a barbell back squat at 70 % 1-RM with 3-min recovery between sets. Prior to all testing days, participants were asked to refrain from exercise and NSAID use for 48 hours. Dietary intake was recorded, muscle soreness was measured through pressure application, and anthropometrics and body composition was measured. Blood samples were obtained to measure several markers, including markers of inflammation, protein, and fatty acid metabolism.⁹

Results regarding perceptions of muscle soreness indicated a significant overall time interaction and non-significant overall group by time effect. Significant TC group reductions from pre-lift levels were found for AST and creatinine 48-h post-lift, bilirubin and ALT 60-min and 48-h post-lift. Significant differences were found lowered in TC for serum and total protein over time and smaller from pre-lift levels over time compared to placebo. No significant
differences were found for isokinetic strength recovery, markers of mechanical damage, physiological stress, and inflammatory or anti-inflammatory markers.\(^9\)

This study was the first to use a powdered form of tart cherries rather than juice or concentrate. Levers et al. showed that short-term supplementation is shown to be effective in reducing muscle soreness, but not for inflammation and oxidative stress, displaying the need for future research to target those variables of exercise-induced inflammation and oxidative stress. Other studies that used hs-CRP and IL-6 as an inflammatory marker also showed no significant differences with supplementation.\(^5\,8\) Lever’s study implies the powdered tart cherry form of supplementation may not attenuate markers of inflammation, strength recovery, or mechanical damage and physiological stress. Limitations include the potential nutrition and hydration differences between groups, which may have contributed to variability as a hemodynamic marker or performance measure. Additionally, the NSAID restriction of 48-hours prior to the study may not have been enough.

The final study related to resistance-training and TC supplementation was a randomized, placebo controlled, crossover design, but focused on lower extremities. Bowtell et al. included 10 well-trained males who had participated in high-intensity intermittent sports and regularly performed resistance training. Exclusion criteria included cardiorespiratory and neuromuscular problems and acute knee/ankle injuries and pain. Participants completed two main trials, which were separated by a two-week washout period, with alternate legs used in each trial. Participants consumed 30 mL twice a day of each supplement (TC concentrate or placebo) for 7 d before and 48 h after exercise. Blood samples and knee extension maximum voluntary contractions (MVC) were performed before, immediately after, and 24 and 48 h after the eccentric exercise. Muscle soreness was measured through algometer. Serum was analyzed for creatine kinase (CK)
activity, nitrotyrosine, hs-CRP, total antioxidant capacity, and protein carbonyls (PC). Pressure pain threshold was also recorded. Results showed that MVC force recovery was significantly faster after TC consumption than placebo. Only serum CK and PC increased significantly from baseline, peaking 24 h after exercise. The exercise-induced increase in CK activity was not different between trials. However, both the percentage and absolute increase in PC was lower in TC than in placebo. There was no significant change over time nor between trials on total serum nitrotyrosine or hs-CRP or in serum total antioxidant capacity.\(^5\)

This study indicates that knee extensor maximum isometric strength was enhanced after consuming Montmorency cherries for seven days before and two days after an intensive knee extensor resistance training session. Although no markers of muscle damage or inflammation were positively affected by TC consumption, there was reduction in serum PC indicative of reduced oxidative damage. Consumption of TC did not seem to be appropriate for providing a protective effect, but that it will help assist functional recovery.\(^5\) The primary limitation to this study was that participants had no instruction related to NSAIDs for the duration of the study. This means results of inflammation, pain, and strength could be attributed to NSAID consumption. It also included a small sample size \((n = 10)\). The current study included a larger sample size \((n=24)\). Participants were instructed to restrict NSAIDs 48 hours prior to collecting baseline data and they were asked to refrain from strenuous exercise, limiting activity to walking and light biking, for the duration of the study.\(^5\)

**Eccentric Exercise**

An eccentric exercise protocol was used to induce pain, strength loss, and inflammation in the current study. Other studies have used an eccentric exercise regimen to induce similar
markers as well.\textsuperscript{5,6,9} For the exercise regimen, Connolly et al. used a modified curl apparatus for the onset of DOMS using two sets of 20 repetitions maximal contractions of the elbow flexors. Participants applied maximal resistance, while the researcher forced the elbow into full extension. Participants performed the two sets of maximal eccentric contractions, with the eccentric phase lasting about three seconds. A 12 second rest was allowed between actions.\textsuperscript{6}

Bowtell et al. first had participants, complete a warm-up of three sets of five repetitions at 50\% 1RM. Participants then completed 10 sets of 10 single-leg knee extensions at 80\% of their 1RM with elongated eccentric phase (lasting 3 s); each set was separated by 2 min of rest. If participants were unable to sustain the workload, weight was decreased by 10\%, and this was then matched during the second trial on the alternate leg. After completing the 10 sets, participants were asked to repeat the three MVC, with the first performed immediately after the last set; subsequently, each MVC was separated by 2 min of rest.\textsuperscript{5} This study followed a similar eccentric exercise protocol as Bowtell et al.\textsuperscript{5}

Kuehl et al. did not use an eccentric exercise protocol, but to induce and mimic damage of eccentric exercise included participants running the Hood to Coast relay race. Relays included 12 runners who completed three segments each with distances ranging from 5.6 to 12.4 km. The race expanded over two mountain ranges, providing opportunity for eccentric muscle damage through the hilly course. Results indicated that upon completion of the race, increase in pain was significantly smaller in the cherry juice group compared with the placebo group.\textsuperscript{7}

Summary
While some studies have been conducted to show the attenuation of TC on pain, inflammation, and strength, there is a need to show the impact of all three variables on
resistance-trained males. Since NSAID use blunts muscle strength, resistance-trained individuals are the population of interest. Due to a number of discrepancies, the current tart cherry research is inadequate to demonstrate the effect on performance in resistance-trained athletes. Therefore, this study’s goal was to examine a natural alternative to NSAIDs by creating an inflamed environment to evaluate the effect of tart cherries on inflammation, pain, and strength. Individuals who do not have adequate nutrition education may be consuming products that do not aid their performance. The purpose of this study therefore was to assess the impact of the tart cherry concentrate on pain, inflammation and strength in order to improve performance for athletes in the future.
CHAPTER III

METHODOLOGY

Participants

Twenty-six resistance-trained males aged 18-29 participated in this study. One participant dropped out and there was not enough plasma available for the other participant, so 24 participants completed the study. Subjects were recruited from Northern Illinois University’s campus classes. Exclusion criteria was anyone who had any blood related conditions or transmitted diseases, cardiorespiratory conditions, past or present knee injuries, or anyone who had not been strength training for at least six months. All subjects were informed of the risks and benefits associated with this investigation and were given written consent (Appendix A) to participate in accordance with Northern Illinois’ Institutional Review Board and Institutional Biosafety Committee (Appendix B).

Experimental Design

This study used a randomized, double-blind, placebo-controlled, experimental design. Subjects were assigned a number and then through a computer random number generator were randomly assigned to either the tart cherry concentrate (TC) or a placebo (PL) group. Participants received-either 1 oz. of Montmorency TC concentrate (King Orchards©; Central Lake, MI) mixed with 4 oz of water or an equivalent placebo (Black Cherry Kool-Aid) twice daily for 8 consecutive days. Subjects reported to the kinesiology laboratory at NIU, on days
one, five, seven and eight of the study. On day one, subjects reported to the laboratory for assessment of pain (Visual Analog Scale), strength (CSMi Humac Norm 770 dynamometer, Stoughton, MA, 2009) and baseline inflammation (blood samples). They received and consumed their first dose of supplementation after their baseline testing in the morning and continued the supplementation through the end of the study (days one-eight). They completed the eccentric exercise on day five. On day seven (48 hours after supplementation), subjects reported to the laboratory for assessment of pain, strength and inflammation (blood samples). This was repeated on day eight (72 hours after the eccentric exercise protocol). The study concluded on day eight, the follow-up testing of pain, inflammation, and strength (see Table 1).

