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THE EFFECT OF ACUTE BEETROOT JUICE SUPPLEMENTATION ON MUSCLE FATIGUE IN KNEE EXTENSOR EXERCISE

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THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
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BY

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ABSTRACT OF THESIS

THE EFFECT OF ACUTE BEETROOT JUICE SUPPLEMENTATION ON MUSCLE FATIGUE IN KNEE EXTENSOR EXERCISE

To examine the effect of acute beetroot juice supplementation on the rate of fatigue as measured by changes in peak torque.

Placebo-controlled, double-blind, cross-over study, 35 recreationally active subjects consumed beetroot (BR) juice or black currant juice (PL) 12 and 2.5 hours before the exercise procedure. Peak torque was measured on the BIODEX dynamometer by performing 50, maximal effort, concentric knee extensions at 90°/s. Blood pressure (BP) was recorded before and after exercise.

No significant difference between BR and PL in the rate of fatigue measured by change in peak torque. By stage 3, subjects retained 87.6±6.9% of strength with BR and 86.7±6.3% with PL ($p = 0.363$). Stages 10 was as follows: BR 47.9±12.6 vs. PL 46.9±12.9% ($p = 0.419$). The rate of work fatigue showed no significant differences. By stage 4, mean percent work fatigue showed 20.6±9% with BR and 21.8±10.1% with PL ($p = 0.224$). Stage 10 was as follows: BR 52.5±12.6% vs. PL 53.2±13% ($p = 0.571$). Post-exercise diastolic BP (BR: 67.2±9.8 vs. PL: 64.5±7.9mmHg, $p = 0.039$) and MAP (BR: 91.6±9.3 vs. PL: 88.8±8.2mmHg, $p = 0.011$) were higher with BR supplementation.

Acute bouts of beetroot juice supplementation had no significant effect on knee extensor muscle fatigue measured during isokinetic contractions.

KEYWORDS: Nitrate Supplementation, Fatigue, Muscle Efficiency, Isokinetic, Concentric Contraction

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THE EFFECT OF ACUTE INORGANIC NITRATE SUPPLEMENTATION ON MUSCLE FATIGUE IN KNEE EXTENSOR EXERCISE

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CHAPTER 1: INTRODUCTION

Background

Oxygen consumption is a crucial criterion to determine exercise capacity in human exercise physiology. In general, oxygen consumption increases linearly relative to work rate (2). Thus, the cost of oxygen consumption is a predictable factor when people exercise at a given work rate. It is not surprising that increased mechanical efficiency by eliminating unnecessary movement after exercise training results in reduced oxygen utilization during exercise. However, recently it has been shown that increasing dietary nitrates also lowers the cost of oxygen consumption at submaximal workloads (1-4, 21-25, 40-41).

It is easy to increase nitrate and nitrite levels in the body by increasing consumption of green leafy vegetables (1-2, 21, 22, 40). It has been known for some time that dietary nitrates offer various cardiovascular benefits that could increase life span (17, 21, 40). More recent data suggest that nitrate has a positive effect on exercise capacity (1-4, 21-25, 40-41). Also, previous studies have reported that inorganic nitrate supplementation reduces the cost of oxygen consumption during exercise (1, 3, 21, 23) and increases tolerance to high-intensity exercise (1-3, 24, 41). Dietary nitrate is known as one of the possible source for generation of nitric oxide (NO) (27) which plays a pivotal role in physiological responses to exercise such as; blood flow and blood pressure regulation, influence on the ATP cost in muscle force generation, and enhanced oxidative phosphorylation (8, 12, 14, 17). Unfortunately, the exact mechanisms explaining the beneficial effects of inorganic nitrate supplementation such as the reduced cost of oxygen consumption, extended time to exhaustion, and increased exercise capacity are not fully understood. Recently, two possible mechanisms have emerged to explain how nitrate supplementation can lower oxygen consumption cost and extend the duration of exercise to exhaustion. One possible mechanism is that mitochondrial efficiency is improved with dietary inorganic nitrate supplementation. Larsen et al. implied that nitrate supplementation reduces proton leakage within the electron transport chain to improve mitochondrial efficiency (25). Others suggest that dietary nitrate supplementation benefits oxygen consumption and tolerance to exercise by increasing muscle contractile efficiency (2). Bailey et al. suggest that increasing contractile efficiency is result of less ATP utilization during muscle contraction by slower rate of cross bridge cycling. These two mechanisms run counter to each other but, nonetheless, it is possible to speculate that dietary nitrate supplementation could change the rate of fatigue as measured during a muscle endurance task if the rate of cross-bridge cycling slows by dietary nitrate supplementation. The comprehensive aim of this research was to examine the effect of dietary nitrate supplementation from beetroot juice on muscle fatigue, thus contributing information which may improve our understanding of the relationship between nitrate supplementation and the rate of fatigue from resistance exercise.

A study conducted by Larsen et al. (25) showed that dietary nitrate supplementation increased the level of plasma nitrite and nitric oxide. Nitrates and nitrites have been believed as the stable inert end products of nitric oxide oxidation mechanism (NO + O_2 => Nitrite, Nitrite + HbO_2 => Nitrate) (27). However, recent study (27) has suggested the mechanism that nitrites can be recycled to generate bioactive nitric oxide. Based on these results, the authors speculated that nitric oxide can be derived from dietary nitrate supplementation and nitric oxide increased oxidative phosphorylation efficiency. After nitrate supplementation, ATP production was improved during submaximal exercise while oxygen consumption was reduced. Oxidative phosphorylation efficiency (P/O ratio) was higher by 19% following nitrate supplementation during submaximal exercise (Nitrate: 1.62±0.07 vs Placebo: 1.36±0.06, $p=0.02$). Authors suggested that oxidative phosphorylation efficiency was improved by reducing the leakage, or slippage, of protons through the membrane in the electron transport chain. The results indicated that respiratory control ratio (RCR), which is the ratio between respiration with the substrate and ADP (state 3 respiration) and respiration with the substrate and ADP phosphorylation to ATP (state 4 respiration), showed a significantly higher value (P=0.006) in the mitochondria with nitrate supplementation compared to placebo. This outcome indicated that nitrate supplementation produced a greater effect of pairing respiration with oxidative phosphorylation. In addition, LEAK respiration, which is the mitochondrial respiration with existing substrates, but without added ADP or phosphates, occurs as compensation for proton leaking and slippage. This LEAK respiration was significantly lower (P=0.02) following nitrate supplementation. Thus, it was suggested that nitrate supplementation reduced proton leakage or slippage both during exercise and during a normal resting state (25).

Bailey et al. (2) published data suggesting that the reduction in cost of oxygen consumption is the result of enhanced muscle contractile efficiency by less total ATP utilization during muscle contractions. They found that inorganic nitrate supplementation in the form of beetroot juice caused a reduction in muscle phosphocreatine utilization. Subjects with a higher nitrate intake were found to have higher phosphocreatine levels than placebo without altering pH level after exercise. In addition, the total ATP turnover rate was estimated to be less with nitrate supplementation. Less ATP is used with nitrate supplementation for exercise at a given work rate because slower cross-bridge cycling reduces the ATP cost during muscle contraction (2). It has been questioned that bioactive components of beetroot juice other than nitrate such as carbohydrate and protein could affect the physiological change in human subjects during exercise (7, 21, 41). However, Bailey et al. reported that nitrate is the key ergogenic ingredient in beetroot juice because if nitrate is extracted from beetroot juice and given as a placebo, the placebo had no effect on muscle contractile efficiency. Thus, these authors claimed that the nitrate is the crucial component and the reduced cost of oxygen consumption is due to decreased ATP cost of muscle force production following dietary nitrate supplementation.

Bailey et al. (2) has demonstrated that the rate of cross-bridge cycling slows with BR juice supplementation resulting in less ATP utilization during muscle force production. If cross-bridge cycling rate is slowed by dietary nitrate supplementation with force held constant, it is reasonable to think that this could change the rate of fatigue by means of less ATP depletion as measured during a muscle endurance task. Therefore, the purpose of the present study was to determine the effects of inorganic dietary nitrate in the form of beetroot juice supplementation on the decrease in the rate of work fatigue of the knee extensors by measuring the change in torque generation and work for each repetition. If nitrate supplementation does result in a lower utilization of ATP from muscle contraction, the supplementation could result in less fatigue in the knee extensors.

Statement of the Problem

To date, no studies have been conducted to investigate the effect of beetroot juice supplementation as an ergogenic aid on strength and resistance exercise performance. The purpose of this study was to determine if acute nitrate supplementation enhances resistance exercise as measured by knee extensor torque generation and the rate of work fatigue. This study measured the rate of fatigue during 50 knee extensions performed at 90°/sec on an isokinetic dynamometer. A slower rate of fatigue following nitrate supplementation would lend support to the idea of a slower cross-bridge cycling and hence an improved muscular efficiency. It was hypothesized that the rate of fatigue measured by change in torque generation over the number of contractions and change in work over time would be significantly lower in the specific velocity (90°/sec) of the knee extensor test following the nitrate supplementation. Furthermore, based on studies which have shown the lower blood pressure after nitrate supplementation (1-4, 21-25, 40-41), we hypothesized that blood pressure following beetroot juice supplementation would be significantly lower before and after fatiguing exercise.

CHAPTER 2: REVIEW OF THE LITERATURE

The purpose of this chapter is to introduce the previous studies describing the effect of nitric oxide and dietary nitrate supplementation on exercise outcomes, potential risk of nitrate/nitrite supplementation, and the case of fatiguing exercise testing to test our hypotheses. Even though there is no supporting literature to demonstrate an acute beetroot juice supplementation on muscle fatigue on isokinetic knee exercise, careful examination is made in this chapter to describe physiological function of nitric oxide on fatiguing exercise.

Physiological Functions of Nitrates (NO_3^-), Nitrites (NO_2^-) and Derived Nitric Oxide (NO)

Dietary nitrate is easy to increase with green leafy vegetables and beetroot juice and it is known to offer cardiovascular benefits that may benefit life span (20). There are several mechanisms for reduction of nitrate to NO. Many previous studies (3, 22-24) illustrated that the classical NO production occurs following the L-arginine pathway. L-arginine is oxidized by enzyme nitric oxide synthase (NOS) to produce NO in human body (endogenous pathway).

Recently, a NOS-independent pathway has been suggested as another possible mechanism of NO production. The inorganic dietary nitrate (NO_3^-) and nitrite (NO_2^-) are reduced to form NO (exogenous pathway) (27). Dietary nitrate is absorbed and extracted by the salivary gland. In the mouth, nitrate is converted to nitrite by nitrite-inducing bacterial enzyme. Nitrite can enter the systemic circulation and be reduced in blood and tissues to form NO by mammalian enzyme nitrite reductase (15, 22-23). The mechanisms converting nitrite to nitric oxide are intensely expedited during hypoxia and acidosis which are presented during exercise (22, 24, 40).

During the nitrate-nitrite-NO pathway, nitrate-derived NO plays a role in several physiological processes. These include: blood flow and blood pressure regulation, ATP cost efficiency, cellular oxygen utilization, and enhancement of oxidative phosphorylation efficiency which can determine the rate of oxygen consumption and tolerance of exercise. Many studies have demonstrated the beneficial effect of nitric oxide (8, 12, 14, 17). It is thought that nitric oxide (NO) plays a pivotal role in physiological function including regulation of blood flow and blood pressure (17), regulatory influence on the ATP cost of force production (12, 14), and cellular oxygen utilization and enhancement of oxidative phosphorylation efficiency (8).

Kapil and colleagues (17) concluded that nitric oxide derived from inorganic nitrate reduces blood pressure and increases blood flow. This reduction in blood pressure is seen in both systolic and diastolic readings. They reported that oral inorganic nitrate ingestion caused an elevation of plasma nitrite which resulted in increased nitric oxide concentration. Since nitrite plays a role in human vasodilation this may explain which expands blood vessels to increase the blood flow.

Galler et al. (12) sought to determine the effect of nitric oxide on force-generating proteins of skeletal muscle. They used slow and fast-twitch rat muscle fibers to examine NO function. The study demonstrated that NO concentrations were able to constrain the mechanical properties and ATPase activity in muscle fibers. They speculated that NO has an effect on the steady-state-isometric contraction, kinetic properties and ATPase activity. They suggested that the change in the rate constant of cross-bridge cycling was the mechanism behind their observation.

Heunks and colleagues (14) indicated that nitric oxide impairs activation of the thin filaments by Ca^{2+} following reduced Ca^{2+} sensitivity and slows cross-bridge cycling kinetics in skeletal muscle. This study used muscle fibers which activated at different Ca^{2+} concentration, and measured Ca^{2+} concentration when maximal force and half of maximal force were generated. They implied that NO has an effect on contractility which reduces the Ca^{2+} sensitivity of force generation. This might be due to the fact that Ca^{2+} activation of the thin filaments are impaired. Their results suggested that spermine NONOate (Sp-NO), a nucleophilic type of NO donor, can be used to liberate NO in aqueous solution. This spermine NONOate-derived NO reduces force generation at submaximal levels of Ca^{2+} activation which is consistent with their hypothesis pertaining to the slow attachment and detachment process between myosin and actin filaments. Also, NO decreases the Ca^{2+} sensitivity of cross-bridge cycle recruitment. These findings suggest NO has a regulatory effect on the ATP cost of force generation.

Lastly, NO plays a role in cellular oxygen utilization and enhances oxidative phosphorylation efficiency, as was determined by Clerc and colleagues (8). This study recruited Rats' liver mitochondria, and measured mitochondrial oxygen consumption and rate of ATP synthesis to see the effect of NO on oxidative phosphorylation efficiency. They found that NO binds to cytochrome oxidase, which is an acceptor in the last part of electron transport system, acting as an inhibitor of mitochondrial respiration and limits ATP synthesis capacity, while energy waste was reduced by NO. Even though NO impairs cytochrome c oxidase on mitochondrial respiration, this impairment reduced oxygen consumption more than ATP production. They, therefore, demonstrated that NO plays a significant role in the improvement of oxidative phosphorylation efficiency by reducing leakage of the proton pump to produce more ATP.

Early Studies on Dietary Nitrate Supplementation and Exercise

Oxygen consumption is one of the most crucial factors in determining exercise capacity in human exercise physiology. Oxygen uptake increases linearly when plotted against work rate in moderate intensity exercise (2). During high-intensity exercise, the cost of oxygen consumption is elevated when carbon dioxide production exceeds oxygen extraction (1). In addition, oxygen consumption in the functioning muscle elevates radically by means of increases in muscle blood flow (22). Following the reasons mentioned above, dietary nitrate supplementation induced exogenous NO generation has a positive regulatory role in exercise capacity and performances.

An article published in 2009 by the Journal of Applied Physiology from Bailey and colleagues (1) reported dietary nitrate supplementation reduces the O_2 cost during low-intensity exercise and enhances tolerance to high-intensity exercise in humans. Eight healthy males who were recreationally active participated in the test. The subjects completed exercise on a cycle ergometer for the pretest, step incremental test with moderate-intensity and severe-intensity cycling for the actual test. Subjects ingested either 0.5 liter of nitrate-rich beetroot juice (BR: 5.5 mmol/day) or low calorie black currant juice (PL) for six days. The study examined plasma nitrite level, blood pressure, muscle oxygenation, and VO_2 responses. It revealed that hemoglobin without oxygen (deoxy-hemoglobin) amplitude was reduced 13 percent after BR ingestion which indicates increased muscle oxygen delivery at the same VO_2 and reduced fractional oxygen extraction. Oxy-hemoglobin increased at baseline during moderate-intensity exercise. There was no change in oxy-hemoglobin during severe-intensity exercise. O_2 uptake was reduced by 19% during moderate-intensity exercise, however, VO_2 was higher during severe-intensity exercise, while time to exhaustion increased following BR supplementation. The authors speculated that the amplitude of the VO_2 slow-component was reduced so that exercise tolerance increased. Also, increased muscle oxygen delivery at a constant VO_2

would result in a reduced fractional oxygen extraction in muscle. Thus, this study demonstrated that reduced oxygen consumption during exercise with BR ingestion was due to less muscle oxygen extraction which resulted in reduced muscle energy utilization. In addition, the authors assumed the 19% reduction of oxygen consumption was due to the fact that either mitochondrial efficiency was increased by reducing proton leakage and generating more ATP or the ATP cost of force production was reduced (1).