**Estimating Sample Size**

A statistical analysis program called G*Power (3.1.9.3; Erdfelder, Faul, & Buchner, 2007) was used to determine a priori the minimum sample size needed given alpha = .05, power = .80, the effect size anticipated = .25 (‘medium’), the number of groups (C and T) = 2, and the noted measures (n= 3) over time (baseline, 48 h, 72 h). Based on this set up, ideally, a minimum of \( n = 36 \) subjects is used to control for a type II error. However, most studies that utilized a similar design have included between 9-23 participants.\(^{4-6, 8, 9, 12}\)
Table 1: Study Timeline

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Testing:</td>
<td>Anthropometrics (Ht, Wt, Body Comp)</td>
</tr>
<tr>
<td>Day one</td>
<td>Measure Strength (MVC)</td>
</tr>
<tr>
<td></td>
<td>Assess Pain (VAS)</td>
</tr>
<tr>
<td></td>
<td>Obtain blood samples- Inflammatory Markers (CRP, SAA)</td>
</tr>
<tr>
<td></td>
<td>Random Assignment (TC or PL)</td>
</tr>
<tr>
<td>Supplementation:</td>
<td>1 oz TC (+4 oz water) OR 4 oz PL 2x/day</td>
</tr>
<tr>
<td>Day 1-8</td>
<td></td>
</tr>
<tr>
<td>Eccentric Exercise:</td>
<td>Knee Extension:</td>
</tr>
<tr>
<td>Day five</td>
<td>Right leg</td>
</tr>
<tr>
<td>Post-Exercise Testing:</td>
<td>Pain Measurement (VAS)</td>
</tr>
<tr>
<td>48 h, 72 h (Day seven, Day eight)</td>
<td>Strength (MVC)</td>
</tr>
<tr>
<td></td>
<td>Obtain blood samples- Inflammatory Markers (CRP, SAA)</td>
</tr>
</tbody>
</table>
Procedure

Preliminary Screening

Prior to random assignment, subjects completed a blood questionnaire, a HHQ, and a screening questionnaire (Appendix C). Screening questionnaires were distributed in the classes and then were collected once complete. Individuals who qualified were contacted via e-mail.

Researchers instructed the subjects to not participate in any lower extremity exercises 48 hours prior to the start of the study and throughout the duration of the study. This included: running, vigorous biking, lifting weights, hiking, etc. Moderate lower extremity exercises, such as light biking and walking were permitted. Subjects were allowed to participate in upper extremity exercises. Subjects were also requested to refrain from NSAID consumption 48 hours prior to the study and not to seek any other treatment for any symptoms of muscle damage. Lastly, subjects were asked to maintain their current diet.

Baseline Testing

Anthropometrics

Height, weight and body composition were obtained on day one of the study in Anderson Hall. Weight, fat mass, body fat percent, fat mass, fat free mass, and body mass index (BMI) were assessed using a bioelectrical impedance scale (Tanita 520 Arlington Heights, IL). Height was measured using a wall-mounted stadiometer (Ayrton S-100 Prior Lake, MN).

Supplementation

TC concentrate or a PL identical in appearance and taste were measured and labeled by a 3rd party individual to ensure that the study remained double blind. Subjects received 1 ounce of
TC concentrate mixed with 4 ounces of water or 4 ounces of black cherry Kool-aid as the PL (twice daily) for 8 consecutive days (days 1-8).

**Strength Protocol**

Determination of 1-repetition max (RM), in order to measure strength using maximal voluntary contraction (MVC), was conducted on day one. In order to determine 1-RM, the protocol followed ACSM handbook of 1-RM (Balady, 2000). 1-RM is the maximal weight that can be lifted once with correct lifting technique (Appendix D). 1-RM was measured on a knee extension machine using the right leg only. Based off the weight the participant could lift, and using the measurement of the knee to ankle of, a conversion from pounds to Newton- meters (NM) was used. Participants then used their right leg for the assessment of MVC.

MVC assessed strength using the CSMi Humac Norm dynamometer machine (CSMi Humac Norm 770 dynamometer, Stoughton, MA, 2009). Subjects were each assigned to a profile within the system. Subjects completed maximal isometric knee flexion at a 90 degree angle to allow for the optimal length of the quadriceps femoris to produce maximal force. MVC was averaged and the average of the three and peak strength was recorded. All data were recorded in Newton-meters. The results were obtained from the dynamometer.

**Pain**

Participants were asked to rate their pain scale on the Visual Analog Scale (VAS) on the day of baseline testing. Participants were given the 100 mm VAS and asked to make a mark on the line which most described their level of pain with general mobility. The VAS used in this study was marked with the anchors of “no pain” to “worst imaginable pain”.
Blood Sampling: SAA and CRP

Blood was collected from a forearm vein by trained phlebotomists (Appendix E) between 10 am and noon, on days one, seven and eight. Blood samples were collected in two 5.0 mL tiger tubes serum separator tubes. Once blood coagulated (usually within 10-20 minutes of being drawn) samples were centrifuged (Compact Centrifuge Clay-Adams, Beckton Dickinson Company) for 15 min at 3000 g to separate plasma from whole blood. Plasma was pipetted off and stored in microcuvette tubes which were frozen at minus 20 degrees C until further analysis. Samples were transported on ice to NIU Medical Laboratory Sciences department and stored in a minus 20 Celsius freezer until further analyzed.

Serum samples were analyzed for SAA and CRP. Commercially available enzyme-linked immunosorbent assay (ELISA) kits were used to measure the plasma concentrations for C-reactive protein (CRP) and serum amyloid A (SAA). C-reactive protein samples (CRP) were analyzed in triplicate using ELISA kits. Plasma concentrations of each marker were calculated by comparison to a pre-established standard curve. Serum amyloid A was measured using sandwich ELISA and concentrations of each marker was first established running a separate 7 point standard curve. Once the appropriate concentration was established SAA levels were analyzed on a separate day.

Eccentric Exercise

On day five of the study, subjects completed the knee extension eccentric exercise protocol. Eccentric training occurs when the muscle is forcibly lengthened or elongated. An eccentric contraction results when the force produced inside the muscle is less than what is
applied to the muscle externally and results in active lengthening of the muscle fibers under some level of load. This protocol utilized the eccentric duration of 3 seconds and was as follows:

This protocol follows the similar protocol of Bowtell et al. and also was reviewed by a certified strength and conditioning specialist. Subjects began with a warm up of 3 minutes biking at moderate resistance. Subjects then completed a warm up of three sets of five repetitions at 50% maximal effort, each separated by a 30-second rest period. Subjects then completed 6 sets of single-leg knee extension starting at about 85% of their 1-RM with an elongated eccentric phase (lasting 5 s) to failure; each set was separated by a 1-minute rest. (An exact 85% could not be obtained because the specific dynamometer used does not increase by increments less than 25 NM). If subjects were unable to maintain the workload, the load was decreased by 25 NM. If subjects exceeded 15 repetitions after the second set, the load was increased by 25 NM. Participants were told to aim between 8-12 reps for sets 1-4 and 6-8 reps sets 5 and 6. Assistants were available to assist in lifting the arm of the dynamometer for the concentric movement, only if the participant was struggling to lift the arm. Participants were not assisted for the eccentric phase. Participants rate of perceived exertion (RPE) was recorded after each set to ensure an RPE between 16-17 by set 4 and to ensure an RPE of 18-20 sets 5 and 6; this encouraged maximal effort. Subjects received verbal encouragement to perform to their maximum potential throughout the exercise protocol (See Appendix F for knee extension procedure on dynamometer).
Follow-up Testing

Subjects reported back to the laboratory 48 h and 72 h post-exercise to measure MVC, pain, and obtain blood samples. Subjects completed the warm up and then three MVC separated by a 15-second rest. All tests using the Humac used the right leg. Subjects used the VAS to assess pain, and trained phlebotomists collected blood samples.

Description of Instrument

Visual Analog Scale

The Visual Analog Scale (VAS) is a unidimensional measure of pain intensity, which has been widely used in diverse adult populations (Appendix D) and has shown to have high reliability.\(^\text{13}\) For pain intensity, the scale is most commonly anchored by “no pain” (score of 0) and “pain as bad as it could be” or “worst imaginable pain” (score of 100 [100-mm scale]). In this study, the descriptive words used as anchors were “no pain” and “worst imaginable pain”. The pain VAS is self-reported by the participant. The respondent is asked to place a line perpendicular to the VAS line at the point that represents their pain intensity. Using a ruler, the score is determined by measuring the distance (mm) on the 10-cm line between the “no pain” anchor and the patient's mark, providing a range of scores from 0–100. In this study, participants were asked to report their level pain with general mobility (walking, sitting, standing).

Normative values have not been determined. In a study assessing the acute measurement of the VAS among patients at two emergency departments, the summary intraclass correlation coefficients for all paired VAS scores was 0.97 [95% CI = 0.96 to 0.98]. The Bland-Altman analysis showed that 50% of the paired measurements were within 2 mm of one another, 90% were within 9 mm, and 95% were within 16 mm. The paired measurements were more reproducible at the extremes of pain intensity than at moderate levels of pain.\(^\text{13}\) Test–retest
reliability has been shown to be good, but higher among literate ($r = 0.94, P < 0.001$) than illiterate patients ($r = 0.71, P < 0.001$) before and after attending a rheumatology outpatient clinic.$^{51}$ Without a gold standard for pain, criterion validity has not been evaluated. For construct validity, in patients with a variety of rheumatic diseases, the pain VAS has been shown to be highly correlated with a 5-point verbal descriptive scale (“nil,” “mild,” “moderate,” “severe,” and “very severe”) and a numeric rating scale (with response options from “no pain” to “unbearable pain”), with correlations ranging from 0.71–0.78 and 0.62–0.91, respectively.$^{52}$ The correlation between vertical and horizontal orientations of the VAS is 0.99.$^{53,54}$

**Statistical Analysis**

Descriptive statistics were used to assess anthropometric variables such as height, weight, body composition, and age. This research design had two groups (TC and PL) and three measures: Pain, Strength, and Inflammation taken over time (eight days). A Split Plot (Mixed) ANOVA where the ‘Mixed’ or the ‘Split’ is the dependent variable measured over time (repeated measure - within) x the groups (TC vs. PL - between) was conducted. In order to assess the attenuation of TC on the measures of Pain, Strength, and Inflammation between groups, an independent sample t-test was used. Using the Bonferroni correction method, an alpha level of $< 0.004$ was used for the independent samples t-test to correct for type I error. An alpha level of $< 0.05$ was used for all other analyses. SAS JMP Version 12.0 (Cary, NC) was used to run statistical analyses.
CHAPTER IV

RESULTS

Participant Characteristics

A total of 24 healthy, resistance-trained men between 18-29 years old completed this study. Physical characteristics of the subjects can be found in Table 2. Descriptive statistics and independent sample t-tests were used to provide the averages of anthropometrics. A one-way ANOVA revealed no significant differences ($p > 0.05$) in anthropometric markers, including lean muscle mass.

Table 2: Physical Characteristics of Subjects

<table>
<thead>
<tr>
<th></th>
<th>Tart Cherry (n = 12)</th>
<th>Placebo (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>22.92 ± .9</td>
<td>22.58 ± .7</td>
</tr>
<tr>
<td>Ht (cm)</td>
<td>174.63 ± 2.1</td>
<td>179.20 ± 2.2</td>
</tr>
<tr>
<td>Wt (kg)</td>
<td>79.36 ± 4.4</td>
<td>84.83 ± 3.4</td>
</tr>
<tr>
<td>Lean Mass (kg)</td>
<td>66.24 ± 3.1</td>
<td>70.06 ± 2.4</td>
</tr>
<tr>
<td>Body Fat Mass (kg)</td>
<td>13.11 ± 3.3</td>
<td>14.75± 2.6</td>
</tr>
<tr>
<td>BMI</td>
<td>26.05± 1.4</td>
<td>26.32 ± .9</td>
</tr>
<tr>
<td>Body Fat %</td>
<td>15.59± 2.9</td>
<td>16.81± 2.3</td>
</tr>
</tbody>
</table>

(Mean ± SE)
Summary of Research Findings

Pain

A Split-Plot ANOVA indicated there was a statistically significant difference across the main effect time period ($p < 0.01$), which accounted for 46% of the variance. Contrast tests showed this was significant at all time points ($p < 0.05$). The perception of pain for both the TC and PL group increased over time, however, an independent sample t-test indicated there were no significant differences between groups ($p > 0.05$). Table 3 shows the average pain at baseline, 48 hours post-exercise and 72 hours post-exercise.

Table 3: 
*Visual Analog Scale (Pain) Measurement*

<table>
<thead>
<tr>
<th></th>
<th>Tart Cherry (n = 12)</th>
<th>Placebo (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain B</td>
<td>4.25 ± 2.2</td>
<td>2.67 ± 1.2</td>
</tr>
<tr>
<td>Pain 48</td>
<td>32.25 ± 7.5</td>
<td>28.67 ± 7.5</td>
</tr>
<tr>
<td>Pain 72</td>
<td>23.42 ± 7.3</td>
<td>17.83 ± 5.2</td>
</tr>
</tbody>
</table>

(Mean ± SE); VAS range: 0-100 mm

Markers of Inflammation

CRP

CRP samples were run in triplicate and showed exceptional test-retest reliability (<1% difference) using sandwich ELISA. Split Plot ANOVA, or repeated measures, was used to analyze blood markers of SAA and CRP over time.

From baseline ($M = .62$ mg/dL) to 48 hours post-exercise ($M = .63$ mg/dL), the mean CRP remained stable and showed no significant changes in the TC group. The mean CRP in the
TC group remained similar at 72- hours post-exercise as well ($M = .60 \text{ mg/dL}$). The PL group decreased from baseline to 48 hours post-exercise, then increased at 72 hours post-exercise ($M = .65, M = .42, M = .84 \text{ mg/dL}$), respectively. There was no statistically significant main effect over time between groups, ($p > 0.05$).

![Figure 1: C- Reactive Protein](image)

**SAA**

Samples were run in duplicate and showed exceptional test-retest reliability (<1% difference) using sandwich ELISA. Overall, there was a significant difference between groups over time from baseline to 48 hours post-exercise ($p = 0.023$). There was a statistically
significant difference across the main effect time period, which accounted for 14% of the variance. There was a statistically significant time interaction effect between the TC and PL group in SAA over time. Within the PL group, there was a statistically significant decrease in SAA over time, occurring between baseline to 48 hours post exercise and from baseline to 72 hours post exercise ($p = 0.013$ and $p = 0.012$) respectively. Interestingly, the baseline SAA level in the PL group ($M = 91.06, SE = 8.14$) was higher than the TC group ($M = 87.26, SE = 8.14$), but this was not statistically significant.