A related investigation was conducted by same author and colleagues in 2010 (3). In this study, the authors focused on the different sources of NO derivation. This study used L-arginine as a precursor of NO and demonstrated that acute L-arginine supplementation (6g of L-arginine product in 500ml of water) reduced the oxygen cost of moderate-intensity exercise and enhanced high-intensity exercise tolerance. A total of nine, healthy men took part in the study. All subjects consumed L-arginine supplementation for three days and performed exercise testing on each day of supplementation (1 hour after ingestion). The exercise protocol was conducted with a series of step tests of both moderate- and severe- intensity and an incremental ramp test. The authors looked at VO_2 amplitude as the difference between baseline oxygen consumption rate and terminal exercise VO_2. As a result of this experiment, VO_2 amplitude in moderate-intensity exercise was reduced by 10% following L-arginine ingestion. Functional gain, which was the ratio of increase in amount of oxygen uptake per minute to the increase in work rate, was decreased after L-arginine supplementation (From 10.8 ml·min·W in PL to 9.7 ml·min·W in L-arginine, *p-value not mentioned). In contrast to the moderate exercise, VO_2 increased from rest to severe-intensity exercise, but VO_2 slow component (the increase of oxygen consumption as time progresses in the severe-intensity exercise where oxygen uptake reaches steady state at a higher than peak VO_2) amplitude showed smaller increases so that it resulted in a 20% increased exercise tolerance during severe-intensity exercise. Based on these results, the authors concluded that the reduced oxygen cost was due to the reduced ATP cost of force production, oxygen cost of ATP production, or both. L-arginine supplementation as well as nitrate supplementation spared utilization of the anaerobic reserves such as creatine phosphate and the accumulation of metabolites such as ADP and inorganic phosphate which related to the fatigue process led to improved exercise tolerance. The authors concluded from the results that acute dietary L-arginine increased NO synthesis, reduced the steady-state oxygen consumption during moderate exercise as well as VO_2 slow component, and increased exercise tolerance during severe-intensity exercise (3).

Lansley and collaborators investigated whether dietary nitrate supplementation reduced oxygen cost and improved exercise tolerance on walking and running in nine healthy males (21). The subjects consumed either nitrate rich beetroot juice (0.5 liter/day) or nitrate depleted juice for 6 days. On days 4 and 5 the subjects performed a treadmill test. Knee-extension exercise was performed on the last day to examine the muscle phosphocreatine level and recovery kinetics by using P-magnetic resonance spectroscopy (P-MRS). They observed that oxygen consumption during moderate-intensity exercise was reduced with a reduction in amplitude of the VO_2 and oxygen cost of walking (BR: 0.70±0.10 and PL: 0.87±0.12 l/min, p<0.01) and running (BR: 2.10±0.28 and PL: 2.26±0.27 l/min, p<0.01). Also, oxygen consumption in severe-intensity was reduced (BR: 3.50±0.62 and PL: 3.77±0.57 l/min, p<0.01) which improved the exercise time-to-exhaustion by 15% (BR: 8.7±1.8 and PL: 7.6±1.5 min, p<0.01). Muscle metabolites concentration was not significantly different with BR compared to PL following knee-extension exercise. The authors first hypothesized that nitrate supplementation induces mitochondrial biogenesis. However, there was no difference in muscle oxidative capacity. They speculated that reduced oxygen cost was due to a reduction in ATP cost during muscle force generation. Consequently, the outcomes related to the nitrite or nitric oxide facilitated effects on muscle contractile function, rather than mitochondrial capacity or volume change (21).

In a follow-up study, Lansley et al. (22) published an article on time trial performance following acute dietary nitrate supplementation using a randomized, double-blinded, and cross-over design. Nine competitive cyclists participated in this study. They performed cycle ergometer time-to-exhaustion trials (TT) during 4-km and 16.1-km with either acute preloading of 0.5 liter of BR (~6.2 mmol of nitrate) or nitrate-depleted BR (PL). Acute beetroot supplementation improved time trial performance by 2.8% during 4-km TT and 2.7% during 16.1-km TT. Also, BR ingestion resulted in an increased power output for same amount of oxygen consumption. The results suggested that nitrate supplementation has the potential to enhance athletic performance at least in events of 5 to 30 minutes in duration. The authors speculated that power output was increased because nitrate facilitated an improvement in muscle contractile efficiency by reducing total ATP turnover and muscle metabolic perturbation, and subsequent reduction of ATP cost on cross-bridge cycle or $Ca^{2}+$ controlling. In addition, nitrate supplementation enhanced a larger volume of muscle blood and increase affinity of local blood flow to oxygen consumption which resulted in the higher intensity exercise performance. Thus, the authors concluded that beetroot supplementation caused improved power output without a change in oxygen consumption so that the power output at a given VO_2 is increased (22).

An article published in 2007 by Larsen and colleagues (23) investigated the effects of dietary nitrate supplementation on oxygen cost during sub-maximal and maximal exercise. Nine healthy males, consisting of either trained cyclists or triathletes, performed both submaximal and maximal cycle ergometer tests with two different dietary designs. Subjects consumed either high doses of nitrate supplementation with 0.1 mmol sodium nitrate/kg body weight/day or lower than normal dietary nitrate intake with sodium chloride (Placebo) for three days. This study found that peak oxygen consumption was significantly lower in submaximal work in higher nitrate supplementation trials which caused an increase in muscle efficiency. This finding indicated that oxygen demand was reduced at submaximal work rate. The authors speculated that since plasma lactate level was not changed during exercise following nitrate supplementation, reduced oxygen consumption during submaximal exercise was not because of cytochrome-c-oxidase inhibition solely. They, therefore, concluded that nitrate supplementation had an effect on proton leakage so that it was reduced over the inner membrane and improved muscular efficiency (23).

Potential Risks

Long term intake of nitrates has been linked to an increased risk of pancreatic and thyroid cancer (19-20). One study conducted by Kilfoy et al. showed that total inorganic dietary nitrate and nitrite intake had no relationship to pancreatic cancer, while high nitrate and nitrite consumption from processed meat increased the risk of pancreatic cancer non-significantly (P=0.11) (20). Another study (19) found that long term (2 years) and higher quintile intake of nitrate and nitrite which was determined by NIH-AARP diet, resulted in an increased risk of thyroid cancer. However, even though nitrate and nitrite in meats was thought to be the risk factor of common cancers, vegetable and fruit intake was found to reduce the risk of cancers (19). Furthermore, a number of studies have shown that regular consumption of inorganic nitrates in fruits and vegetables results in lower blood pressure and other cardiovascular benefits (1-4, 21-25, 40-41).

Additionally, even though directly ingested nitrites are considered to cause an adverse reaction which increases the risk factor of cancer (19-20), dietary nitrate supplementation in the form of beetroot juice is beneficial (38). This is because the small amount of nitrites in blood will be converted from nitrates by means of oral bacteria. Some previous studies have been conducted to examine the relationship of dietary nitrate and nitrite to common cancers including pancreatic and thyroid cancers. It has been shown that eating more vegetables and fruits and less meat or animal fat has beneficial effects on reducing the risk of some cancers and cardiovascular disease (38).

Fatiguing Exercise Testing

Several previous studies have investigated the effect of beetroot juice supplementation on the cost of oxygen consumption in submaximal and maximal exercise or time-trial performance. However, no study has examined the effect of dietary nitrate ingestion on resistance exercise or fatiguing exercise. Since this thesis research has investigated the effect of beetroot juice supplementation on muscle fatigue in isokinetic knee exercise, this section is focused on dealing with previous research with fatiguing exercise testing.

Concentric muscle contractions take place frequently in daily activities and in various sports competitions. Continuous maximal voluntary muscle contractions or multiple muscle actions bring about muscle fatigue. In 2000, Kawabata et al. published evidence which indicated knee flexor and extensor muscle fatigue pattern and the characteristics of muscle fatigue in various sports players. They tested three groups (baseball, soccer and marathon player) using isokinetic dynamometer and by having them perform three trials of 50 repetitions of right knee extension and flexion at a velocity of 180°/s at MVC with 10minutes of rest between trials. The fatigue rate of knee extensor muscle over the trials did not differ much between the three groups. However, the fatigue rate of concentric contractions was greater than that of eccentric contractions (18). Eccentric contractions are affected by a lower motor unit activation and energy expenditure than concentric contractions which means that eccentric action use less ATP than concentric action during cross-bridge cycling activity. Thus concentric actions are linked to a greater metabolic demand for oxygen (9), which results in greater fatigue rate when performed at the same velocity.

As far as the work fatigue rate resistance and reduction in the rate of fatigue are concerned, Pincivero and Campy (35) published a study in 2004 regarding the effect of rest interval length on knee extensor muscle fatigue during 6 weeks of strength training in healthy males. They showed that increasing resting time for muscle recovery in between trials of exercise, restoration from the resting period will cause greater muscle force for the reason that various time-dependent mechanisms triggering muscular fatigue might be recovered to pre-fatigue state. They trained three randomly assigned groups using short rest time, long rest time and control (no training) group. Work fatigue was measured at 2, 4 and 6 weeks following the pre-testing. Even though isokinetic peak torque for long term resting period group was elevated after training, work fatigue rate and power fatigue rate did not change significantly with either short-term resting period or long-term resting period. Despite no significant effect in muscle fatigue on knee extensor exercise with a single bout of 30 repetitions, the authors speculated that multiple bouts of fatigue testing are needed to examine the improvement of muscle fatigue resistance.

One study dealt with using supplementation and muscle fatigue during isokinetic contractions. Derave et al. (10) conducted a study using β-alanine supplementation which augments muscle carnosine content and attenuates fatigue during repeated isokinetic contraction bouts in trained sprinters. In a placebo-controlled, double-blind study, fifteen male athletes consumed either 4.8g/day of β-Alanine or placebo for 4 weeks and performed five bouts × 30 repetitions of maximal voluntary knee extensions at 180°/s separated by one minute of resting period between bouts. Significant elevation was observed in knee extension torque in every single bout of 30 contractions with β-Alanine supplementation. Also muscular fatigue was reduced slightly but considerably in later bouts of exercise with β-Alanine supplementation. The authors proposed that β-Alanine increased the level of carnosine in muscle and this carnosine loading attenuated muscular fatigue in continuous dynamic contractions.

The studies discussed above quantified muscle fatigue during isokinetic knee extensions. Pincivero conducted a series of investigations by using the following two methods in order to quantify muscle fatigue: 1) Calculation of the declining slope in peak torque, work and power from single highest value by each repetition across the 30 repetitions and 2) the Fatigue Index (F.I) (18, 34). The following equations were using to determine F.I in order to yield a percent reduction for each variable:

1) Percent decrease = 100 – [(last 5 repetitions / first 5 repetitions) × 100]
For subjects who attained their single highest repetition value for each isokinetic variable differently in which the single highest value was not in the first five, a second equation was applied:
2) Percent decrease = 100 – [(last 5 repetitions / highest consecutive 5 repetitions) × 100]

The highest consecutive 5 repetitions were determined by means of the two conjoined repetitions prior to, and following, the single highest value out of total repetitions. His initial study found that the calculation of muscle fatigue by using the first F.I seemed to be underestimated when the first five repetitions were applied, which is a contrast to the second equation (34). The author suggested that the second formula of F.I, by using the best value from each subject, was more accurate estimation of muscular fatigue.

In 2004, Pincivero (35) used a first order linear regression equation to calculate muscle fatigue. The author stated that it is appropriate to compute the decline in work and power through the contractions. The declined slope can then be attained to “quantify the rate of decrease in work ($N \cdot m \cdot rep^{-1}$) and power ($Watts \cdot rep^{1}$)” in each exercise session. He also mentioned that quantifying muscle fatigue rate by means of the slope calculation was reliable since it showed high reliability coefficients ranging from ICC= 0.78-0.82 between testing days.

Similar to those methods used by Kawabata et al. (18) were those found by Pincivero (35). They used the method to calculate the muscle fatigue rate by following formula.

$$F = (\text{Max torque of the first 5 repetitions} - \text{Max torque of the last 5 repetitions}) / \text{Max torque of the first 5 repetitions} \times 100$$

From the result of this study, it seems that the rate of fatigue during knee extensor muscle group was greater than that of the flexor muscle group. Furthermore, the fatigue rate in marathon athletes was smaller than in baseball and soccer players, and it was suggested that runners had better fatigue resistance. According to the outcome of the study, the method of calculating muscular fatigue rate seemed to be fairly accurate.

Summary

In consideration of this research, it is hypothesized that the effect of nitrate supplementation and muscle fatigue are unknown, although several early studies examined dietary nitrate intake on endurance exercise and performance. As a result, it is important to examine the relationship between acute beetroot juice supplementation and the rate of muscle fatigue after 50 maximal effort isokinetic knee extensor exercise. The purpose of this study is to expand our current knowledge of the importance of nitrate supplementation on muscle fatigue.

CHAPTER 3: METHODOLOGY

This chapter explains the methods used during the exercise testing protocol and nutritional supplementation procedures. The first two sections explain information of study subjects and exclusion criteria. The last two sections describe the details of the exercise testing and supplemental procedures.

Subjects

Thirty six adults (26 males, 10 females), habitually active or recreationally trained, between 19 and 44 years of age were recruited and signed informed consent. One female subject did not want to follow through with dietary protocol and was excluded from the study before testing measurements. Subjects were recruited primarily from the University of Kentucky undergraduate and graduate student population through word-of-mouth and Institutional Review Board approved posted recruitment flyers. The purpose of the research was explained to each subject and all subjects read, understood and signed an informed written consent form prior to taking part in any study procedures. Participants who were interested in this study were screened using the Physical Activity Readiness Questionnaire (PAR-Q), food frequency questionnaire (FFQ) and a medical history questionnaire (MHQ). FFQ asked subjects' daily and weekly food consumption including vegetables, fruits, and meats to estimate daily nitrate consumption and to exclude subjects who had been consuming more than 600mg/day of nitrate. MHQ examined subjects' medical history, physical characteristics, and their daily activity to verify the subjects were eligible to participate in to this study. The subjects were informed of the benefits and risks involved in the procedures.

This study was conducted as a double blind, cross-over design in which the order of testing was randomly assigned. The subjects were asked to report to the laboratory fully rested and reminded to avoid strenuous exercise 24 hours prior to each testing period. In addition, each subject was given a list of foods high in nitrate (Appendix 1) and instructed to refrain from the consumption of these starting 48 hours prior to the first testing session and continued until all testing sessions were completed. Moreover, the subjects were solicited not to use antibacterial mouth wash and chewing gum 48 hours before each testing session because these products kill oral bacteria which play a pivotal role in converting dietary nitrate to nitrite (21). There were no instruction and direction of caffeine consumption and smoking during the period of experiment. The procedures in this study were approved by the Institutional Ethics Committee.

Exclusion Criteria

Individuals were excluded from the study if they:

- reported knee problems by MHQ
- were unable to perform maximal effort knee extensions
- were unable to execute the knee extensor exercise using proper form
- were unable to follow through with dietary protocols
- had been consuming more than 600mg/day of nitrates and nitrites screened by FFQ
- had uncontrolled blood pressure
- reported any condition that could effect the safety of the subject or the veracity of the research, as determined by the researcher.

Exercise Testing Procedure

The knee extensor muscle group of each subject’s self-selected dominant leg was tested. Each subject completed exercise testing on three separate days, which included one familiarization session and two actual tests sessions. Peak torque was measured on the Biodex dynamometer (Biodex System 3, Shirley, New York, USA) by performing 50 maximal efforts, concentric knee extensions at 90°/s. All knee extensor testing was supervised by the same investigator. Pre-testing was performed by each subject in order for them to become familiar with the device. The subject was seated on a chair and the theoretical middle of knee was visually aligned with the axis of rotation of the dynamometer. The position of the chair and the dynamometer were recorded so that they could be duplicated for subsequent testing sessions. During the test, the subjects were secured to the dynamometer by four different bands (2 shoulder, a waist, and a thigh straps) to limit upper body and pelvis movement. This helped isolate the testing muscle groups and avoided any upper body involvement with torque generation. The total knee extension range of motion was 80°, between 15° of maximum extension to 95° of flexion (0°= full leg extension). Prior to testing the leg was weighed in order to correct the torque to include leg weight.

The subjects performed 50 maximal knee extensions at 90°/s followed by passive knee flexion also at 90°/s. Each subject was instructed prior to beginning the test to employ maximal effort by contracting as hard as possible for each repetition. Consistent verbal encouragements were provided during each test. Some subjects (8 out of 35 subjects from investigator’s observation) were asked to breathe normally during 50 contractions of isokinetic knee extensor exercise if they were attempting to effectively exhale even as keeping their mouth and nose closed, while other subjects were not notified to breathe normally during exercise testing. Peak torque and work for each repetition of knee extensor were measured. Peak torque was determined as the single highest value attained from each repetition. In addition, since higher values of torque were typically generated after the velocity exceeded 85°/s, isokinetic work was analyzed as the area underneath the torque curve from the first point where the velocity surpassed 85°/s until 700 milliseconds later. The change in peak torque generation and work over the number of contractions was used as a fatigue index. Peak torque and the rate of work were averaged over five consecutive repetitions and then expressed as a percentage. The 50 contractions were divided into 10 stages with five consecutive contractions. Work rate from each repetition was measured in the same way as peak torque.

Blood pressure (BP) of the brachial artery was measured each day of actual exercise testing session. First BP was recorded after 10 minutes of quite sitting using a sphygmomanometer and a stethoscope at resting state (pre-exercise BP). This blood pressure was approximately 2.5 hours after taking the last BR supplementation since last dose of beetroot juice was supplied 2.5 hours before each exercise testing. Second BP (post-exercise BP) was measured at the cessation of 50 contractions of knee extensor exercise. An investigator wrapped a sphygmomanometer cuff around each subjects' left arm to record brachial artery while the subjects were sitting on the chair after the exercise testing. Time interval between the cessation of exercise testing and BP record is about 10 seconds to 20 seconds. Systolic and diastolic BP were measured and mean arterial pressure (MAP) was calculated as $[(2 \times \text{diastolic}) + \text{systolic}] / 3$.