![Figure 2: Serum Amyloid A](image)
Strength

Table 4 reports the maximum voluntary contraction performance. Data were obtained in newton-meters. An independent sample t-test was conducted to assess the differences between groups in overall strength. Peak baseline strength, was not significantly different ($p > 0.004$) between groups ($M = 305.7, SD = 77.9$). After completing the exercise protocol and consuming the supplement for seven consecutive days, participants returned to the laboratory, 48 hours later (day seven) and 72 hours later (day eight). A split-plot ANOVA indicated that there were no significant differences between groups over time for both peak and average MVC.

Table 4:

<table>
<thead>
<tr>
<th>Maximum Voluntary Contraction Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Tart Cherry</strong></td>
</tr>
<tr>
<td>(n = 12)</td>
</tr>
<tr>
<td><strong>Placebo</strong></td>
</tr>
<tr>
<td>(n =12)</td>
</tr>
<tr>
<td>Peak Strength B</td>
</tr>
<tr>
<td>287.25 ± 17.1</td>
</tr>
<tr>
<td>305.67 ± 22.5</td>
</tr>
<tr>
<td>Peak Strength 48</td>
</tr>
<tr>
<td>263.72 ± 16.7</td>
</tr>
<tr>
<td>287.08 ± 27.2</td>
</tr>
<tr>
<td>Peak Strength 72</td>
</tr>
<tr>
<td>282.75 ± 19.3</td>
</tr>
<tr>
<td>301.67 ± 29.9</td>
</tr>
<tr>
<td>Average Strength B</td>
</tr>
<tr>
<td>265.08 ± 16.5</td>
</tr>
<tr>
<td>280.75 ± 21.4</td>
</tr>
<tr>
<td>Average Strength 48</td>
</tr>
<tr>
<td>240.63 ± 14.9</td>
</tr>
<tr>
<td>263.42 ± 27.0</td>
</tr>
<tr>
<td>Average Strength 72</td>
</tr>
<tr>
<td>258.17 ± 17.5</td>
</tr>
<tr>
<td>278.50 ± 30.2</td>
</tr>
</tbody>
</table>

(Mean ± SE)
Figure 3: Peak Maximum Voluntary Contraction
CHAPTER V
DISCUSSION

This is one of the first studies to assess the impact of tart cherry concentrate on pain, inflammation and strength on resistance-trained males. It was hypothesized that supplementing with tart cherry concentrate for five consecutive days prior to an eccentric exercise and for the subsequent three days would reduce perceptions of pain, markers of inflammation, and improve strength recovery 48 hours and 72 hours post-exercise. The results of this study indicate that the supplementation did not favorably affect perceptions of pain, markers of inflammation, or strength performance.

Pain

It was hypothesized that the perception of pain would decrease following eccentric muscle contractions in the tart cherry group compared to individuals consuming the placebo 48 hours and 72 hours post-exercise. However, the findings showed that there were no significant differences between groups after exercise. Participants used the VAS, which has shown to have high reliability of acute pain. However, one factor to consider in using the Visual Analog Scale (VAS), is the participant’s perception of pain is a subjective measurement. One disadvantage encountered with the VAS is that participants seemed to have difficulty finding the point on the line that best applied to his current pain- this could be related to the fact that the VAS only has two verbal anchors. In addition, participants that are strength-trained may have a higher tolerance
for pain; therefore, the reported pain level would be less than their counterparts of other healthy athletic individuals.

Other studies have shown similar results. Howatson et al. and Bowtell et al. also showed no differences between the TC and PL group. Howatson et al. also used a VAS and Bowtell et al. used pain pressure threshold, both subjective measurements. It was surprising that both of these groups found no differences in pain over time, considering inflammatory markers decreased in both studies. The current study’s findings are consistent with the inflammatory results in that the supplement did not decrease muscle inflammation or pain.

In direct contrast, some studies have found that TC supplementation decreases pain. Connolly et al., which used a 0-10 scale showed the increase in pain was significantly smaller in the TC group compared with the PL group. Discrepancies are likely related to the differences in amount and type of exercise in the studies as well as the subjective attribute of the measurement.

**Markers of Inflammation**

Inflammatory markers of CRP and SAA at 48 hours and 72 hours post-exercise were consistent with each other. Both decreased 48 hours post-exercise and then increased 72 hours post-exercise. The CRP and SAA data indicated that the inflammatory response to completing eccentric exercise was not attenuated by consuming cherry juice. Both the strength and pain data support this interpretation. The placebo group had a higher baseline SAA than the treatment group. Surprisingly, however, 48 hours post-exercise, there was a statistically significant drop in SAA in the PL group, as well as a significant difference between groups at 48 hours post-exercise. This showed a significant time interaction effect between the TC and PL group in SAA over time. This result indicated TC did not favorably reduce acute inflammation.
Most studies assessing the effect of TC on markers of muscle damage after exercise gathered data 24-hours and 48-hours post-exercise, except for Bell et al.⁸ and Connolly et al.⁶, so we cannot determine how the TC supplementation assisted in recovery after 48 hours post-exercise. Bell et al. found increases in inflammatory marker data after exercise for plasma IL-8 and hs-CRP; however, there were no significant differences between groups. There was a discrepancy between those two inflammatory markers and IL-6, however, which did show group differences. The discrepancy between IL-6 and hs-CRP was significant especially since IL-6 is implicated as a signaling molecule for the expression of hs-CRP.⁵⁵,⁵⁶ This discrepancy was not resolved in that study, so the researchers suggested that further work is needed to identify the mechanism by which TC exerts its anti-inflammatory responses in response to strenuous exercise.⁸

Levers et al. and Bowtell et al. only assessed its participants until 48 hours post-exercise and neither found significant changes in any inflammatory markers over time between groups.⁹,⁵ Howatson et al., which also assessed markers of muscle damage until 48 hours post-exercise, found that IL-6, CRP and uric acid were influenced by tart cherry consumption following a marathon. However, there were discrepancies since CK, LDH and DOMS were not different between the cherry juice and placebo groups.⁴

Rationale for differences between the current study and other studies may be due to differences in the amount and type of exercise. It is possible the single-leg muscle exercise was insufficient to produce a systemic inflammatory response. In addition, SAA levels are related to BMI, waist circumference, %fat, subcutaneous abdominal fat, and sagittal diameter but not visceral fat.⁵⁷ In this study, the PL group had a higher BMI and % body fat, however this was not significant between groups. One other possible explanation for the difference is related to a
limitation of this study in that the participants were not required to fast prior to obtaining blood samples. However, fasting samples are not required for CRP.\textsuperscript{58}

**Strength**

MVC was measured at baseline, 48 hours and 72 hours post-exercise. Both average and peak torque was recorded. Results indicated that strength recovery after exercise was not different between groups. This is consistent with the current study’s findings related to markers of muscle damage but inconsistent with other studies.

Connolly et al. showed isometric elbow flexion strength loss was significantly greater in the placebo group than the cherry juice group.\textsuperscript{6} Howatson et al. showed similar results; following TC juice consumption, isometric strength recovered significantly faster in the TC than PL group.\textsuperscript{4} MVC force recovery was significantly faster after cherry juice consumption than placebo consumption, as shown by Bowtell et al. MVC was also superior 72 hours post-exercise in the TC group compared to the placebo in the study assessing male soccer players.\textsuperscript{8}

The only study that found similar results to the current study indicated no significant differences in the group effect over time of isokinetic strength recovery work performed. However a moderate to large Cohen’s d effect size was noted in the TC compared to PL for drop in the 3-repetition summation of flexion, extension, and total work performed 60-min post lift. Additionally, results from Lever et al. revealed a non-significant time interaction and non-significant group x time effect.\textsuperscript{9} Discrepancies in this study were attributed to variation in intensity, duration and modality compared to the other studies.