Dietary Supplementation

1) Administration

Each subject completed both a placebo and beetroot juice supplementation in each experimental session which was randomly assigned in a crossover and double blind design. The subjects ingested 70mL × 2 bottles = 140 mL of either inorganic nitrate (Nitrate concentration: 8.0mMol/day) from beetroot juice (BR) or placebo drink (PL) (black currant juice: negligible nitrate concentration). The subjects consumed the first bottle of beverages at 12hours before exercise and the second bottle of beverages at 2.5 hours before exercise testing. Both beetroot juice and placebo were randomly given to the subjects by a separate investigator, who did not participate in data collection. The beverages were released in a brown paper bag to the primary investigator to pass to the subjects. The separate investigator kept track of the order of beverages and informed primary investigator after all testing was completed. Both beverages were administered in identical black bottles. All subjects had at least a 72 hours wash-out and recovery period between the two exercise testing sessions.

2) Beetroot Juice

The BR (Beet It stamina shot, James White Drinks, Ipswich, UK) was commercially available beetroot juice (~4.0mMol/bottle of Nitrate). The content of nitrate, calories, and protein level were found in nutritional information label.

3) Placebo beverage

The PL beverage was modified to be isocaloric and isonitrogenous with the BR beverage. Additional sugar (sugar syrup) and protein (beneprotein powder, Nestle Nutrition, Vevey, Switzerland) were included to match BR's carbohydrate and protein composition and to ensure that the nitrates were the only differences between the two drinks. PL beverage and the BR were similar in odor, color, taste, and appearance.

Statistics and Data Analysis

The study utilized a randomized, double-blind, cross-over design in which the same subjects were measured at two different trials with two different treatment beverages. Excel (Microsoft® Excel 2010, Redmond, WA) was used to manipulate raw data. Since the raw data were exported from the Biodex dynamometer in text file, these files were converted to the Excel data sheets, and were able to manipulate in Excel. Raw data were manipulated into 50 contractions in order to find peak torque and work rate for each contraction. Then, the peak torque and work by each repetition across 50 contractions were separated by 10 stages with each stage included 5 repetitions. The rate of fatigue was calculated by fatigue index (F.I) by following equation.

Eq1. Percent decrease = 100 – [(averaged last 5 repetitions / averaged first 5 repetitions) × 100].

Peak torque and work rate were averaged over 5 consecutive contractions and then expressed as a percentage of 5 contractions. Thus, the ratio of the first stage (the first 5 repetitions) to the each of stages showed the percent fatigue rate.

SPSS (version 20.0; SPSS, Chicago, IL) was used to perform the two-tailed paired *t*-tests and two-way Analysis of Variance (ANOVA) with repeated measures. Paired *t*-tests were used to assess the differences between the BR and PL in mean peak torque, mean maximum work and in blood pressures. Changes in mean peak torque and maximum work rate across 50 maximal voluntary contractions for 35 subjects and mean percent remained torque and the rate of work fatigue at multiple stages were analyzed by two-way ANOVA (supplement × time changes) repeated measures for BR and PL. The significance level was accepted when P-value < 0.05. Data were expressed as mean ± standard deviation (M ± SD), unless stated differently.

CHAPTER 4: RESULTS

The purpose of this chapter is to report the findings of this study related to the effect of acute inorganic dietary nitrate supplementation on muscle fatigue in knee extensor exercise in the context of hypotheses proposed in Chapter 1. Applicable tables and figures are provided.

Subjects

Thirty six (26 males, 10 females) were recruited and signed informed consent, but one female subject did not want to follow through with dietary protocol and was excluded from the study before any testing measurement begin. Thus, total 35 subjects completed this study. Age, height, weight and body mass index (BMI) of participants are showed in Table 1.

Mean Peak Torque and Mean Maximum Work

Mean peak torque (Nm) and mean maximal work (J) during the 50 contractions across 35 subjects are presented in Table 2. Mean peak torque is defined as the highest torque produced by each subject during the 50 contractions which is then the averaged across 35 subjects. The descriptive data for the mean peak torque (Nm) for each subject with different supplements are shown in Appendix 2. A paired t-test was used to evaluate the difference between BR and PL for mean peak torque. There was no statistical difference between BR and PL in mean peak torque across 35 subjects ($p=0.663$). Mean peak torque with BR was 0.6% lower than with PL.

The mean maximal work is described as an average of single highest work during the 50 contractions, in which each participant completed their highest work value for a single repetition. The illustrative data for the mean maximal work (J) for each subject are also shown in Appendix 2. The difference between BR and PL for the mean maximum work was analyzed using a paired t-test. There was no statistically significantly difference between BR and PL in mean maximum work across subjects (p= 0.781). Maximum work done by 35 subjects was 0.3% higher with BR than PL.

Changes in Peak Torque and Maximum Work

Changes in absolute peak torque and maximum work rate are illustrated in Figure 1 and Figure 2, respectively. Both parameters showed steady decline over the 50 contractions, but there was no significant difference between the PL and BR conditions. Separate ANOVA tables for peak torque and maximum work between BR and PL treatment are listed in Appendix 3 and raw data of both torque and work with all 35 subjects with each treatment are shown in Appendix 4.

Muscle Fatigue

A two-way ANOVA with repeated measure was used to analyze the rate of fatigue between conditions over time. There were no significant differences between BR and PL in the rate of fatigue by either peak torque or work over 50 contractions. Peak torque and the rate of work for 50 contractions were divided into 10 stages. Each stage was averaged over five consecutive repetitions. Figure 3 shows the change in peak torque over 10 stages for BR versus PL expressed as a percentage of mean remained strength. By stage 3 (11th-15th reps), subjects retained 87.6±6.9% of their strength with BR and 86.7±6.3% with PL. Results for stages 6 (26th-30th) and 10 (46th-50th) were as follows: BR 64.1±11.4 vs. PL 63.2±11.7 % and BR 47.9±12.6 vs. PL 46.9±12.9%, respectively. Figure 4 shows the percent changes in the rate of fatigue for work over 10 stages between BR and PL. By stage 4 (16th – 20th reps), mean percent work fatigue showed 20.6±9% with BR and 21.8±10.1% with PL. Outcomes for stage 6 (26th-30th) and 10 (46th-50th) were as follows: BR 36 ±10.1% vs. PL 37.2±12.1% and BR 52.5±12.6% vs. PL 53.2±13%, respectively. Tables 3 and 4 shows the outcome of a two-way ANOVA with repeated measures which indicates the rate of fatigue data by torque generation and work rate over treatment and time changes. There was no significant treatment effect ($p = 0.614$ and $p = 0.609$, respectively) which means that BR supplementation had no effect when compared to PL treatment in this study, while both conditions showed a significant time effect ($p < 0.001$). There was no significant interaction which means that the rate of fatigue was similar between BR and PL conditions.

Supplementations and Blood Pressure

Blood pressure data are summarized in Table 5. No significant differences in resting BP were observed between BR and PL before fatiguing exercise. Even though systolic blood pressure after exercise testing showed no differences, diastolic and MAP did show significant differences between BR and PL. Figure 3 shows the BP changes in diastolic phase (A) and MAP (B) after fatiguing exercise between BR and PL. After fatiguing exercise, diastolic BP (BR 67.2±9.8 vs. PL 64.5±7.9mmHg, $p < 0.05$) and mean arterial pressure (MAP: BR 91.6±9.3 vs. PL 88.8±8.2mmHg, $p < 0.05$) both increased with BR supplementation, differing from PL conditions.

Table 1. *Age, height and weight in 35 male and female subjects.*

Variable	Means ± SD	Range
Age (years)	24 ±3.9	19 - 36
Height (cm)	174. 5 ± 10.2	157. 5 - 203.2
Weight (kg)	71.8 ± 13.3	49.9 - 113.4
BMI	23.4 ± 2.9	19 – 32.9

Table 2. *Differences between BR and PL in mean peak torque and maximum work across 35 subjects (Means ± SD, BR = beetroot, PL = Placebo).*

	BR	PL	%Δ (BR / PL)	*P*-value
Peak Torque (Nm)	186.7 ± 46.4	187.6 ± 48.1	0.6	0.663
Maximum Work (J)	7821.3 ± 2054.9	7796.3 ± 2041	0.3	0.781

(Nm: Newton meter, J: Joule)

Figure 1. *Changes in absolute mean peak torque generation across 50 maximum voluntary contractions for 35 subjects (beetroot versus placebo).*

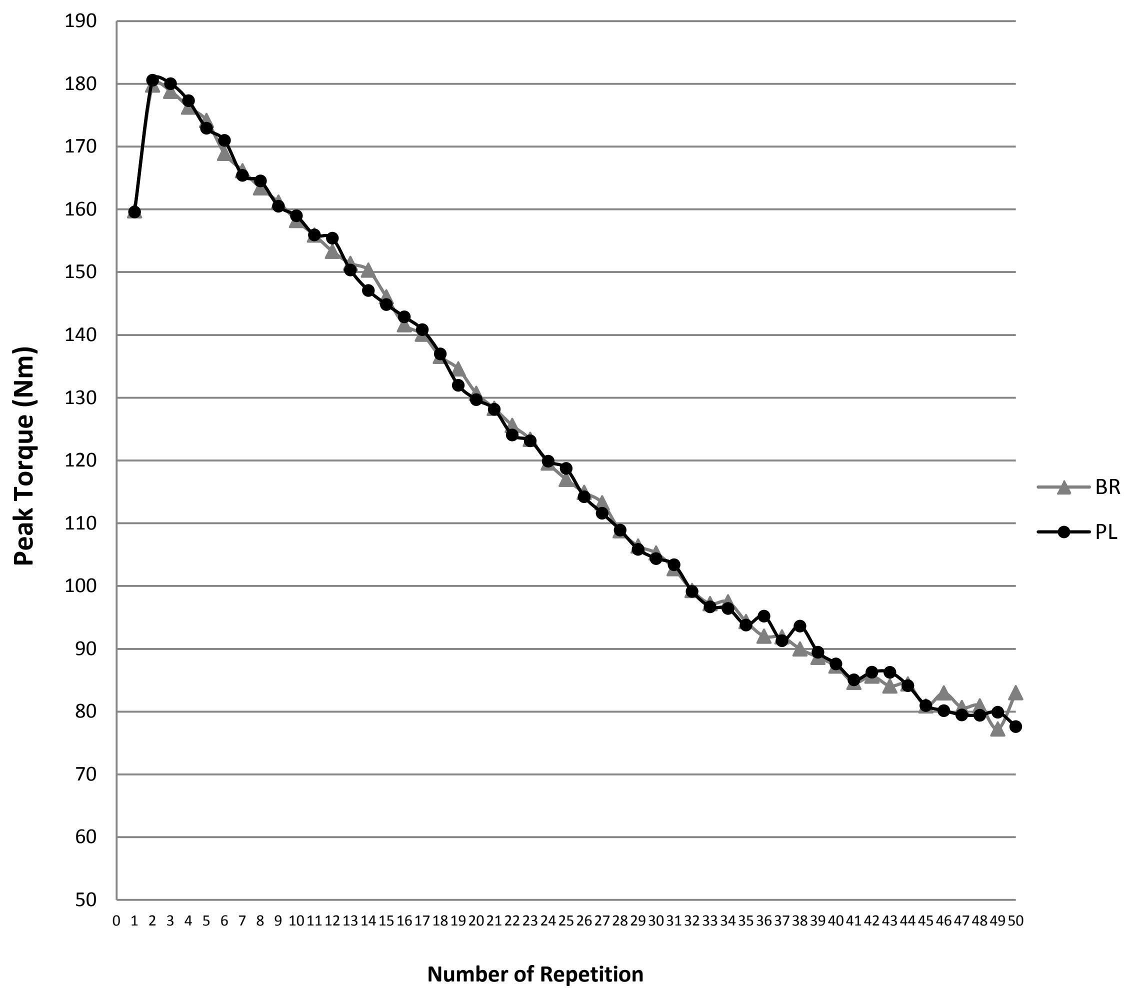


Figure 2. *Changes in absolute mean maximum work rate across 50 maximum voluntary contractions for 35 subjects (beetroot versus placebo).*

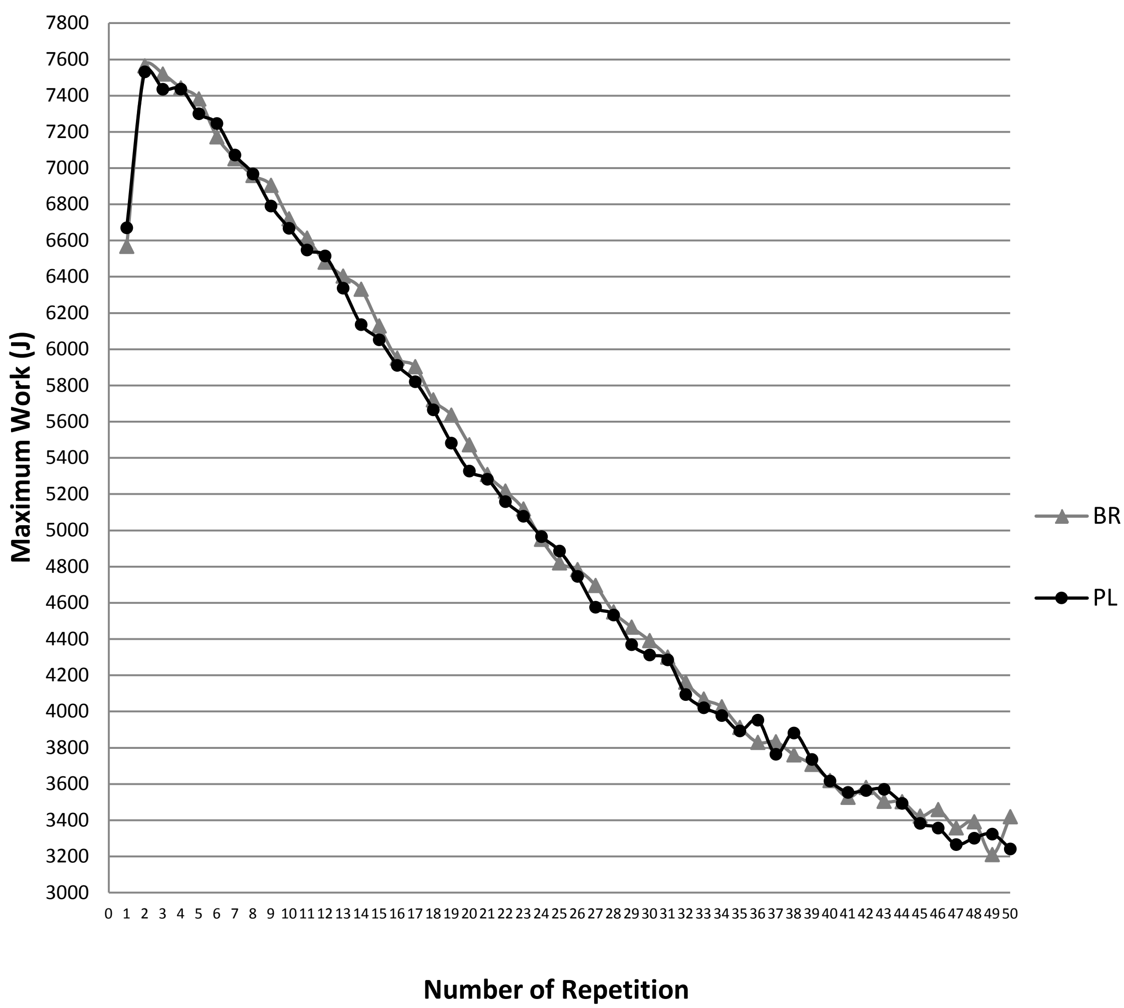


Figure 3. *Percent change in peak torque over 10 stages for beetroot versus placebo across 35 subjects.*