Other possible reasons for differences between the current and other studies could be related to insufficient effort put forth by the participant during MVC. Participants were instructed
to complete MVC at 100% maximum efforts, after completing the warm-up. However, it is possible participants did not exert 100% effort, which would affect results.

**Strengths and Limitations**

The strengths of this study revolve around the analysis of several variables related to muscle damage, including, assessment of pain, inflammatory markers and performance. This double blind experimental study design was also favorable for the goals of this study. Furthermore, the sample size was larger than other comparable studies of similar design and purpose. Lastly, this study aimed to take into account possible confounding variables through the screening process and throughout the study design to prevent those factors from affecting the study results.

This research study is not without its limitations, which should also be considered. Firstly, participants were randomized into two groups using a computer randomization generator, however, participants were not placebo-control matched. The randomization ideally accounts for variability between groups, however analysis indicated the placebo group was stronger in lean body mass by 5.8%. However, when comparing the right leg lean mass between groups, the mass of the PL group did not significantly affect peak or average MVC. So regardless if groups were placebo-control matched, this may not have affected the strength results.

Another limitation includes the use of self-reported data for several screening questions and demographic variables. Participants self-reported on screening questions including past or present knee injuries, strength training 2-3 days a week for the last 6 months, and regular consumption of NSAIDs. However, in spite of this, previous studies support the use of self-reported data as differences between self-reported data for medical history and self-reported
anthropometrics were small.\textsuperscript{59,60} In addition, compliance with consuming all of the TC and PL supplement was not guaranteed. Along with this, a 48 hr restriction of NSAID consumption prior to each session could not be promised either, despite email reminders to continue to refrain from NSAID consumption.

Furthermore, participants were not asked to control hydration and/or nutrition status in the interest of making this study as generalizable as possible to the population of resistance-trained males. However, variability in nutrition/hydration status between groups may have affected performance outcomes.

Lastly, an unexpected limitation arose when the sterile urine cups used to hold the supplement and placebo beverages were found to have a faulty seal. Researchers were not able to obtain alternate cups that would have been adequate in quantity for the participants. The research team tried to troubleshoot the situation by sealing the top of the cups with parchment paper, however the cups continued to leak once transferred to the laboratory. That being said, the amount of tart cherry supplement determined to attenuate variables (2 oz/day) was likely not consumed by participants.

\textbf{Conclusion}

This research aimed to examine a natural alternative to NSAIDs by creating an inflamed environment to evaluate the effect of tart cherries on inflammation, pain, and strength. The results of this study indicated that supplementing with tart cherry concentrate prior to an eccentric exercise, does not provide a protective effect against muscle damage. Findings related to pain, are consistent with some of the other studies that have assessed tart cherry concentrate in relation to exercise.\textsuperscript{4,5} The current findings indicated that there was a significant difference over
time measured for pain; however this was not favorable for the TC group. Due to the discrepancies in findings compared to other studies and aside from the limitations of this study, the authors of this study believe that there is a gap in research related to the mechanism of action, which is needed to better understand the protective effect of the supplement.

**Recommendations for Future Studies**

Although this research study did not indicate favorable evidence for consuming tart cherries as a nutritional supplement, future research should target the mechanism of short-term supplementation of TC and other phytochemical containing nutrition supplements on high-intensity anaerobic exercise. Additional evidence for the mechanism of TC supplementation on endurance exercise is also needed. Not only is there a need for future research, but there is a need for education as well. Individuals who do not have adequate nutrition education may be consuming products that do not aid their performance. As athletes and exercise enthusiasts alike consume nutritional products, it is necessary for health care professionals to be educated on the effect of existing nutrition supplements. Education should target health care professionals on the use of nutritional supplements, like TC, in order to improve performance for athletes in the future.
REFERENCES


14. Hawker GA, Mian S, Kendzerska T, French M.Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res.* 2011;63 (S11), S240–S252.


17. Targońska-Stepniak B, Majdan M. Serum Amyloid A as a Marker of Persistent Inflammation and an Indicator of Cardiovascular and Renal Involvement in Patients with Rheumatoid Arthritis. *Mediators Inflamm* 2014;(Article ID 793628), 7 pages.


APPENDIX A
CONSENT FORM
CONSENT FORM:
The Effect of Tart Cherry Concentrate on Pain, Inflammation and Strength

You are being asked to take part in a research study the effect of tart cherries on pain, inflammation and strength. We are asking you to take part because you are a resistance-trained male between the ages of 18-29. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

Purpose: The purpose of this study is to assess the effect of tart cherries on pain, inflammation and strength. You must be a resistance-trained male between the ages of 18-29 and meet the eligibility criteria as determined through a screening survey, blood questionnaire and healthy history questionnaire. These questionnaires should take approximately

Procedure: If you agree to be in this study, on day 1 you will need to report to Anderson Hall to obtain blood samples, determine 1-repetition max (RM) and will be given cherry juice. Collection of blood samples involves collection of intravenous blood sample collected by a trained phlebotomist. You will be randomly assigned to consume 8 oz of a tart cherry beverage or visually similar placebo two times a day (once in the morning and once in the afternoon) for 8 days. On day 5, you will need to report to the laboratory for an exercise protocol. After consuming the cherry juice for 8 days, you will need to report to the laboratory 48 hours and 72 hours after consuming the beverage, for assessment of pain, obtaining blood samples and measuring strength, as described below.

Obtaining blood samples: The blood will be drawn by putting a needle into a vein in your arm. About 11.5 mL of blood will be collected. This will take about five minutes. This will occur for a total of three times: Day 1, Day 7 and Day 9 of the study.

Determine 1-RM: You will be asked to complete a light warm up for 5 minutes on a bike, and then complete a warm up of knee extension of 5-10 reps at 40-60% perceived maximum. After a 1-minute rest, 3-5 reps at 60-80% perceived maximum will be completed. After adding a small amount of weight, the participant will complete a 1-RM. If the lift is successful, a rest period of 3-5 minutes will be provided. The goal is to find the 1-RM within 3-5 maximal efforts. This should take about 15 minutes.

Exercise: This will include an eccentric exercise protocol that will involve a warm up of three sets of five repetitions at 50% 1RM, each separated by a 2-minute rest period. Participants will then complete three-knee extension maximum voluntary contractions (MVC) at 90° knee flexion angle, separated by 2 minute rest. Participants will then complete 10 sets of 10 single-leg knee extension at 80% of their 1RM with an eccentric phase lasting 3 s; each set will be separated by 2 min of rest. If participants are unable to maintain the workload, the load will be decreased by 10%. After completing the 10 sets, participants will be asked to complete three MVC, with the first performed immediately after the last set; thereafter, each MVC will be separated by 2 min of rest. Participants will receive verbal encouragement to perform to their maximum potential throughout the exercise protocol. This should take about 20 minutes.
Follow-up (48h and 72 h post-supplementation- Day 7 and Day 9): Report to Anderson Hall to obtain blood samples (11.5 mL each time), measure strength through maximum voluntary contractions (measured through knee-extensions on the dynamometer), and measure pain (through a Visual Scale). This should take about 20 minutes.

Risks and benefits:
There is the risk that you may be sore after the exercise on day 5. Additionally, the needle stick may hurt when obtaining blood. There is a small risk of bruising, fainting and infection. The benefit to you will be your name entered into the raffle for a drawing of a gift card.

Compensation: You may earn extra credit if you are taking a class that offers credit for research studies. The class instructor will assign credit according to class policy. You will also be entered in a raffle to win one of five $20 gift cards.