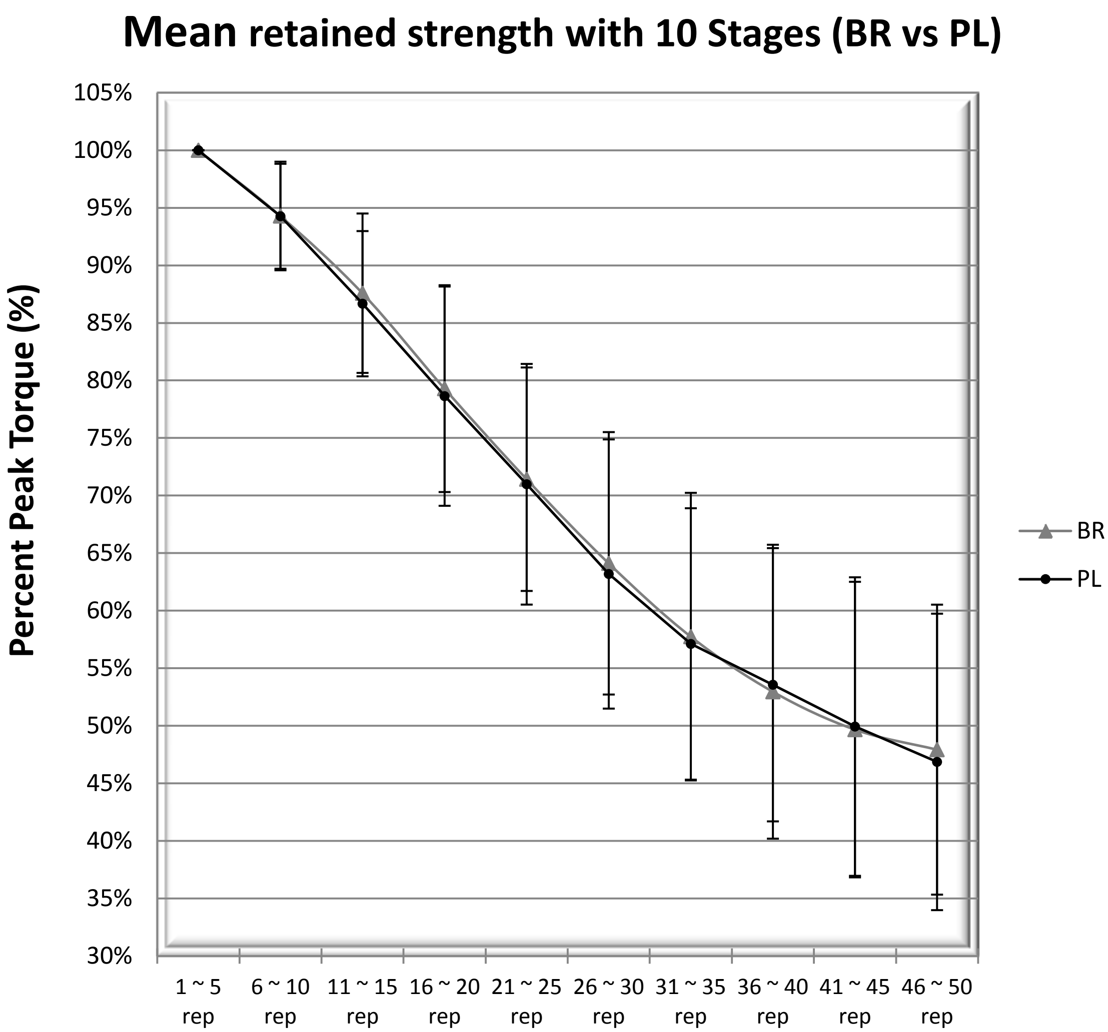


Figure 4. *Change in the rate of work fatigue over 10 stages for beetroot versus placebo across 35 subjects.*

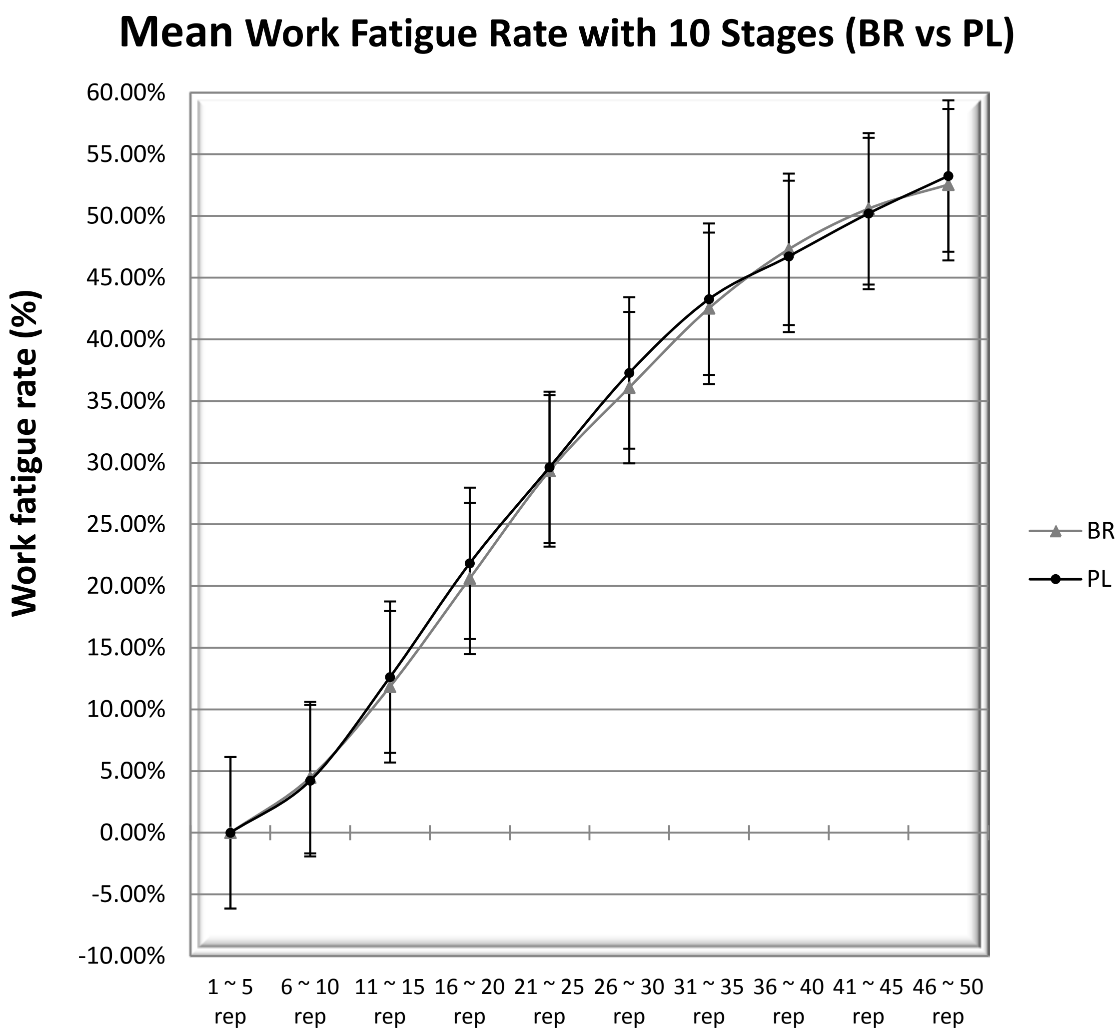


Table 3. *Two-way analysis of variance with repeated measures on the rate of fatigue by torque generation at multiple stages with beetroot and placebo treatment.*

The Rate of Fatigue by Torque Generation					
Source	SS	DF	Mean Square	F	Sig.
Treatment	.003	1	.003	.259	.614
Error(Treatment)	.368	34	.011		
Time	15.967	8	1.996	471.414	.000
Error(Time)	1.152	272	.004		
Treatment - Time	0.005	8	.001	.583	.792
Error (Treatment-Time)	.275	272	.001		

Table 4. *Two-way analysis of variance with repeated measures on the rate of fatigue by work rate at multiple stages with beetroot and placebo treatment.*

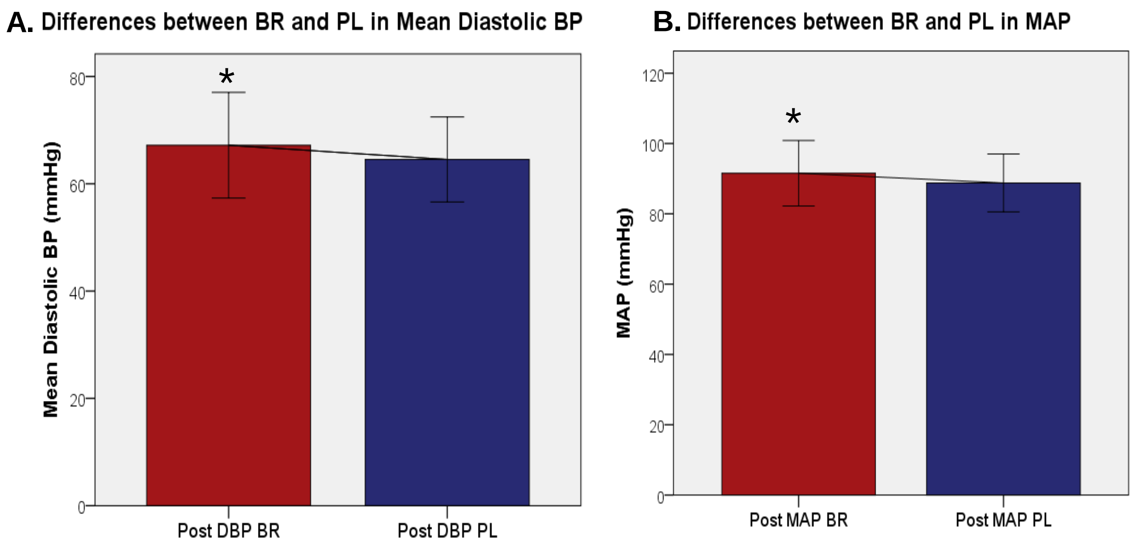
The Rate of Fatigue by work					
Source	SS	DF	Mean Square	F	Sig.
Treatment	.003	1	.003	.266	.609
Error(Treatment)	.334	34	.010		
Time	16.708	8	2.088	454.874	.000
Error(Time)	1.249	272	.005		
Treatment – Time	.006	8	.001	.792	.610
Error (Treatment-Time)	.271	272	.001		

Table 5. *Blood pressure at pre-exercise and post-exercise with beetroot and placebo supplementation.*

	BR	PL
Pre BP systolic (mmHg)	111.71 ± 7.7	111.41 ± 6.8
Pre BP Diastolic (mmHg)	70.82 ± 8.7	70.06 ± 7.8
Pre MAP (mmHg)	84.45 ± 7.8	83.84 ± 6.8
Post BP systolic (mmHg)	140.29 ± 12.9	137.29 ± 15.1
Post BP Diastolic (mmHg)	67.18 ± 10.2*	64.53 ± 7.9
Post MAP (mmHg)	91.54 ± 9.3*	88.78 ± 8.2

(BP: Blood Pressure, MAP: Mean Arterial Pressure.) * Different from PL, $P < 0.05$.

Figure 5. *Mean post exercise diastolic BP (A) and post exercise MAP (B) after beetroot and placebo supplementation (M±SD, N= 34. * p<0.05 vs. PL).*



CHAPTER 5: DISCUSSION

This chapter presents the discussion of the findings of this study. The first section in this chapter includes the original research questions followed by the rationale behind beetroot juice supplementation, the effect of BR on muscular responses, blood pressure, and nutritional aspects of the study beverages.

Original Research Questions

This was the first study to examine the effect of acute beetroot juice supplementation as a source of inorganic nitrate on acute muscular endurance during knee extensor fatiguing exercise. Thus, the current study has raised some questions.

1. Does BR juice supplementation lower muscle fatigue as measured by change in torque generation and work rate over the 50 contractions in the specific velocity of the knee extensor test?
2. Does BR juice supplementation lower blood pressure before and after fatiguing exercise?

The outcome of this study suggested that acute beetroot juice supplementation had no significant effect on knee extensor muscle fatigue as measured by isokinetic contractions in habitually active or recreationally trained individuals. Acute beetroot juice supplementation also had no effect on peak torque and maximum work rate. In addition, beetroot juice supplementation increased post exercise diastolic blood pressure and mean arterial pressure in the brachial artery. These findings did not support the alternative hypotheses of the current study and were inconsistent with the improvement of performance and hemodynamics parameters observed by previous studies following dietary nitrate supplementation (1-4, 21-25, 40-41). However, these findings are important as a first step in elucidating the effect of inorganic dietary nitrate on muscular fatigue and resistance exercise since this is the first study to examine the relationship between acute BR supplementation and muscular fatigue in humans.

Rationale

Dietary nitrate supplementation via beetroot juice or sodium nitrate has been shown to increase muscular contractile efficiency in force production by reducing muscle phosphocreatine utilization and total ATP turnover rate (2). Dietary nitrate supplementation has also been demonstrated to increase mitochondrial efficiency by increasing oxidative phosphorylation efficiency (25). Previous studies have shown that mitochondrial production of ATP was improved by reducing proton leakage in the electron transport chain and the amount of oxygen utilization per ATP molecule synthesized was reduced (4, 8, 25). Thus, increased mitochondrial efficiency enables the human body to reduce oxygen cost during exercise without influencing maximal capacity to exercise. Even though many previous studies have demonstrated that nitrate supplementation results in positive effects on exercise capacity, mechanisms behind this positive effect are unclear. The question remains in how nitrate supplementation reduces the cost of oxygen during endurance exercise (1, 3, 21, 23), improves exercise performance (5, 7, 22) during rowing and cycling and improves exercise tolerance (1-3, 24, 41). These effects may be due to increased mitochondrial efficiency. One study has also suggested that dietary nitrate supplementation benefits oxygen consumption and tolerance to exercise by increasing muscle contractile efficiency, rather than an improvement in mitochondrial efficiency (2, 25). Bailey et al. (2) demonstrated that the rate of cross-bridge cycling slows with BR juice supplementation resulting in less ATP utilization during muscle force production. If cross-bridge cycling rate is slowed by dietary nitrate supplementation with the same amount of force generation, it is reasonable to think that this could change the rate of fatigue by means of less ATP depletion as measured during a muscle endurance task. Nonetheless, our findings do not support reduced muscle fatigue by means of increasing muscle contractile efficiency after acute BR supplementation. Even though the current study did not measure muscle metabolic responses and rate of cross-bridge cycling to examine muscle fatigue, outcomes from the present study showed no significant differences on the rate of muscle fatigue in knee extensor fatiguing exercise between BR and PL treatments.

The effect of acute BR supplementation on muscular responses

The current study found no statistical differences between BR and PL on peak torque, work rate, and the rate of fatigue after acute dose of BR supplementation. These results demonstrated that the BR supplementation has no positive effect on muscle force generation and muscular work. Acute periods of nitrate supplementation have previously been shown to have positive effect on exercise capacity and exercise performance including improvement of cycling time trial performance (22), lowering oxygen cost of moderate-intensity exercise (40) and reduced peak oxygen consumption and ratio of VO_2 / power at maximal intensity exercise (4). Acute beetroot juice supplementation has also been conjectured to enhance physiological functions such as regulation of blood flow and blood pressure (17), regulatory influence on the ATP cost of force production (12, 14), and cellular oxygen utilization and enhancement of oxidative phosphorylation efficiency (8) during exercise which are similar to after long term ingestion of nitrate supplementation. These physiological responses following acute nitrate supplementation enable us to speculate a reduction in the rate of muscle fatigue. However, it is unknown if the rate of fatigue examined in the current study was influenced by muscle contractile efficiency or mitochondrial efficiency.

This study showed that the rate of fatigue by measuring torque generation and work rate in each set of fatiguing exercise were similar in BR and PL trials. Both trials with BR and PL showed approximately 52% ~ 53% of total fatigue at the end of 50 repetitions. The fatiguing exercise protocol used in this study was similar to the fatiguing exercise testing used by Pincivero et al. (34) and Kawabata et al. (18). Pincivero et al. (34) conducted an investigation by calculating the declining slope in peak torque, maximum work and power from single highest value by each contraction across the 30 repetitions of maximal knee extension and flexion concentric contractions in order to quantify muscle fatigue. The total fatigue rate was shown about 30% to 40%. Kawabata et al. (18) tested three groups (baseball, soccer and marathon athletes) using an isokinetic dynamometer. Each group performed three trials of 50 repetitions of right knee extension and flexion at a velocity of 180°/s with 10minutes of rest between trials and which resulted in 40% to 56% total fatigue.

In contrast to the present study, it has been demonstrated that 6 days of beetroot juice supplementation increases muscle contractile efficiency in incremental knee extensor exercise by measuring muscle metabolic responses in low-intensity and high-intensity exercise (2). Bailey et al. (2) suggested that dietary nitrate supplementation reduced ATP utilization in muscle during exercise by decreasing muscle phosphocreatine degradation and ADP and phosphate accumulation, and further increased the cost of oxygen utilization in muscle. However, their findings may have resulted from the peak work rate being established by using a two-legged knee extension ergometer as opposed to the 50 maximal one-legged isokinetic contractions used in the present study. This is because peak oxygen uptake and peak work rate are not increased in proportion to active muscles so that one-legged knee extensor exercise resulted in higher peak oxygen uptake and peak work rate compared to the one leg in two-legged exercise (31). Although muscle metabolic responses and oxygen consumption to one-legged isokinetic knee extension exercise after acute BR supplementation were not directly measured, the higher oxygen and ATP utilization during one-legged knee extension exercise may result in decreased cost of oxygen utilization in exercising muscle and increased ATP utilization.

Nitrate Supplementation

Previous studies have administered beetroot juice (Beet It original) in 500ml beverages which contained from 5.1mMol to 6.2mMol of nitrate per day (1-2, 21, 40). All levels of nitrate containing drinks resulted in significant increases in plasma nitrates and nitrites. Although this study did not measure the plasma nitrite level, we believed it is reasonable to assume that the BR used in this study resulted in both increases in plasma nitrates and nitrites. This study used acute doses of concentrated beetroot juice with 8mMol/day because it has been shown that acute doses of 5.2 to 6.2mMol/day nitrate supplementation resulted in a significant improvement of oxygen utilization efficiency and time-trial performance in elite cyclists (4, 22, 40). Even though this study used a BR supplementation with higher nitrate concentration (8mMol/day) compared to the other studies (5.2 to 6.2mMol/day), we tested non-elite athletes and muscular endurance exercise under the mechanism of muscle contractile efficiency improvement instead of oxygen utilization efficiency in athletes which may have partly contributed to varying results. Nonetheless, a fatiguing exercise protocol such as used in the present study may require a longer duration of BR supplementation in order to produce decreases in the rate of fatigue. Vanhatalo et al. (40) has shown that although both acute and chronic dietary nitrate supplementation lowers oxygen cost and blood pressure, the peak power output and the work rate related to gas exchange threshold were higher after 15 days of BR ingestion.