Your answers will be confidential. The records of this study will be kept private. In any sort of report we make public we will not include any information that will make it possible to identify you. Research records will be kept in a locked file; only the researchers will have access to the records.

Taking part is voluntary: Taking part in this study is completely voluntary. If you decide to take part, you are free to withdraw at any time.

If you have questions: The researchers conducting this study are Natasha Kirkbride and Dr. Judith Lukaszuk. Please ask any questions you have now. If you have questions later, you may contact Natasha Kirkbride at z1805457@students.niu.edu or at 419-377-8516. You can reach Dr. Lukaszuk at jmlukaszuk@niu.edu. You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

I understand that if I wish further information regarding my rights as a research subject, I may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

Your Signature ___________________________________ Date __________________

Your Name (printed)
_____________________________________________________________________

This consent form will be kept by the researcher for at least one year beyond the end of the study.
APPENDIX B
IRB AND IBC APPROVAL LETTERS
13-Nov-2017

TO: Natasha Kirkbride
    School of Health Studies

RE: Protocol # HS17-0284 “Effect of tart cherry concentrate on pain, inflammation, and strength”

Your Initial Review submission was reviewed and approved under Expedited procedures by Institutional Review Board #1 on 13-Nov-2017. Please note the following information about your approved research protocol:

Protocol Approval period: 13-Nov-2017 - 12-Nov-2018

If your project will continue beyond that date, or if you intend to make modifications to the study, you will need additional approval and should contact the Office of Research Compliance and Integrity for assistance. Continuing review of the project, conducted at least annually, will be necessary until you no longer retain any identifiers that could link the subjects to the data collected. Please remember to use your protocol number (HS17-0284) on any documents or correspondence with the IRB concerning your research protocol.

Please note that the IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Unless you have been approved for a waiver of the written signature of informed consent, this notice includes a date-stamped copy of the approved consent form for your use. NIU policy requires that informed consent documents given to subjects participating in non-exempt research bear the approval stamp of the NIU IRB. This stamped document is the only consent form that may be photocopied for distribution to study participants.

It is important for you to note that as a research investigator involved with human subjects, you are responsible for ensuring that this project has current IRB approval at all times, and for retaining the signed consent forms obtained from your subjects for a minimum of three years after the study is concluded. If consent for the study is being given by proxy (guardian, etc.), it is your responsibility to document the authority of that person to consent for the subject. Also, the committee recommends that you include an acknowledgment by the subject, or the subject's representative, that he or she has received a copy of the consent form. In addition, you are required to promptly report to the IRB any injuries or other unanticipated problems or risks to subjects and others. The IRB extends best wishes for success in your research endeavors.
December 12, 2017

MEMORANDUM

TO: Judith Lukaszuk  
    School of Health Studies  
    Natasha Kirkbride  
    School of Health Studies

RE: Approval of the use of recombinant DNA and/or pathogenic substances in research and/or instruction substances

The following project involving the use of recombinant DNA and/or pathogenic substances was reviewed and conditionally approved by the Institutional Biosafety Committee (IBC) at its meeting on November 16, 2017. Based on your responses to the committee’s request for changes, the protocol has now been approved.

Title: Effect of Tart Cherry Concentrate on Pain, Inflammation, and Strength

IBC/ORC #: S17-0004  
Biosafety level: BL2  
Lab: NIU- Anderson Hall

This approval is effective for one year from the date of review, until November 16, 2018. If your project will continue beyond that date, you should contact the Office of Research Compliance and Integrity (815-753-9251) for assistance with additional approval procedures.
Screening Survey (with Answers)

This survey will use the term *strength train* defined as a method of improving muscular strength by gradually increasing the ability to resist force through the use of free weights, machines, or the person's own body weight.

1. Are you a male student between the ages of 18-29?
   - Yes
   - No

2. Do you strength train at least 2-3 times a week?
   - Yes
   - No

3. Have you been consecutively strength training for six months or more (with less than one month throughout of not strength training)?
   - Yes
   - No

4. Do you complete eccentric training on a regular basis?
   *Eccentric training defined:* occurs when the muscle is forcibly lengthened or elongated. An eccentric contraction results when the force produced inside the muscle is less than what is applied to the muscle externally and results in active lengthening of the muscle fibers under some level of load.
   - Yes
   - No

5. Do you have any cardiorespiratory conditions that prevent your daily living activities?
   - Yes
   - No

6. Do you have any lower extremity injuries (past or present) that impair your ability to exercise?
   - Yes
   - No

7. Do you have knee (patellofemoral) pain?
   - Yes
   - No

8. Are you allergic to tart cherry juice or any cherry components (e.g. polyphenols, anthocyanins, anthocyanidins)?
   - Yes
   - No
9. Are you currently taking NSAIDs (anti-inflammatory) medication?
   - Yes
   - No

10. Are you currently consuming fish oil?
    - Yes
    - No

11. Are you currently consuming a Vitamin E supplement?
    - Yes
    - No

12. Are you right hand dominant?
    - Yes
    - No

13. Please provide an email address to be contacted by, should you qualify to be included in this study:

   ________________________________________________________________

Thank you for taking the time to complete this survey. You will be contacted if you qualify to be included in this research study.

*Bolded= Eligibility
Health/Blood Questionnaire

Name:                     Date:

Please answer the following by checking **YES** or **NO**:  

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever had a bleeding condition or a blood disease?</td>
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<td></td>
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<tr>
<td>Do you have Sickle Cell Anemia, or any other blood conditions?</td>
<td></td>
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<tr>
<td>Have you ever had liver disease, viral hepatitis, or a positive test for hepatitis?</td>
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<tr>
<td>Have you ever had malaria?</td>
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<td>Have you ever had, or come into contact with persons possessing a sexually-</td>
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<tr>
<td>transmitted disease?</td>
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<tr>
<td>In the past 12 months have you had a tattoo applied, ear or skin piercing, accidental</td>
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<tr>
<td>needlestick, or come into contact with anyone else's blood?</td>
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<tr>
<td>Have you ever used needles to take drugs, steroids, or anything else not prescribed</td>
<td></td>
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<tr>
<td>by your doctor?</td>
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<tr>
<td>In the past 12 months, have you had sexual intercourse with anyone who has ever used</td>
<td></td>
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<tr>
<td>needles to take drugs, steroids, or anything else not prescribed by their doctor?</td>
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<tr>
<td>Have you ever had a positive test for the HIV/AIDS virus?</td>
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<tr>
<td>In the past 12 months, have you had sexual intercourse with anyone who has HIV/AIDS</td>
<td></td>
<td></td>
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<tr>
<td>or has had a positive test for the HIV/AIDS virus?</td>
<td></td>
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</tbody>
</table>

*All subjects have the right to not complete the form if they chose but they will be excluded for safety reasons.  
*If a subject answer YES but chooses not to disclose more information they will be excluded for safety reasons.  

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

Name(Print)-

Signature-                     Date-
Health History Questionnaire

Please answer the following questions to the best of your ability. For the following questions, unless otherwise indicated, circle the single best choice for each question. As is customary, all of your responses are completely confidential and may only be used in group summaries and/or reports. All information collected is subject to the Privacy Act of 1974. If you have any physical handicaps or limitations that would require special assistance with this questionnaire, please let your trainer know. This form is in accordance with the American College of Sports Medicine guidelines for risk stratification when followed correctly by your trainer. Your trainer should be certified with a national organization in order to use these forms correctly.

Name: ___________________________ Ht: _______ Wt: _______
Gender: ___________________________ Age: _______ Birthday: _______
Address: ___________________________
City: ___________________ State: _______ ZIP: _______ Phone: _______
Emergency Contact: ________________________ Phone: _______
Personal Physician: ________________________ Phone: _______
E-mail: ___________________________

1. Have you ever had a definite or suspected heart attack or stroke? ______Yes ______No
2. Have you ever had coronary bypass surgery or any other type of heart surgery? ______Yes ______No
3. Do you have any other cardiovascular or pulmonary (lung) disease (other than asthma, allergies, or mitral valve prolapse)? ______Yes ______No
4. Do you have a history of: diabetes, thyroid, kidney, liver disease. ______Yes ______No (circle all that apply)
5. Have you ever been told by a health professional that you have had an abnormal resting or exercise (treadmill) electrocardiogram (EKG)? ______Yes ______No
6. If you answered YES to any of Questions 1 through 5, please describe: ____________________________

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Page 1 of 4
Date: 11/19/03
P04-026
7. Do you currently have any of the following:
   a. pain or discomfort in the chest or surrounding areas that occurs
      when you engage in physical activity? .......................... Yes  No
   b. shortness of breath ...........................................  Yes  No
   c. unexplained dizziness or fainting ................................. Yes  No
   d. difficulty breathing at night except in upright position
      ................................................................. Yes  No
   e. swelling of the ankles (recurrent and unrelated to injury)  
      ................................................................. Yes  No
   f. heart palpitations (irregularity or racing of the heart on more than one occasion)  
      ................................................................. Yes  No
   g. pain in the legs that causes you to stop walking (claudication)  
      ................................................................. Yes  No
   h. known heart murmur ............................................ Yes  No
   Have you discussed any of the above with your personal physician?  ........................................ Yes  No

8. Are you pregnant or is it likely that you could be pregnant at this time?  ........................................ Yes  No
   If yes, what is your expected due date?  .................................................................

9. Have you had surgery or been diagnosed with any disease in the past 3 months?  ........................................ Yes  No
   If yes, please list date and surgery/disease  .................................................................

10. Have you had high blood cholesterol or abnormal lipids within the past 12 months
    or are you taking medication to control your lipids?  ........................................ Yes  No

11. Do you currently smoke cigarettes or have you quit within the past 6 months?  ........................................ Yes  No

12. Have your father or brother(s) had heart disease prior to age 55  OR
    mother or sister(s) had heart disease prior to age 65?  ........................................ Yes  No

13. Within the past 12 months, has a health professional told you that you
    have high blood pressure (systolic ≥ 140 OR diastolic ≥ 90)?  ........................................ Yes  No

14. Currently, do you have high blood pressure or within the past 12 months,
    have you taken any medicines to control your blood pressure?  ........................................ Yes  No

15. Have you ever been told by a health professional that you have a fasting
    blood glucose greater than or equal to 110 mg/dl?  ........................................ Yes  No

16. Describe your regular physical activity or exercise program:
    type:  .................................................................
    frequency: ________ days per week
    duration: ________ minutes
    intensity: low moderate high (circle one)
    BMI: ________

17. If you have answered YES to any of questions 7-16, please describe:
    ........................................................................
    ........................................................................
18. Are you currently under any treatment for any blood clots? Yes No
19. Do you have problems with bones, joints, or muscles that may be aggravated with exercise? Yes No
20. Do you have any back/neck problems? Yes No
21. Have you been told by a health professional that you should not exercise? Yes No
22. Are you currently being treated for any other medical condition by a physician? Yes No
23. Are there any other conditions (mitral valve prolapse, epilepsy, history of rheumatic fever, asthma, cancer, anemia, hepatitis, etc.) that may hinder your ability to exercise? Yes No
24. During the past six months, have you experienced any unexplained weight loss or gain (greater than ten pounds for no known reason)? Yes No
25. If you have answered YES to any of questions 18-24, please describe:

26. Please list below all prescription and over-the-counter medications you are currently taking:

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Reason for taking</th>
<th>Dosage</th>
<th>Amount/Frequency</th>
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</table>

27. Are there any medicines that your physician has prescribed to you in the past 12 months which you are currently not taking? Yes No
If so, please list:

28. I have answered the Health History Questionnaire questions accurately and completely. I understand that my medical history is a very important factor in the development of my fitness/wellness program. I understand that certain medical or physical conditions which are known to me, but that I do not disclose to my trainer, may result in serious injury to me. If any of the above conditions change, I will immediately inform my trainer of those changes. I, knowingly and willingly, assume all risks of injury resulting from my failure to disclose accurate, complete, and updated information in accordance with the attached questionnaire. I also understand that in order to properly risk-stratify my Health History Questionnaire, my trainer should have a minimum of a national certification as a personal trainer. My trainer also verbally explained this statement to me to my understanding.

Client’s Signature: ___________________________ Date: ________________
Trainer’s Signature: ____________________________ Date: ________________
For Use by the Personal Trainer ONLY

Check the identified ACSM major coronary risk factors below:

- Lipids (TCH > 200 OR HDL < 35)
- Cigarette Smoking (or quit within the past 6 months)
- Family History
- High Blood Pressure/Blood Pressure Medications
- Diabetes/glucose > 110 mg/dl
- Sedentary
- BMI > 30
- Pregnancy
- Metabolic Disease
- Respiratory Disease (asthma, emphysema, chronic bronchitis)
- Signs or Symptoms of Cardiovascular Disease
- Diagnosed Cardiopulmonary/Metabolic Disease
- Cardiovascular Disease
- Annual medical clearance required
- Medical Clearance Required

Risk Stratification
- Apparently Healthy
- One or No Risk Factors (no medical clearance required)
- Apparently Healthy Male > 45; Female > 55
- One or No Risk Factors (initial medical clearance required)
- High Risk, No Signs or Symptoms
- Two or More Risk Factors (medical clearance required)
- High Risk, with Signs and Symptoms
- One or More Signs/Symptoms With or Without Risks (medical clearance required)
- Known Disease
- Diagnosed Cardiopulmonary/Metabolic Disease (annual medical clearance required)
- Pregnancy
- Medical Clearance Required

All clients needing written medical clearance from their personal physician must give it to their trainer prior to beginning their exercise program.

Additional Comments:

---

Health History Questionnaire follows the American College of Sports Medicine recommendations for risk stratification. This must be performed on all clients in order to determine the need for medical clearance and/or exercise modifications. Any trainer or those making exercise recommendations should be certified in the proper use of the risk stratification process through a national organization.

If a client has a YES response to anything on page 1, he/she has KNOWN DISEASE, and must have medical clearance prior to beginning exercise.

If he/she has a YES response to anything on #7 a-h on page 2, your client is HIGH RISK WITH SIGNS/SYMPTOMS and must have medical clearance prior to exercise. If your client has a YES response to questions #8 or #9, he/she must have medical clearance.

YES responses to two or more on questions 10-16 on page 2, your client is HIGH RISK WITHOUT SIGNS OR SYMPTOMS and must have medical clearance unless he/she also has a YES answer in question #7 making them still HIGH RISK WITH SIGNS/SYMPTOMS.

All other questions on page 3 are at your own discretion. Remember, when in doubt, refer out. Please also refer to the most recent edition of ACSM's Guidelines for Exercise Testing and Prescription (Williams & Wilkins) as well as the most recent edition of the ACE Personal Trainer Manual (American Council on Exercise) for more explanations on the risk stratification. It is your responsibility as a trainer to remain updated on all changes or modifications for risk stratification in determining the need for medical clearance and exercise modifications/recommendations.

Thank you for using Premier Performance, Inc. Fitness Forms. Due to copyrights, you are not allowed to modify these forms in any way without the expressed written permission of Premier Performance, Inc. You are also not allowed, by law, to sell these forms or modifications thereof.