Dietary Controls

Previous studies (1-2, 5, 41) asked subjects to refrain from consumption of foods rich in nitrates prior to and during the study. Other studies recorded foods and fluid that participants consumed 24 hours before the first test, and duplicated the foods and fluid in the subsequent trials in order to control dietary nitrate intake (21-22). Even though Vanhatalo et al. (40) allowed their subjects to have a normal diet which included vegetables with high nitrate and nitrite contents, plasma nitrite level was significantly increased after beetroot juice supplementation and cost of oxygen was reduced during submaximal exercise after beetroot juice ingestion. Thus, this would suggest that the beneficial effect of BR supplementation on exercise efficiency is applicable without dietary control. In this study, participants were asked to restrict their consumption of nitrate-rich vegetables such as lettuce and spinach for two days prior to the first actual testing session until the study was completed. Our dietary control was similar to previous studies (1-2, 5, 41) that limited additional nitrate consumption other than BR prior to and during the study. Thus, the combination of the compound from the other food sources, rather than dietary nitrate from beetroot juice alone, may not significantly affect the outcomes of this study. In addition, the current study controlled the subjects not to use antibacterial mouth wash and chewing gum 48 hours before each testing session to ensure leading to appreciable increase in plasma nitrates because these products kill oral bacteria which play a pivotal role in converting dietary nitrate to nitrite (21).

Anti-oxidant property in both BR and PL

Previous studies have used placebo beverages made of nitrate depleted BR (7, 21-22, 41) or black currant juice with negligible nitrate content (1-2, 5, 40) since the beneficial effect of BR supplementation is based on the systemic reduction of dietary nitrate to nitric oxide. The use of black currant juice and nitrate depleted BR allowed those studies to investigate the effect of BR as an ergogenic aid with nitrate acting as the bioactive component.

Exercising muscle continually generates reactive oxygen species (ROS) which may exert muscle fatigue. However, it is unknown if other bioactive compounds in BR or PL beverage may play a role in decreasing the rate of fatigue (36). The present study used black currant juice as a placebo beverage which contains the antioxidant vitamin C. Reactive oxygen species (ROS) which are increased by strenuous exercise may play a role in fatigue in working muscle because ROS elevates oxidative stress in exercising muscle (36). High doses of pharmacologic antioxidants such as N-acetylcysteine have been shown to depress muscle fatigue in rodent muscles and undamaged human muscle (36). Thus, we speculated that even though the testing beverages (BR) are supplied from natural food sources, antioxidant properties of both BR and PL may reduce oxidative stress in working muscle and further confound our outcomes related to muscle fatigue during and after exercise.

Beetroot juice contains other bioavailable antioxidants such as betalain according to a research from Wootton and Ryan (42). The authors suggested that BR supplementation, especially Beet it stamina shot, increases total antioxidant capacity (TAC) in the post digestion phase (42). Again, anti-oxidants may play a role in lowering oxidative stress induced muscular fatigue by reducing ROS. In the current study, we approached our hypothesis that acute beetroot juice supplementation significantly reduces muscle fatigue because of nitrate induced improvement of muscle contractile efficiency. Even though the findings which indicated beetroot juice stamina shot contains anti-oxidants from the study (42), there was no significant difference in the rate of muscle fatigue between BR and placebo in the current study. Thus, one possible explanation is that anti-oxidant properties in placebo and beetroot juice might elicit similar outcomes on the rate of fatigue.

The effect of BR and PL on blood pressure

In this study, there were no significant differences in resting BP between BR and PL before fatiguing exercise, while diastolic and MAP showed significantly higher in BR compared to PL. Nitric oxide derived from dietary nitrate is a known vasodilator (17, 24), and several authors have speculated that NO regulates blood pressure and blood flow as well as tissue oxygenation at rest and after exercise (1, 24). Several studies have suggested that acute or long-term BR juice supplementation reduces systolic blood pressure (1-2, 21-22, 40-41). Other studies have shown that neither systolic nor diastolic blood pressures are affected by BR in the resting state (5, 7). Similar to these studies, the present study showed no significant differences in resting BP between BR and PL prior to the start of fatiguing exercise. Diastolic and mean arterial pressure, however, were both increased with BR supplementation after fatiguing exercise compared to the PL. Previous studies with reduced systolic blood pressure (1-2, 21- 22, 40-41) after BR supplementation measured BP at rest before exercise testing, while only one study (5) recorded post exercise blood pressure. Bond et al. (5) reported increased systolic and diastolic blood pressure immediately post-exercise, one minute post-exercise and two minutes post-exercise with six sets of maximal intensity rowing performances. Even though data from Bond et al. (5) were not statistically significant, these data seem to align with results from current study. It can be speculated that upper body muscle contraction involved in during isokinetic knee extensor exercise may be responsible for the acute effect on diastolic blood pressure and MAP in working muscles.

While the reason for results of BP in the current study is unknown, spontaneous Valsalva maneuver during maximal voluntary contraction may additionally increase blood pressure (30). However, we asked the subjects to breathe normally during knee extensor exercise in order to avoid this maneuver. We observed that most of subjects (27 out of 35 subjects) did not perform this maneuver, while some subjects needed a verbal reminder during 50 contractions of isokinetic knee extensor exercise.

The antioxidant contents of both BR and PL might contribute to the blood pressure changes we observed after fatiguing exercise. In a meta-analysis, Juraschek et al. (16) found that vitamin C supplementation reduced both systolic and diastolic blood pressure significantly because vitamin C increases nitric oxide production by elevating endothelial nitric oxide synthesis (NOS) as a potential vasodilator (16). However, the doses and duration of supplementation reported by Juraschek et al. (500mg/day and 8weeks, respectively) greatly exceeded the doses from our study (approximately 21mg/day).

Equipment Factors

It has been shown that the isokinetic dynamometer is a reliable isokinetic muscular strength measurement device. Lund et al. suggested that the Biodex dynamometer system 3 is highly reliable which shows little learning effect from device (26). Also, one previous study suggested that isokinetic concentric knee extension testing of peak torque and work rate were favorably reliable (37). Even though Sole et al. (37) tested heterogeneous groups of subjects with different gender, experience of isokinetic strength testing, and physical activity background, no difference between heterogeneous groups of subjects was found on isokinetic dynamometer strength measurement (37). Thus, isokinetic concentric knee extension test by using Biodex dynamometer system 3 in current study has no known deleterious effects on muscle fatiguing protocol by measuring change in peak torque and work rate.

Strengths and Limitations

Previous studies (1-2, 5, 41) requested subjects to refrain from consumption of foods rich in nitrates prior to and during the study. Other studies recorded foods and fluid that participants consumed 24 hours before the first test, and duplicated the foods and fluid in the subsequent trials in order to control dietary nitrate intake (21-22). However, other studies did not match the number of calories and amino acids in the placebo beverage. These differences could contribute to the overall findings. In present study, the PL beverage was modified to be isocaloric and isonitrogenous with the BR beverage which is strength of the current study. Additional sugar (sugar syrup) and protein (beneprotein powder, Nestle Nutrition, Vevey, Switzerland) were included to match BR’s carbohydrate and protein composition.

The present study has some limitations. First, this study did not measure plasma nitrate and nitrite level for either treatment. However, the BR treatment provided a dietary nitrate dose (8 mMol / day) which has been shown to increase nitrite in circulation. Second, we did not assess the major components of placebo beverage to determine if it possessed any vasodilation properties. Ideally, future studies need to monitor whether reactive oxygen species are increased following fatiguing exercise stimuli and the effect of anti-oxidants on ROS during fatiguing exercise. Third, each subject chose their own exercise testing time, thus, some of the subjects did not perform at the same time for each testing. This may influence blood pressure and performance by the impact of diurnal variations on vascular parameters.

Future Research

According to the outcomes from Vanhatalo et al. (40), long term ingestion of BR juice may result in a higher power output, work rate, and VO2max, as well as lower systolic and diastolic BP specifically prominent after ≥12 days of BR intake. These finding suggested that nitrate supplementation may have a duration-dependent effect. Higher power output and work rate after 15 days of nitrate supplementation may be associated with a reduced ATP turnover / power output ratio and ATP turnover / work rate ratio which related to fatigue process led to improved exercise tolerance. Thus further studies with longer duration of nitrate supplementation are needed with muscular fatigue.

Conclusion

The results of this study suggest that acute BR supplementation has no effect on the rate of muscular fatigue as measured by repeated knee extensor exercise. Acute BR supplementation before knee extensor exercise appears to provide no positive effect on the maximal force generation and maximum work rate. These results cannot be supported by a reduced ATP utilization and increased muscular contractile efficiency. In addition, comparable to the several previous studies, diastolic blood pressure and MAP did not change in resting state after acute beetroot juice supplementation compare to the PL supplementation. In contrast with previous studies which showed a reduced blood pressure, the outcomes on BP in present study showed increased diastolic blood pressure and MAP after fatiguing exercise. These outcomes suggest that the potential beneficial effect of acute BR juice supplementation on blood pressure has to be reevaluated if it may play a positive role in potential vasodilator.

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Appendix 1. *Lists of vegetables high in nitrate and nitrite.*

1. Classification of vegetables according to nitrate content.

Nitrate content (mg/100 g fresh weight)	Vegetable varieties
Very low, <20	Artichoke, asparagus, broad bean, eggplant, garlic, onion, green bean, mushroom, pea, pepper, potato, summer squash, sweet potato, tomato, watermelon
Low, 20 to <50	Broccoli, carrot, cauliflower, cucumber, pumpkin, chicory
Middle, 50 to <100	Cabbage, dill, turnip, savoy cabbage
High, 100 to <250	Celeriac, Chinese cabbage, endive, fennel, kohlrabi, leek, parsley
Very high, >250	Celery, cress, chervil, lettuce, red beetroot, spinach, rocket (rucola)

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2. Nitrate and Nitrite contents of edible components of vegetables

Vegetable types and varieties		Nitrite (*mg/100 g fresh weight*)	Nitrate (*mg/100 g fresh weight*)
Root vegetables	Carrot	0.002–0.023	92–195
	Mustard leaf	0.012–0.064	70–95
Green vegetables	Lettuce	0.008–0.215	12.3–267.8
	Spinach	0–0.073	23.9–387.2
Cabbage	Chinese cabbage	0–0.065	42.9–161.0
	Bok choy	0.009–0.242	102.3–309.8
	Cabbage	0–0.041	25.9–125.0
	Cole	0.364–0.535	76.6–136.5
Wax gourd	Wax gourd	0.001–0.006	35.8–68.0
	Cucumber	0–0.011	1.2–14.3
Nightshade	Eggplant	0.007–0.049	25.0–42.4

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Appendix 2. *Descriptive data for mean peak torque and mean maximum work from 50 contractions across 35 subjects.*

Sub#	Peak tq(Nm) BR	Peak tq(Nm) PL	Max wrk(J) BR	Max wrk(J) PL
1	117.01	111.99	4835.20	4607.80
2	132.46	128.40	5765.30	5633.80
3	176.53	177.48	7414.30	7207.50
4	198.49	193.20	7794.40	7351.80
5	221.54	243.23	8965.20	9940.70
6	205.41	207.44	7643.70	8147.00
7	136.26	133.28	5471.30	5339.90
8	205.54	201.20	8869.20	8888.60
9	239.98	251.23	10557.40	10872.60
10	159.99	176.53	6572.70	7380.70
11	160.53	175.58	6414.30	6939.90
12	163.10	174.76	6965.20	7496.60
13	163.78	158.63	7262.80	6832.30
14	232.93	225.47	10251.80	9872.80
15	140.06	146.02	5917.00	6236.90
16	148.06	146.02	6046.90	6043.70
17	122.57	122.57	5194.30	5241.70
18	203.37	183.71	8877.90	7416.10
19	191.58	200.12	7771.40	7883.70
20	117.28	110.09	5030.40	4645.10
21	186.29	178.29	7876.10	7632.30
22	123.52	139.92	5357.70	5950.00
23	352.38	367.70	15683.40	15645.30
24	199.31	173.00	8567.00	7285.20
25	186.70	197.81	8037.60	8383.80
26	215.44	232.79	8597.80	9104.50
27	202.02	194.70	8436.40	8072.00
28	227.10	220.73	8650.60	8617.00
29	167.17	177.34	6987.30	7430.20
30	235.91	226.56	9972.20	9772.30
31	197.41	193.75	7862.30	7673.90
32	215.30	223.85	9178.60	9234.80
33	170.56	172.46	6852.30	6852.30
34	230.49	208.25	9555.80	8532.40
35	190.36	192.25	8509.00	8704.00
Average	186.70	187.60	7821.30	7796.30
Std.deviation	46.36	48.07	2054.94	2041.03
std.error mean	7.84	8.12	347.34	344.99

Appendix 3. *The ANOVA between beetroot and placebo treatment by 50 contractions for 35 subjects.*

The Within-Subject Effect by Torque Generation					
Source	SS	DF	Mean Square	F	Sig.
Treatment	4.913	1	4.913	.004	.950
Error(Treatment)	42244.787	34	1242.494		
Contractions	3687663.381	49	75258.436	169.916	.000
Error(Contractions)	737895.283	1666	442.914		
Treatment - Contraction	2259.676	49	46.116	.616	.983
Error (Treatment-Contraction)	124747.398	1666	74.878		

The Within-Subject Effect by work					
Source	SS	DF	Mean Square	F	Sig.
Treatment	201539.803	1	201539.803	.003	.956
Error(Treatment)	2181192729	33	66096749.37		
Contractions	6556036337	49	133796659.9	279.713	.000
Error(Contractions)	773467570.1	1617	478334.923		
Treatment – Contractions	6070174.349	49	123881.109	.252	1.000
Error (Treatment-Contractions)	795467786.1	1617	491940.499		

Appendix 4. *Raw data of beetroot and placebo treatment from all 50 contractions across 35 subjects in peak torque generation and work rate*

Peak Torque (ft·lb) - BR

Rep # / Sub #	1	2	3	4	5	6	7
1	101.1	111.6	119.2	179.9	176.3	70.1	127.0
2	117.0	132.5	170.3	179.6	211.6	143.4	125.5
3	111.4	119.6	176.5	177.5	216.3	176.9	115.8
4	105.9	125.5	158.1	183.6	219.1	173.3	117.1
5	107.2	123.2	167.6	171.0	211.9	205.4	136.3
6	96.3	121.5	169.2	160.1	208.4	161.2	129.9
7	83.2	117.4	151.2	183.0	221.5	175.6	120.8
8	100.5	112.5	168.9	181.5	184.1	152.4	118.5
9	95.7	108.9	163.2	198.5	203.5	142.1	120.9
10	104.4	109.8	144.3	182.2	176.0	152.0	128.4
11	104.5	111.3	152.0	189.4	173.3	139.1	108.9
12	102.4	107.4	137.9	175.8	174.2	170.2	108.7
13	102.9	101.3	145.9	162.7	168.9	152.1	124.2
14	102.9	103.3	138.0	163.8	183.4	171.2	122.0
15	97.1	95.4	138.2	175.4	169.1	147.4	121.5
16	95.4	95.0	132.3	161.7	189.1	137.6	126.6
17	93.6	94.2	121.1	178.2	177.7	140.9	104.9
18	101.8	93.1	119.9	174.6	180.3	131.5	117.4
19	90.2	90.4	119.9	175.0	176.5	114.3	117.7
20	91.4	90.4	114.2	175.7	161.1	139.2	111.2
21	86.5	86.8	102.2	158.8	162.8	150.2	120.7
22	85.8	86.2	116.2	167.2	168.0	130.7	102.2
23	90.8	84.9	116.1	169.6	144.4	130.8	108.1
24	80.8	75.8	116.6	155.5	132.1	127.7	109.6
25	84.9	81.6	125.1	167.7	133.3	116.2	107.8

Rep # / Sub #	1	2	3	4	5	6	7
26	84.1	81.3	109.6	165.1	157.4	130.3	116.1
27	75.5	78.1	112.5	166.6	159.4	134.1	108.1
28	87.2	76.5	109.3	157.8	136.0	128.4	99.1
29	74.7	75.2	114.4	148.3	138.2	121.2	101.1
30	81.2	70.5	102.1	153.6	134.4	146.2	98.0
31	80.0	72.0	105.2	162.8	122.6	135.3	94.2
32	80.3	68.5	105.1	162.3	109.6	110.9	103.2
33	81.5	67.7	95.2	142.9	121.3	127.2	108.5
34	79.5	65.5	100.5	151.6	120.4	122.7	109.7
35	70.5	65.1	91.7	138.4	111.0	122.2	105.3
36	72.5	57.6	82.7	149.0	127.9	119.4	107.2
37	75.1	63.7	86.8	152.9	113.5	95.9	103.9
38	73.3	59.5	71.9	160.5	90.4	103.6	100.1
39	74.0	66.6	75.5	149.0	91.7	104.0	97.8
40	74.0	58.8	78.0	157.4	109.0	89.1	97.8
41	75.2	59.5	79.3	142.4	93.0	113.8	100.9
42	76.9	54.9	77.6	147.5	112.4	115.4	95.9
43	72.3	55.5	72.5	145.5	95.6	119.4	90.6
44	76.1	57.5	84.1	152.7	86.4	105.6	94.4
45	68.7	60.2	72.4	145.5	72.7	106.7	94.2
46	66.3	54.5	76.1	142.5	71.2	106.2	97.9
47	67.1	51.7	82.4	144.0	63.3	103.9	93.8
48	74.0	43.0	64.3	142.8	102.5	95.0	93.3
49	65.9	58.4	76.2	142.0	97.1	92.7	87.0
50	71.5	51.0	79.3	143.2	106.3	105.8	85.7
AVG	86.22	83.05	113.76	162.29	145.32	130.12	108.70
Peak	117.00	132.4	176.52	198.49	221.54	205.40	136.25

Rep # / Sub #	8	9	10	11	12	13	14
1	188.7	232.7	144.9	131.4	141.1	129.8	200.1
2	205.5	233.9	160.0	150.4	161.9	155.5	232.9
3	201.3	240.0	159.7	141.1	163.1	159.2	219.5
4	195.4	214.4	157.8	130.3	160.3	161.2	206.4
5	197.7	217.6	145.6	126.1	160.9	155.5	205.4
6	190.9	218.7	132.3	116.9	152.9	163.8	218.4
7	188.2	216.9	133.0	132.7	149.7	157.0	209.6
8	182.8	216.0	136.0	125.7	148.6	152.7	205.8
9	189.1	213.7	142.0	132.1	142.0	149.7	212.5
10	176.8	213.0	145.2	120.8	140.3	146.6	210.4
11	176.8	202.8	146.2	160.5	138.3	146.0	196.5
12	174.2	192.4	151.2	132.3	138.7	129.5	186.7
13	176.0	184.5	139.2	128.9	137.8	141.1	190.6
14	162.0	189.8	148.5	144.7	131.0	129.3	184.5
15	163.8	169.5	143.0	142.2	128.8	140.3	173.3
16	163.6	163.9	143.3	125.4	129.2	136.8	163.8
17	157.4	159.3	142.2	138.7	126.4	131.1	181.3
18	152.7	181.5	140.6	115.5	121.6	123.5	168.0
19	152.3	161.5	143.7	108.9	120.8	127.7	155.5
20	144.8	172.1	137.2	132.7	117.3	120.5	135.9
21	142.9	156.2	130.6	89.5	113.9	112.3	158.4
22	141.4	128.9	130.0	132.3	113.6	120.0	161.5
23	137.6	148.2	126.9	106.0	110.5	120.7	134.8
24	131.0	126.5	123.2	91.7	107.1	121.6	152.1
25	134.8	140.6	125.1	100.1	106.2	108.9	123.8

Rep # / Sub #	8	9	10	11	12	13	14
26	134.2	115.4	131.2	95.2	106.0	110.1	121.8
27	130.7	126.8	112.3	106.0	105.3	110.2	122.0
28	123.4	106.6	123.2	73.1	104.3	113.8	132.1
29	116.2	126.4	127.4	79.3	94.1	108.5	130.2
30	109.7	132.2	122.4	88.8	99.7	111.2	111.6
31	101.0	124.1	120.7	95.2	93.7	106.2	129.1
32	74.7	132.6	111.6	110.0	92.7	93.4	110.1
33	109.0	113.8	122.6	104.7	92.9	97.9	98.7
34	103.4	119.3	107.9	110.2	91.7	102.4	113.3
35	110.6	128.8	102.1	89.2	86.5	101.7	88.4
36	99.0	108.1	114.4	104.3	77.3	83.9	118.0
37	101.4	109.4	117.7	88.1	86.8	100.2	110.4
38	105.2	125.1	109.1	98.0	80.7	96.3	93.8
39	98.8	122.3	107.9	88.1	85.8	91.5	102.2
40	95.3	107.8	102.2	81.8	81.2	95.7	95.4
41	95.4	96.4	101.8	83.2	79.5	83.1	89.1
42	90.8	102.5	98.6	98.3	76.9	97.8	119.9
43	89.6	104.5	103.3	78.6	81.5	87.2	109.3
44	89.6	111.7	96.7	75.5	78.0	82.3	109.4
45	89.8	101.4	86.5	87.0	76.5	88.8	87.0
46	88.1	95.9	105.1	91.2	77.3	86.1	111.0
47	80.8	85.7	113.9	83.5	75.7	89.1	110.0
48	89.8	96.8	110.6	78.6	83.7	86.8	104.3
49	84.9	90.6	97.5	53.7	72.5	78.2	95.3
50	75.0	101.6	114.6	96.9	72.5	79.3	120.0
AVG	134.28	149.60	125.77	107.91	110.28	116.43	146.39
Peak	205.54	239.97	159.98	160.52	163.10	163.78	232.92

Rep # / Sub #	15	16	17	18	19	20	21
1	139.8	112.3	112.5	183.7	138.0	106.0	167.7
2	132.7	148.1	122.6	203.4	171.8	114.7	186.3
3	134.6	137.9	121.8	191.8	191.6	117.3	183.0
4	140.1	139.1	119.3	192.4	189.5	114.6	185.3
5	128.8	120.8	115.1	185.6	186.8	108.6	166.2
6	136.5	128.1	115.1	185.6	178.4	109.1	156.2
7	125.5	125.1	105.6	181.1	174.0	109.0	158.2
8	125.4	137.3	106.8	185.1	168.0	105.8	156.3
9	123.8	129.5	103.4	198.5	128.8	104.5	159.7
10	119.6	131.8	102.1	179.8	158.6	103.4	154.0
11	117.8	120.8	99.7	177.6	156.6	104.9	142.0
12	113.2	116.5	96.8	183.4	151.3	96.5	141.1
13	116.1	123.2	90.3	177.9	137.5	96.8	147.6
14	116.3	112.7	94.0	181.1	147.2	96.0	173.5
15	112.8	114.0	89.6	169.7	152.0	99.4	156.3
16	106.7	115.0	81.2	174.1	152.1	93.8	138.8
17	104.1	117.3	82.4	173.4	134.2	93.0	141.4
18	97.5	106.8	74.6	163.6	156.9	89.8	152.7
19	103.0	101.1	83.1	152.5	148.9	84.1	147.2
20	94.1	107.1	79.6	144.1	128.3	84.1	146.0
21	100.2	101.7	81.6	153.7	133.4	85.7	145.8
22	92.6	99.4	77.0	148.1	126.0	79.7	134.4
23	96.9	84.3	72.1	149.8	139.1	77.8	145.8
24	95.2	90.4	61.7	138.0	140.6	79.7	130.4
25	96.1	101.4	63.2	147.0	125.8	59.9	112.0

Rep # / Sub #	15	16	17	18	19	20	21
26	79.7	87.3	64.3	151.0	125.0	76.2	126.8
27	89.2	85.4	62.9	137.9	131.9	75.5	115.2
28	77.7	73.5	59.5	136.1	119.7	72.1	111.2
29	89.5	81.3	60.9	134.6	117.1	78.1	111.0
30	82.0	62.1	54.5	129.3	121.5	70.5	112.3
31	81.2	70.9	53.0	129.3	124.7	69.7	87.0
32	70.0	70.4	54.8	124.6	115.9	71.5	107.7
33	76.5	64.1	54.0	115.4	114.0	66.0	113.6
34	65.6	75.0	52.6	113.1	102.9	67.5	102.0
35	76.2	64.5	51.7	123.4	104.8	69.3	86.5
36	70.5	68.3	50.2	112.7	101.4	60.9	82.3
37	65.2	61.0	44.1	122.7	107.0	67.1	82.6
38	77.8	66.6	42.8	110.2	102.9	63.3	94.6
39	64.8	58.7	46.1	111.0	107.4	64.7	92.1
40	69.8	66.6	47.5	117.0	97.9	73.1	87.3
41	64.8	56.5	49.6	102.0	90.8	63.3	78.6
42	57.2	63.0	47.6	98.0	100.7	67.2	89.9
43	65.9	69.8	34.6	108.2	84.1	61.4	85.6
44	65.5	69.8	53.3	100.9	109.3	60.1	80.9
45	63.9	65.5	43.4	110.0	94.4	59.2	79.7
46	64.8	62.1	53.7	103.3	104.9	63.5	82.7
47	69.3	56.9	38.0	107.2	101.4	58.3	75.4
48	63.5	66.8	41.5	96.7	100.9	66.7	86.6
49	54.0	48.8	45.4	94.9	74.6	58.4	71.9
50	70.0	63.2	46.1	104.0	95.7	66.7	85.8
AVG	92.88	92	72.06	144.29	129.32	81.69	123.14
Peak	140.05	148.05	122.56	203.37	191.57	117.27	186.28

Rep # / Sub #	22	23	24	25	26	27	28
1	112.9	271.4	153.9	166.1	193.9	165.1	227.1
2	118.5	352.4	185.7	186.7	200.0	201.3	211.8
3	123.2	343.8	184.0	182.8	211.9	202.0	194.6
4	118.1	334.5	195.1	180.5	205.1	197.7	192.4
5	123.5	332.7	199.3	177.3	215.4	198.1	197.7
6	117.1	311.3	198.6	172.7	209.9	197.1	169.1
7	114.0	317.8	192.0	161.7	204.6	193.5	170.6
8	109.3	302.9	185.1	158.6	205.4	187.5	183.2
9	113.8	274.8	179.2	171.0	191.8	180.5	174.0
10	108.2	276.5	174.0	166.9	195.4	170.8	171.4
11	110.2	295.7	171.5	159.0	198.1	169.3	157.7
12	95.2	298.8	172.2	163.0	193.9	169.7	145.8
13	100.5	285.3	165.8	163.1	192.1	167.0	183.0
14	100.5	275.9	164.1	162.4	178.6	161.3	174.5
15	100.3	278.5	160.4	155.6	193.3	154.6	157.0
16	105.6	259.4	151.3	149.1	178.2	150.5	165.5
17	99.1	260.0	147.9	139.2	187.4	143.2	162.3
18	104.9	264.7	145.1	136.4	169.6	139.9	151.6
19	100.1	261.5	144.4	141.0	160.1	139.5	163.0
20	101.6	251.4	141.1	140.6	175.0	136.7	141.5
21	96.7	251.1	142.8	126.6	154.3	136.4	143.6
22	101.6	230.5	130.3	118.8	161.7	125.5	138.2
23	103.7	243.4	129.1	120.0	146.7	129.8	119.4
24	102.0	219.1	124.5	116.5	146.8	130.3	152.8
25	102.1	217.5	134.6	112.7	147.4	120.8	135.2

Rep # / Sub #	22	23	24	25	26	27	28
26	90.7	200.3	125.7	111.2	138.2	112.3	127.7
27	91.8	189.7	111.9	92.9	134.1	114.8	145.5
28	82.8	195.4	120.0	99.2	142.9	110.6	127.7
29	82.3	184.3	116.7	101.8	133.7	105.8	99.0
30	87.0	182.8	112.1	100.9	140.9	106.7	91.8
31	82.8	186.4	112.7	99.8	120.3	93.3	111.4
32	84.7	178.2	112.1	90.3	118.5	89.3	110.8
33	77.7	171.6	113.2	85.1	116.9	91.0	90.4
34	81.3	172.7	105.1	79.0	118.4	81.6	94.8
35	79.0	166.4	109.0	79.0	125.5	73.9	92.3
36	70.9	151.4	105.1	72.5	128.7	72.9	86.4
37	83.9	151.4	106.4	76.3	117.5	74.3	103.2
38	72.9	160.0	99.4	71.5	111.4	73.3	96.7
39	69.8	146.8	105.1	73.2	125.5	89.8	93.4
40	70.4	134.9	109.0	64.5	112.7	92.1	91.7
41	80.9	142.9	106.6	70.0	113.3	86.5	73.3
42	73.2	131.0	100.3	64.9	107.9	82.8	69.7
43	67.9	147.8	102.0	70.9	110.0	79.7	71.7
44	66.3	153.6	102.1	67.0	116.6	78.9	77.6
45	67.1	121.1	102.0	66.6	101.1	88.1	81.2
46	67.1	139.2	95.7	65.2	104.3	70.9	82.2
47	64.8	123.9	98.0	60.7	96.1	87.5	88.4
48	61.8	132.9	98.0	70.2	87.7	80.5	69.8
49	64.1	127.0	118.8	64.9	83.8	86.6	86.0
50	65.8	113.1	103.6	70.2	97.8	95.2	97.2
AVG	91.401	218.31	135.24	115.93	150.40	125.73	130.85
Peak	123.51	352.37	199.30	186.69	215.43	202.01	227.09

Rep # / Sub #	29	30	31	32	33	34	35
1	159.2	221.4	182.8	201.5	133.4	200.4	189.1
2	164.9	225.3	197.4	215.3	153.5	230.5	190.4
3	165.0	235.2	185.3	211.0	158.4	225.3	179.9
4	161.3	235.9	190.9	208.8	170.6	213.5	177.5
5	160.1	226.7	177.1	198.6	161.1	208.8	176.0
6	167.2	227.1	174.8	187.6	158.9	205.7	165.8
7	156.6	228.0	158.8	181.0	159.0	198.4	161.2
8	143.4	212.9	178.4	173.0	158.1	195.4	156.5
9	147.4	205.5	170.3	183.4	149.8	184.4	152.9
10	149.1	203.6	164.5	178.3	147.1	187.1	145.8
11	138.7	195.4	161.7	165.4	150.1	181.8	137.3
12	141.8	203.2	163.2	168.3	156.9	178.4	135.6
13	136.9	194.8	159.6	150.5	147.8	178.2	128.8
14	129.9	188.6	161.1	137.6	141.4	163.5	126.9
15	128.8	170.0	158.6	136.1	140.9	160.1	119.4
16	120.7	171.6	151.2	108.2	140.5	159.3	120.3
17	119.0	168.0	149.0	131.8	144.8	145.3	114.3
18	117.1	162.4	146.4	92.2	132.6	142.6	111.2
19	120.1	161.7	147.5	115.8	132.7	141.0	108.2
20	101.6	156.9	141.1	94.9	123.9	138.7	102.9
21	112.4	155.1	141.7	90.0	129.3	138.0	99.2
22	108.2	143.6	134.6	102.2	131.1	130.4	98.0
23	104.5	146.8	137.6	91.1	129.1	127.0	94.9
24	103.3	148.1	122.3	87.9	123.0	127.4	95.0
25	95.6	135.6	129.9	77.7	115.0	124.6	85.3

Rep # / Sub #	29	30	31	32	33	34	35
26	90.7	138.0	119.6	78.0	120.9	117.0	84.3
27	76.9	132.6	118.2	93.1	123.2	113.6	80.4
28	77.3	126.6	113.1	81.3	115.7	116.1	79.5
29	78.8	119.7	108.1	58.7	113.2	117.7	76.1
30	81.6	113.9	107.1	71.9	110.6	112.0	71.7
31	83.7	107.1	100.7	66.7	105.1	100.7	68.6
32	73.2	107.0	98.0	74.7	100.1	94.4	64.7
33	67.1	102.0	98.0	54.1	98.7	87.7	61.4
34	66.4	97.2	103.4	92.7	93.4	86.4	63.5
35	76.1	102.5	90.8	75.5	95.2	88.8	60.3
36	67.0	92.7	92.1	70.6	93.4	90.8	58.8
37	68.2	91.1	86.1	72.8	87.2	89.8	53.3
38	74.0	89.8	86.4	59.8	91.0	84.7	53.0
39	63.9	89.2	81.3	52.3	79.6	81.8	51.2
40	59.1	88.5	84.2	53.1	82.2	76.1	53.1
41	68.1	82.3	76.3	62.6	77.8	72.9	51.1
42	51.7	80.9	71.2	64.8	85.1	72.9	52.9
43	74.2	69.8	71.0	63.6	72.5	73.6	53.6
44	63.2	65.9	64.7	58.7	77.1	72.4	51.1
45	67.8	77.6	71.9	44.5	75.7	61.7	52.5
46	61.1	69.7	60.2	85.3	80.8	67.0	51.8
47	62.5	78.0	68.5	51.2	76.7	66.8	48.7
48	63.6	66.2	66.0	56.0	79.2	60.9	51.8
49	51.5	73.2	63.9	67.7	72.9	55.2	48.0
50	57.1	65.5	61.8	63.2	74.4	60.2	46.9
AVG	101.55	141.01	122.97	107.22	117.41	128.14	97.214
Peak	167.17	235.91	197.40	215.30	170.56	230.48	190.35