These forms have important legal consequences. An attorney should be consulted on all important matters including the preparation of legal forms or when you question the suitability of the form for your intended purpose. The American Council on Exercise® (ACE®) and Premier Performance, Inc. will not accept liability for any financial loss or damage in connection with the use of these forms. If you have further questions concerning preparation of these forms, please consult an attorney.

It is the responsibility of the trainer/fitness professional/etc. using these forms to use them appropriately. By using these forms, the purchaser/user of these forms agrees that he/she shall defend, indemnify and hold Premier Performance, Inc. and ACE harmless against any claims, liabilities, judgments, losses, costs and expenses, including reasonable attorney fees from claims by the purchaser/user or from third parties arising from the publication, distribution or sale of these forms. Premier Performance, Inc. and ACE will not be responsible for any injury, illness, etc. that may occur by those not qualified as fitness professionals as determined by a national organization such as ACE or ACSM, or by those who act in negligence. All procedures should follow the guidelines/standards as stated by ACSM or ACE in providing safe exercise recommendations.
APPENDIX D
EXERCISE PROTOCOLS AND SCALES
Determination of 1-RM:

1. Participants will complete a light warm-up of 5 minutes of biking.

2. Participants will then perform a light warm-up of 5-10 reps at 40-60% perceived maximum.

3. Following a 1-minute rest with light stretching, the subject will complete 3-5 reps at 60-80% of perceived maximum.

4. The subject should be close to a perceived 1-RM in step 2. A small amount of weight is added, and a 1-RM lift is attempted. If the lift is successful, a rest period of 3-5 minutes will be provided. The goal is to find the 1-RM within 3-5 maximal efforts. The process of titrating the increase in weight up to a true 1-RM can be improved by prior familiarization sessions that allow approximation of the 1-RM. Clear communication with the subject is needed to facilitate determination of the 1-RM. This process will be continued until a failed attempt occurs.

5. The 1-RM will be reported as the weight of the last successfully completed lift. (Balady, 2000)
Visual Analog Scale:
APPENDIX E
VENIPUNCTURE PROCEDURE
Venipuncture Procedure:

1. Identify the patient. Always ask the patient to state full name.
2. Assemble your supplies.
3. For multiple specimen collection of whole blood, serum and/or plasma use the following order for collecting several specimens during a single venipuncture:

   Note: manufacturers may use different colors for caps. Check the label for additive.

   a. Blood culture: use protocol for filling bottles or use a syringe
   b. Serum: no Additive-plain red cap or gold cap with separator gel
   c. Chemistry tests: sodium heparin or lithium heparin- light freen cap or plasma separator tube with separation gel.
   d. Hemotology tests: EDTA-lavender cap
   e. Coagulation tests; sofium citrate-light blue cap
4. Reassure and position the patient. The arm should be supported.
5. Apply the tourniquet and have the patient make a fist.  
   The tourniquet should not stop blood flow in the veins for more than 1 minute before the blood is drawn because this causes hemoconcentration.
6. Select the venipuncture site. The median cubital and cephalic veins are used most frequently.
7. Clean the venipuncture site with an alcohol pad, making one smooth circular pass of the venipuncture site. Allow the skin to dry to prevent hemolysis of the specimen and to prevent the patient form having a burning sensation when the venipuncture us performed.  
   Do not touch the vein site after cleaning it (or cleanse your finger tip as well).
8. Near the venipuncture site, use your thumb to draw the skin tight. With needle bevel facing up, line up the needle with the vein. Penetrate the skin in a quick and smooth motion,. Hold the vacutainer holder with one hand and push the tubes on wit the other hand. Enter the vein at an angle of approximately 15-30 degrees.
9. Label the tube with the patients name after the sample is collected.
APPENDIX F
KNEE EXTENSION PROCEDURE
Knee Extension Procedure:

**Isokinetics**
As explained in the Computer Sports Medicine Inc (CSMI) manual, “Isokinetics describes a process in which a body segment accelerates to achieve a preselected fixed speed against an accommodating resistance. No matter how much force is exerted by the patient, segment velocity will not exceed the pre-selected speed. As torque is produced in an attempt to overcome the pre-selected speed, the resistance varies to exactly match the force applied at every point in the range of motion.” The CSMI isokinetic testing has shown to be accurate, objective, reproducible and safe. It has commonly been used in rehabilitation for areas including shoulder, elbow, forearm, wrist, hip, knee, ankle, and back testing. As the patient reduces force output either because of pain or weakness, there is an immediate reduction of resistance. This function is key to this study because of the corresponding measurements that will be obtained through the dynamometer. (CSMI, 2006)

**Biomechanical Considerations**
According to the CSMI, the knee is the easiest to test on the CSMI Norm System. Only one of the major knee extensors is a two-joint muscle with an origin above the hip joint. Studies have indicated that the positioning of the knee test creates maximum flexor and extensor forces with a high level of reproducibility.
The test speed may be affected by the degree of hyperextension of the joint. Slow test speeds do not elicit hyperextension, however higher test speeds “the inertia of the limb tends to help the contracting muscles overcome the passive resistance of skin, fascia, and articular structures so that significant hyperextension may occur.” The thigh may also slightly lift of the chair during high speed testing. In light of these considerations however, the torque measurement is not significantly affected, except during the first 1/8 second of a high-torque contraction. Even so, clinical applications with a ±5° error relative to the position angle are accepted because of the overall range of motion is quite accurate (CSMI, 2006).
Knee Extension Set-up:

Reclining Chair Preparation
• Install Contralateral Limb Stabilizer in chair receiving tube #2 (if indicated.)

Dynamometer Preparation
• To install adapter on dyna input arm:
  1. Secure Knee/Hip Pad on Knee/Hip Adapter with the pad offset toward the dynamometer.
  2. Insert adapter into long end of input arm and secure.

Position Patient
• Position patient appropriately on chair; provide Lumbar Cushion (if indicated.)
  1. Have patient move forward or back on seat until the knee is just lightly touching the chair-seat cushion.
  2. Rotate Crank to adjust chair-back to meet patient’s back.

• Chair-Seat Fore/Aft: Move and secure chair at an appropriate distance from dyna to properly align knee axis of rotation with dyna axis.
• Position Knee/Hip Pad on patient's leg and secure.
• Secure Thigh Stabilizer Strap.
• Test patient's ROM. Adjust set-up if required.
• Record all scale values and click OK.
APPENDIX G
DEBRIEFING LETTERS
Effect of Tart Cherry Concentrate on Pain, Inflammation and Strength

Debriefing Letter for Intervention Group Participants

You were randomly assigned to the intervention group and as such were provided a tart cherry concentrate for the treatment. The tart cherry concentrate was mixed with 1 oz of water. The color and taste properties were similar to the placebo group. Being in the tart cherry group, you may have experienced some of the effect of being in the intervention group.

At the conclusion of the study, the participants in the control/placebo group will be un-blinded and provided with the knowledge of the group they were assigned to as well.

Acknowledgement:
I, ______________________________, understand that I was a part of the intervention group and received tart cherry concentrate.

Signature: ____________________________ Date: _____________
Effect of Tart Cherry Concentrate on Pain, Inflammation and Strength

Debriefing Letter for Placebo Group Participants

You were randomly assigned to the control group and as such were provided a fruit juice with similar color and taste properties as the tart cherry juice. Being in the control group, you most likely did not experience any changes in pain, inflammation or strength due to the juice.

At the conclusion of the study, the participants in the treatment group will be un-blinded and provided with the knowledge of the group they were assigned to as well.

Acknowledgement:

I, ________________________________, understand that I was a part of the placebo group and received a placebo beverage for the duration of the study.

Signature: ________________________________ Date: _____________