Peak Torque (ft·lb) - PL

Rep # / Sub #	1	2	3	4	5	6	7
1	111.99	109.96	126.09	184.53	219.78	135.18	103.58
2	105.62	128.40	159.17	176.26	243.23	203.37	133.28
3	106.84	118.23	173.00	182.36	233.20	207.44	129.35
4	111.99	122.70	165.82	184.12	235.64	201.47	122.84
5	100.47	116.46	163.78	182.22	230.35	203.78	118.36
6	106.97	122.43	177.48	171.65	226.15	196.46	109.96
7	103.72	114.02	160.53	135.18	227.91	182.76	116.19
8	103.99	113.62	152.94	174.90	213.00	162.56	118.36
9	97.35	111.85	160.80	169.07	194.29	167.85	101.28
10	105.21	108.47	151.44	177.48	207.03	173.27	107.11
11	105.21	105.21	145.89	181.82	196.73	170.16	121.21
12	99.38	102.91	146.16	193.20	200.25	175.99	102.23
13	95.99	103.04	138.84	180.87	198.49	170.29	115.38
14	91.92	100.87	149.82	183.17	176.39	163.10	108.33
15	81.08	98.57	141.82	175.04	177.48	156.73	121.21
16	101.96	96.26	125.55	174.49	189.14	172.05	114.97
17	98.03	93.82	132.33	183.17	182.76	173.54	107.11
18	103.86	86.77	126.36	178.97	189.27	157.41	108.19
19	104.67	96.53	118.36	173.82	183.98	151.58	106.16
20	99.52	94.64	116.46	167.31	186.29	139.24	116.19
21	103.86	86.37	115.92	170.43	168.39	140.87	108.06
22	90.98	85.15	87.99	167.17	168.80	144.39	105.89
23	97.35	82.98	107.52	167.58	184.53	142.09	105.35
24	90.03	84.47	111.99	161.48	174.90	112.94	100.87
25	88.94	62.64	107.92	166.49	167.99	104.13	111.04

Rep # / Sub #	1	2	3	4	5	6	7
26	89.21	75.52	101.42	158.09	158.36	127.18	101.42
27	92.74	71.45	99.11	159.72	152.12	120.40	107.65
28	87.31	72.27	102.09	157.68	158.63	117.01	100.87
29	78.37	69.69	95.45	153.21	147.92	136.67	102.50
30	82.03	68.74	111.72	156.73	141.95	122.70	102.50
31	87.72	71.99	96.40	155.38	132.60	119.58	100.87
32	80.13	62.91	95.31	158.90	125.14	105.75	97.75
33	85.96	64.13	84.20	154.43	128.67	119.45	106.57
34	73.62	62.37	111.99	151.17	111.99	107.11	103.45
35	84.74	58.71	102.23	150.90	118.36	101.82	102.91
36	76.20	67.11	105.62	151.44	110.09	90.16	97.75
37	81.76	59.66	97.62	142.77	107.11	105.75	98.97
38	78.50	55.86	95.72	135.31	115.79	91.38	96.40
39	76.33	54.64	88.53	142.23	114.02	109.55	104.67
40	68.06	54.10	106.70	138.84	112.94	117.14	93.82
41	70.37	59.38	98.16	136.12	97.08	100.60	96.53
42	74.03	52.61	107.11	136.94	98.84	103.31	104.53
43	76.47	55.86	94.77	140.46	94.91	107.92	108.19
44	74.71	55.59	93.82	135.72	93.14	119.18	100.47
45	75.93	60.06	89.76	136.12	94.77	97.21	103.31
46	75.11	48.81	89.08	119.04	94.36	102.77	99.38
47	64.67	55.32	100.06	134.77	93.42	101.01	100.06
48	69.15	48.67	81.89	119.99	85.42	92.87	100.47
49	69.69	49.35	99.38	128.12	93.14	78.77	104.40
50	68.60	54.10	92.47	135.72	92.33	85.55	92.33
AVG	88.97	81.11	118.09	159.05	156.98	135.79	106.81
Peak	111.99	128.40	177.48	193.20	243.23	207.44	133.28

Rep # / Sub #	8	9	10	11	12	13	14
1	191.85	200.93	143.45	114.70	168.66	123.52	201.07
2	201.20	251.23	175.99	158.36	171.24	141.68	225.07
3	189.27	233.07	170.70	161.61	173.27	138.70	225.47
4	189.54	216.39	176.53	147.11	174.76	148.60	221.00
5	191.71	183.85	161.34	175.58	171.51	156.60	215.44
6	194.02	200.66	174.09	149.82	165.82	158.63	211.91
7	187.65	201.34	170.83	127.58	168.39	150.63	219.10
8	174.76	208.93	152.94	116.19	164.33	142.50	192.80
9	183.98	200.53	138.02	146.56	156.05	143.04	201.20
10	174.36	178.29	155.65	152.39	157.27	145.75	198.09
11	169.07	187.65	158.36	123.24	157.68	143.58	195.78
12	161.48	184.93	147.11	141.68	151.04	140.60	199.44
13	167.17	182.63	143.99	133.95	146.16	138.84	184.80
14	156.73	189.27	153.48	117.82	147.24	129.62	178.70
15	157.27	173.82	160.80	119.04	144.12	134.90	180.05
16	151.72	173.14	139.65	125.55	138.29	133.55	172.87
17	144.67	168.26	147.24	139.78	132.06	123.38	162.02
18	135.31	192.39	141.55	132.06	124.87	132.19	152.53
19	133.01	167.99	123.24	113.62	123.38	119.99	170.29
20	131.51	164.73	151.44	153.07	122.43	117.41	156.73
21	140.60	150.36	139.51	141.28	116.87	126.77	153.07
22	134.09	154.43	132.46	116.06	120.80	111.45	156.60
23	120.53	149.00	137.21	136.12	111.31	107.11	147.24
24	127.45	132.46	138.16	118.77	113.35	121.07	143.45
25	119.18	139.38	137.62	137.62	110.23	118.63	141.55

Rep # / Sub #	8	9	10	11	12	13	14
26	129.75	126.23	137.07	132.06	106.57	111.31	137.21
27	115.92	140.46	120.67	122.16	109.14	114.57	136.67
28	112.94	155.78	134.36	133.95	106.02	108.47	121.35
29	108.74	122.84	124.19	139.24	104.94	103.99	121.89
30	106.43	132.46	96.26	112.67	99.25	109.28	125.28
31	107.25	116.19	119.72	95.99	87.86	98.43	121.21
32	108.06	127.04	106.30	103.18	94.09	97.62	117.01
33	106.43	119.99	103.72	90.43	94.09	95.18	122.57
34	96.26	117.82	105.75	123.65	89.62	105.08	124.87
35	104.26	114.43	107.25	92.33	87.04	88.81	131.51
36	103.99	122.84	114.84	96.13	83.93	103.86	126.23
37	99.38	121.35	92.06	106.16	88.94	91.52	108.87
38	97.35	97.21	125.96	120.26	83.38	107.11	113.89
39	96.67	106.84	103.58	76.87	80.81	94.36	107.92
40	97.35	88.94	101.69	78.10	78.91	98.30	110.09
41	91.79	96.26	105.89	90.98	72.13	87.45	101.01
42	88.81	99.79	104.53	93.55	77.15	90.03	124.06
43	90.30	115.11	111.18	103.99	77.82	103.45	126.09
44	85.82	86.77	111.58	101.28	79.18	80.26	114.02
45	79.99	85.69	101.82	87.31	71.72	84.74	106.57
46	88.94	83.11	109.14	92.06	71.86	83.93	104.80
47	91.52	65.08	90.57	115.11	69.01	81.35	108.47
48	88.53	107.25	106.57	109.55	69.01	92.87	103.31
49	80.26	66.30	106.30	107.92	66.84	87.72	111.18
50	79.99	67.79	110.36	94.77	68.60	86.64	108.47
AVG	129.70	145.38	130.45	120.39	114.98	115.10	150.82
Peak	201.20	251.23	176.53	175.58	174.76	158.63	225.47

Rep # / Sub #	15	16	17	18	19	20	21
1	146.02	113.21	112.94	150.36	178.02	93.28	141.68
2	143.17	146.02	122.57	174.22	200.12	109.41	155.24
3	145.34	139.38	120.40	166.09	194.83	110.09	161.75
4	143.58	136.26	119.85	165.00	195.24	109.82	163.10
5	140.87	141.82	116.33	173.54	185.61	101.69	170.97
6	136.67	124.87	114.02	150.36	191.71	96.94	162.70
7	137.07	130.57	101.82	164.73	185.20	99.38	162.16
8	132.46	115.79	106.57	183.71	180.46	97.21	168.80
9	129.62	125.01	105.48	159.85	166.22	97.48	178.29
10	128.67	118.50	101.01	160.80	172.32	90.03	161.21
11	123.24	107.38	95.45	161.21	169.21	88.67	160.53
12	118.63	122.29	101.14	154.83	161.34	84.47	160.39
13	124.87	117.55	95.31	141.82	162.16	86.37	151.31
14	124.33	112.40	89.35	148.60	159.58	85.69	152.26
15	114.84	105.48	87.18	154.16	160.26	74.98	169.07
16	120.80	99.38	81.76	158.09	149.95	74.30	145.07
17	119.04	103.18	79.99	150.63	151.58	76.47	148.19
18	109.01	107.92	78.37	140.19	142.36	75.79	152.53
19	106.02	90.30	79.18	146.84	149.55	72.94	134.77
20	109.96	94.50	60.74	139.11	134.90	73.35	146.97
21	111.31	91.11	71.04	143.31	142.09	71.59	145.21
22	105.48	91.38	74.30	138.02	133.68	77.69	137.21
23	103.72	92.47	69.28	134.50	131.79	58.30	133.68
24	98.43	90.57	70.10	137.34	127.72	65.62	126.77
25	101.69	81.62	61.83	137.62	123.79	59.66	126.09

Rep # / Sub #	15	16	17	18	19	20	21
26	94.64	66.57	54.91	129.62	120.53	64.81	126.63
27	104.26	68.47	59.66	126.09	112.94	61.28	110.77
28	94.77	62.10	49.76	110.63	112.94	58.44	102.36
29	92.47	72.27	49.35	120.80	112.67	56.54	93.69
30	83.25	70.37	42.57	116.87	107.25	66.84	107.25
31	95.04	66.71	48.27	117.68	109.55	63.59	109.28
32	88.67	64.81	55.18	115.92	104.13	61.83	88.26
33	80.94	55.05	54.10	106.70	104.13	63.72	106.02
34	89.08	62.37	45.15	96.53	106.02	59.25	107.79
35	86.77	58.57	54.10	100.47	95.99	58.84	88.26
36	88.81	64.67	52.20	109.96	99.11	57.89	90.70
37	95.45	63.32	47.59	113.08	93.01	62.77	91.25
38	87.31	58.71	47.05	107.11	98.70	61.96	96.26
39	77.55	64.27	53.15	105.75	85.28	57.49	102.09
40	87.99	58.03	49.62	106.02	78.64	68.60	82.84
41	90.16	69.01	46.91	93.69	80.54	55.59	87.45
42	88.94	58.98	44.74	85.01	83.65	56.94	86.91
43	80.13	64.40	46.23	91.92	87.59	53.55	85.69
44	80.13	70.10	41.22	86.37	80.54	52.61	69.96
45	77.82	66.71	50.84	97.21	78.37	56.81	77.82
46	91.52	65.08	48.27	87.04	59.93	56.13	76.74
47	77.28	57.49	47.18	89.48	86.23	50.84	62.50
48	59.25	53.83	37.01	85.01	70.23	56.67	84.06
49	70.77	63.59	41.35	90.30	73.21	55.32	81.89
50	74.03	58.03	41.35	88.81	63.86	50.17	76.20
AVG	104.24	87.65	70.48	128.26	127.09	71.99	122.17
Peak	146.02	146.02	122.57	183.71	200.12	110.09	178.29

Rep # / Sub #	22	23	24	25	26	27	28
1	126.36	271.30	150.90	170.83	200.53	157.82	177.75
2	137.21	335.43	156.19	187.65	232.79	175.31	187.24
3	139.92	367.70	173.00	197.81	222.63	188.73	220.73
4	139.78	338.95	169.07	187.37	213.54	189.27	217.07
5	131.65	327.29	162.43	184.93	209.47	194.15	198.49
6	115.52	334.89	160.39	182.36	210.69	194.70	180.32
7	116.87	314.55	157.82	179.24	210.02	191.17	177.48
8	113.21	312.79	159.85	176.26	215.71	188.59	181.54
9	115.24	301.13	141.68	162.70	215.17	184.80	174.76
10	115.38	292.99	141.41	170.70	206.22	176.26	188.05
11	113.89	302.08	149.28	164.73	207.58	166.49	162.56
12	110.91	282.42	169.34	165.00	207.71	171.78	194.70
13	107.65	282.15	156.87	165.55	204.86	158.50	154.16
14	103.31	270.76	147.78	163.38	200.25	162.43	159.17
15	105.08	287.30	146.43	156.87	202.42	155.38	153.34
16	103.04	283.37	143.04	153.07	192.93	162.43	156.19
17	102.91	278.21	138.97	151.17	189.14	144.94	154.02
18	97.48	259.10	138.56	141.68	182.36	142.23	155.38
19	95.99	259.77	121.07	142.36	170.83	142.50	150.63
20	89.35	264.52	118.63	133.01	177.07	135.04	126.09
21	96.81	259.37	126.23	130.97	173.14	123.79	110.50
22	84.06	240.25	120.13	112.80	173.95	117.96	117.28
23	93.96	237.00	121.35	126.90	163.51	115.79	121.62
24	82.70	224.93	124.60	122.16	161.34	117.82	130.97
25	87.18	224.12	105.75	125.14	168.26	108.87	112.26

Rep # / Sub #	22	23	24	25	26	27	28
26	80.13	213.68	106.84	113.89	169.07	101.69	114.57
27	87.04	190.76	125.55	107.25	151.58	103.72	103.31
28	81.62	190.90	94.50	107.52	144.80	111.31	113.48
29	77.96	186.83	106.97	101.69	157.95	95.72	100.60
30	73.35	183.44	103.18	101.69	152.12	85.01	95.45
31	65.49	177.88	118.50	97.35	146.29	90.98	119.04
32	69.01	179.51	101.14	93.96	146.02	84.06	86.23
33	74.84	167.44	100.87	82.57	141.68	74.71	87.18
34	74.84	148.46	100.60	84.33	142.63	79.72	82.03
35	71.45	154.02	89.48	71.04	129.35	81.76	97.21
36	71.86	150.22	99.79	90.30	136.12	89.21	82.70
37	56.54	150.50	85.15	77.28	141.01	72.54	97.08
38	63.05	147.65	109.96	87.04	135.18	80.26	76.06
39	61.42	151.04	80.67	84.74	130.16	70.64	79.99
40	64.94	145.21	106.84	78.50	142.77	64.67	80.26
41	63.18	129.07	88.81	79.45	119.58	70.50	64.27
42	63.99	128.12	114.57	78.77	128.80	65.62	58.84
43	62.23	125.68	87.99	72.54	114.57	66.16	58.84
44	58.44	124.87	90.98	74.84	124.06	66.98	71.45
45	52.06	114.43	75.25	66.57	128.94	69.15	51.93
46	47.45	123.24	83.79	70.37	114.84	60.47	58.44
47	51.93	109.82	91.25	68.47	117.41	69.01	60.88
48	53.28	125.28	86.37	65.76	123.65	63.05	68.47
49	51.11	114.97	109.14	68.06	119.18	60.74	63.99
50	43.52	108.19	88.53	69.42	121.21	58.57	64.94
AVG	86.92	217.87	120.95	120.96	165.82	118.06	121.99
Peak	139.92	367.70	173.00	197.81	232.79	194.70	220.73

Rep # / Sub #	29	30	31	32	33	34	35
1	168.66	199.85	182.90	196.46	132.33	186.97	192.25
2	176.66	219.10	193.75	223.85	172.46	208.25	189.41
3	177.34	219.51	180.73	201.34	148.60	204.19	178.15
4	176.39	226.56	179.92	198.22	148.46	197.14	173.00
5	171.65	211.24	175.85	186.97	132.33	194.02	169.75
6	170.02	221.00	178.83	200.66	137.75	184.66	169.61
7	170.56	207.98	169.34	182.49	128.12	172.87	164.46
8	168.53	214.76	172.32	188.46	147.78	178.56	163.65
9	162.56	205.54	168.93	171.10	153.34	169.75	157.14
10	154.16	198.36	171.10	159.72	151.44	165.68	148.60
11	155.24	199.58	158.77	152.67	150.90	160.39	146.43
12	149.82	188.73	160.80	155.51	122.57	169.75	141.01
13	144.67	181.14	153.34	149.41	120.67	167.99	135.45
14	145.34	172.73	152.53	155.78	110.50	158.77	126.50
15	136.94	165.00	146.43	121.21	126.09	155.65	123.52
16	127.99	171.92	148.87	112.53	128.94	158.36	119.85
17	132.73	172.60	145.48	89.08	139.38	153.34	120.40
18	127.18	167.71	142.63	89.21	119.04	148.46	115.52
19	121.48	152.67	133.68	95.86	106.16	148.33	111.85
20	115.11	141.55	130.29	84.33	114.57	130.84	102.50
21	116.87	159.04	134.36	80.67	100.60	131.51	103.99
22	112.80	152.39	138.56	88.67	120.67	131.65	97.21
23	109.55	140.46	134.50	82.16	122.70	128.80	92.06
24	105.21	137.07	126.36	82.84	118.63	120.26	93.55
25	99.52	137.48	124.06	106.84	127.58	135.18	88.13

Rep # / Sub #	29	30	31	32	33	34	35
26	89.89	137.34	118.09	76.33	111.31	130.16	86.23
27	84.33	131.11	125.55	81.35	114.02	116.19	78.23
28	84.87	133.68	116.74	66.71	122.97	104.67	78.77
29	82.30	121.75	111.72	74.98	102.36	100.74	75.79
30	89.48	115.65	108.60	88.67	119.85	106.84	67.52
31	87.31	112.40	106.02	84.06	118.91	106.84	66.71
32	86.64	110.23	100.87	70.50	109.14	112.53	62.50
33	79.04	104.53	98.43	56.40	94.64	110.63	64.94
34	79.99	102.09	97.35	57.08	107.11	105.75	62.37
35	73.76	90.43	90.98	69.82	106.43	108.19	60.61
36	69.96	94.77	88.13	80.94	94.64	113.35	57.08
37	72.94	86.37	88.81	48.67	91.52	99.79	58.98
38	75.11	98.84	88.67	79.32	102.64	107.11	54.91
39	74.03	89.48	83.52	67.25	97.21	99.52	59.11
40	54.78	85.96	76.47	57.35	88.94	87.72	55.05
41	73.89	87.04	76.60	52.47	95.45	90.98	59.11
42	68.06	78.23	74.98	57.89	96.40	90.16	55.18
43	73.62	72.67	76.06	57.76	98.43	81.62	55.18
44	76.47	74.57	73.62	55.32	93.82	93.01	54.10
45	58.84	73.89	69.15	66.71	91.38	81.21	53.96
46	47.45	75.11	68.47	80.26	93.96	82.16	52.33
47	69.01	70.91	67.79	49.22	77.15	83.25	54.23
48	58.84	71.32	65.76	59.38	74.30	86.77	56.00
49	72.40	62.77	67.25	54.23	78.10	90.30	58.84
50	55.05	67.11	66.16	67.11	76.33	82.98	57.49
AVG	108.70	138.24	122.20	104.32	114.77	130.68	99.38
Peak	177.34	226.56	193.75	223.85	172.46	208.25	192.25

Maximum Work (ft·lb) - BR

Rep # / Sub #	1	2	3	4	5	6	7
1	4244.80	4486.10	5097.00	6836.60	7020.20	2281.50	5026.70
2	4835.20	5765.30	7269.40	7073.30	8445.80	5824.30	5415.00
3	4486.20	5207.30	7414.30	6864.30	8934.70	6843.70	4834.60
4	4273.50	5544.60	6901.30	6699.10	8915.00	6807.90	4804.60
5	4468.30	5525.90	7304.30	6479.20	8815.50	7643.70	5471.30
6	3951.30	5356.90	7186.10	5819.00	8618.60	6276.00	5386.40
7	3689.00	5185.90	6718.30	6606.20	8965.20	6585.50	4835.70
8	4169.20	5007.20	7061.80	6635.20	7394.70	5977.60	4732.80
9	3973.10	4914.40	7046.40	7794.40	8010.40	5629.70	4707.50
10	4358.00	4909.40	6339.60	7616.50	7015.00	5805.20	4750.10
11	4243.70	4936.10	6518.70	7565.50	7220.00	5942.50	4239.20
12	4303.70	4762.30	6063.10	7140.10	7435.00	6155.40	4094.40
13	4248.40	4533.40	6232.80	6806.80	7242.20	5769.20	4807.10
14	4150.60	4598.80	5897.00	6730.70	7520.90	6017.70	4858.10
15	4008.50	4297.50	5852.10	6992.50	6904.80	5435.00	4805.00
16	3901.80	4207.80	5850.90	6631.70	7969.00	5198.20	4798.00
17	3802.70	4181.80	5210.50	7118.30	7410.30	5731.00	4018.30
18	4066.20	4063.20	5224.40	7024.10	7343.50	5086.90	4458.00
19	3639.10	4021.40	4771.50	6998.00	7157.70	4298.70	4510.00
20	3632.60	4041.60	4819.90	7081.40	6559.20	5347.10	4275.90
21	3605.70	3940.30	4629.70	6696.60	6547.90	5637.20	4589.60
22	3531.40	3762.30	5110.40	6720.40	6883.70	4985.90	4206.60
23	3687.30	3742.00	4855.90	6808.00	6004.30	4901.50	4334.70
24	3237.30	3351.90	5027.90	6482.00	5677.80	5060.80	4064.40
25	3436.70	3515.10	5218.90	6593.30	4915.70	4819.90	3960.20

Rep # / Sub #	1	2	3	4	5	6	7
26	3356.00	3565.40	4790.10	6647.80	6499.60	5100.00	4372.50
27	3047.50	3480.60	4882.90	6665.50	6610.00	5266.00	4141.50
28	3486.70	3400.50	4830.00	6258.00	5630.10	4835.00	3818.00
29	3035.80	3338.60	4854.20	6440.00	5738.60	4675.20	3876.10
30	3381.20	3127.00	4461.50	6332.80	5499.30	5506.50	3501.40
31	3370.00	3193.30	4566.70	6576.20	5209.90	4939.70	3670.70
32	3248.90	3043.00	4446.10	6518.60	4807.90	4274.60	4217.90
33	3329.20	3023.50	4019.80	5917.10	5144.70	4995.00	4218.80
34	3182.90	2810.70	4173.60	6351.20	5081.90	4780.30	4436.20
35	2893.20	2864.40	3899.40	5600.80	4513.80	4746.80	4078.60
36	2935.40	2611.50	3712.10	5822.80	4873.10	4472.30	4355.10
37	3076.30	2780.10	3829.60	6092.40	4989.30	3662.60	4141.10
38	2992.20	2576.10	3210.40	6338.70	4035.10	4130.20	4096.70
39	3005.80	2868.40	3523.80	6115.90	3869.80	3876.40	3845.30
40	3164.80	2552.30	3360.50	6235.30	4585.80	3519.60	3888.80
41	3069.00	2623.00	3454.10	5939.00	4100.00	4552.10	3924.50
42	3093.50	2427.40	3410.90	6010.10	4673.70	4391.40	3941.00
43	2879.20	2441.00	3123.50	6029.50	3938.60	4457.50	3649.30
44	3063.20	2495.00	3528.30	6224.10	3601.90	3954.50	3755.20
45	2831.80	2600.70	3175.40	6122.20	3257.60	4105.10	3855.00
46	2831.40	2337.40	3377.30	5637.00	3248.50	4168.10	3957.70
47	2797.90	2262.40	3754.80	6037.30	2832.40	4068.10	3813.10
48	3074.00	1988.30	2881.20	5977.20	4301.40	3949.30	3856.90
49	2674.00	2518.80	3293.90	5492.70	4116.10	3755.40	3565.20
50	2984.80	2188.60	3287.70	5838.90	4184.40	4019.10	3557.90
Peak	4835.20	5765.30	7414.30	7794.40	8965.20	7643.70	5471.30
AVG	3534.98	3659.53	4909.40	6500.69	6005.41	5005.26	4290.37

Rep # / Sub #	8	9	10	11	12	13	14
1	7986.50	9601.30	5585.40	5296.80	5713.90	5935.50	8937.40
2	8869.20	10360.20	6572.70	5903.30	6777.90	6872.90	10251.80
3	8784.30	10557.40	6448.20	5423.80	6903.40	7055.20	9656.80
4	8586.80	9399.90	6560.20	5363.00	6965.20	7262.80	9242.50
5	8575.60	9883.40	6305.10	4983.80	6901.10	6915.60	9251.70
6	8398.30	9950.10	5780.90	4805.70	6580.60	7090.30	9354.50
7	8216.80	9914.70	5679.70	5092.60	6566.90	6991.30	9290.80
8	8023.30	9818.50	5772.80	5045.70	6502.20	6696.40	9350.80
9	8187.30	9583.00	6205.60	5461.80	6283.60	6685.50	9474.00
10	7756.10	9421.80	5916.80	4679.80	6186.70	6415.20	9167.40
11	7632.60	9043.20	5719.60	6414.30	6125.20	6550.90	8337.60
12	7600.60	8184.10	5928.50	5466.20	6108.70	5791.80	8272.70
13	7664.00	8263.50	5456.80	5190.40	6019.80	5933.90	7958.30
14	7173.10	8126.70	5980.70	5788.10	5763.00	5802.40	7990.00
15	7170.90	7490.90	6067.90	5491.30	5683.70	6021.40	7480.40
16	6993.30	7169.40	6020.00	4757.80	5586.80	6054.80	6955.60
17	6930.10	7147.10	5859.70	5235.90	5502.90	5841.10	7577.00
18	6694.80	8004.60	5829.00	4454.10	5369.80	5558.20	6936.60
19	6509.70	7108.00	5790.60	4572.50	5337.70	5485.40	6739.70
20	6338.90	7250.00	5497.40	5186.70	5137.50	5406.60	5939.10
21	6146.60	6805.10	5081.20	3522.10	4945.10	5154.00	6423.40
22	6122.30	6171.00	5515.70	4685.80	4751.80	5280.70	6596.00
23	5687.50	6303.30	5403.20	4065.40	4811.40	5072.60	5765.60
24	5376.10	5471.80	5192.50	4047.60	4677.90	5283.90	6272.30
25	5794.20	6044.90	4880.60	3826.90	4585.60	5060.20	5094.60

Rep # / Sub #	8	9	10	11	12	13	14
26	5444.60	5111.10	5334.70	3994.80	4562.10	4887.80	5308.40
27	5522.80	5369.90	4538.70	4285.00	4545.20	4632.90	5479.90
28	5181.00	4751.90	4937.50	3306.40	4445.60	4869.00	5429.40
29	4990.80	5530.30	5048.00	3446.30	4203.90	4768.90	5467.80
30	4617.10	5530.50	4662.50	3678.90	4262.40	4969.20	4902.00
31	4241.80	5438.20	4864.20	3994.90	4024.30	4535.20	5649.30
32	3078.00	5807.90	4485.30	4191.60	3976.70	3963.80	4788.60
33	4610.40	5100.70	4718.80	3706.40	3966.60	4171.20	4406.70
34	4103.20	4951.70	4262.90	3910.50	3928.70	4561.40	4548.00
35	4367.50	5460.00	3856.20	3377.60	3769.60	4203.30	3940.70
36	4190.30	4531.20	4333.50	3805.00	3394.00	3886.60	4725.10
37	4392.80	4530.00	4649.30	3275.50	3790.00	4393.50	4786.90
38	4279.20	5072.70	4311.00	3752.00	3526.80	4368.70	4133.50
39	4071.80	5155.20	4225.90	3539.60	3704.80	4088.50	4558.60
40	3974.80	4180.10	3952.10	3204.20	3543.90	4237.20	3927.30
41	3934.60	4329.80	3948.40	3270.30	3391.00	3460.10	3985.00
42	3985.00	4511.60	3955.30	3541.90	3388.10	4163.50	5084.10
43	3703.90	4775.40	3757.80	3101.40	3539.70	3823.90	4593.20
44	3900.90	4574.80	3735.30	3237.80	3326.10	3540.20	4416.30
45	3862.30	4448.00	3516.60	3175.10	3338.60	3829.50	3846.60
46	3797.20	4274.20	4133.60	3392.80	3359.90	3784.30	4461.20
47	3360.10	3891.20	4314.00	2973.20	3251.70	3913.70	4705.00
48	3611.60	4193.10	4110.60	2881.60	3544.70	3811.60	4183.30
49	3670.80	3841.90	3719.10	1950.00	3171.20	3507.80	4046.70
50	3227.00	4526.80	4350.20	2958.40	3106.20	3684.20	4904.40
Peak	8869.20	10557.40	6572.70	6414.30	6965.20	7262.80	10251.80
AVG	5746.77	6539.24	5055.45	4214.25	4777.00	5125.49	6291.89

Rep # / Sub #	15	16	17	18	19	20	21
1	5619.80	4662.90	4834.90	8043.30	6094.80	4576.20	6720.80
2	5809.30	6046.90	5114.50	8877.90	6937.40	5012.10	7485.10
3	5917.00	5596.90	5194.30	8417.90	7771.40	5030.40	7794.20
4	5906.30	5516.90	5116.10	8338.90	7747.60	4850.30	7876.10
5	5606.00	4967.50	4959.20	7783.90	7598.60	4562.10	7091.80
6	5689.10	5284.50	4879.10	7995.50	7014.00	4639.70	6991.00
7	5381.50	5162.00	4554.90	7393.40	6888.50	4527.30	6930.20
8	5525.70	5681.80	4642.20	8068.00	6083.40	4516.40	7129.30
9	5481.70	5191.50	4503.60	8510.00	5517.90	4383.90	7011.00
10	5288.20	5301.90	4311.10	7830.40	6481.60	4205.20	6840.40
11	5135.50	4905.30	4339.90	7583.30	5763.70	4241.00	6166.40
12	4807.80	4934.80	4156.00	7977.40	6039.60	3982.00	6280.20
13	5060.50	5369.30	3919.00	7433.40	5247.30	3859.00	6428.60
14	5093.60	4945.80	4043.90	7927.30	5516.30	3878.60	7161.00
15	4866.00	4585.50	3886.30	7365.70	5906.90	3953.20	6675.40
16	4629.10	4555.30	3460.00	7517.00	5656.20	3801.80	6132.50
17	4684.00	4915.50	3523.30	7635.00	5044.30	3754.40	6329.90
18	4300.40	4545.20	3178.00	7201.20	6088.20	3743.10	6282.80
19	4344.80	4312.20	3322.60	6663.40	5967.00	3503.40	6371.10
20	4219.20	4337.80	3368.40	6319.80	5044.30	3409.40	6354.10
21	4193.30	4348.20	3263.20	6463.80	4560.20	3296.00	6143.00
22	4026.60	4002.40	3103.90	6342.60	4993.00	3263.20	5656.00
23	4058.30	3567.30	2923.00	6330.70	5887.40	3102.20	6230.60
24	3876.80	3810.50	2543.70	5948.90	5613.00	2981.10	5196.80
25	4249.40	4103.00	2692.00	6157.00	5007.60	2411.10	4450.00

Rep # / Sub #	15	16	17	18	19	20	21
26	3239.60	3628.20	2661.80	6492.40	4995.50	3047.60	5330.20
27	3835.30	3570.60	2592.80	5882.50	5452.10	2968.30	4827.00
28	3358.90	3152.50	2527.70	5822.10	4917.10	2825.40	4667.90
29	3806.20	3462.60	2492.20	5574.20	4800.90	3013.60	4520.10
30	3392.40	2853.40	2334.50	5485.60	4847.10	2785.10	4567.70
31	3365.00	3165.20	2285.70	5454.10	5062.80	2758.00	3776.20
32	3009.80	2984.70	2409.20	5264.70	4788.90	2816.00	4433.70
33	3329.40	2732.40	2252.60	4871.90	4765.70	2548.20	4753.80
34	2937.10	3185.10	2229.50	4819.30	3922.40	2629.00	4206.90
35	3211.80	2715.50	2242.80	5270.20	3986.00	2786.90	3592.20
36	2988.60	2959.40	2229.90	4861.50	4073.90	2293.80	3319.10
37	2910.40	2537.20	1912.90	5166.10	4233.10	2596.80	3270.20
38	3281.80	2702.90	1865.60	4630.20	4016.20	2531.20	4181.90
39	2746.20	2422.50	1990.40	4522.40	4257.10	2516.20	4092.80
40	2870.10	2784.20	2114.40	4687.60	3947.90	2844.10	3350.10
41	2908.00	2405.00	2130.50	4315.40	2978.30	2309.00	3040.20
42	2526.80	2795.00	2089.40	4081.60	3980.00	2625.60	3601.70
43	2862.80	2771.50	1555.80	4606.50	3215.50	2445.30	3644.40
44	2898.00	2768.80	2281.50	4426.20	4333.40	2331.60	3132.00
45	2821.90	2675.50	1865.80	4678.00	3691.00	2308.30	3498.10
46	2618.20	2510.50	2222.00	4437.60	4172.00	2480.70	3102.50
47	3023.90	2423.90	1601.90	4429.10	4119.40	2314.90	2920.90
48	2624.20	2729.80	1786.30	4325.70	3864.10	2620.50	3715.20
49	2314.70	2077.20	1938.90	3895.40	2708.70	2361.20	3097.90
50	2987.00	2429.80	2058.40	4370.40	4035.00	2574.80	3696.60
Peak	5917.00	6046.90	5194.30	8877.90	7771.40	5030.40	7876.10
AVG	3992.76	3821.89	3070.11	6169.93	5112.69	3296.30	5201.35

Rep # / Sub #	22	23	24	25	26	27	28
1	4651.00	12337.90	6992.60	7154.80	6876.90	6477.20	8247.10
2	5073.00	15683.40	7904.70	8037.60	8316.60	7866.00	8650.60
3	5090.90	15311.60	8003.90	7833.60	8520.90	8175.50	8038.90
4	5208.80	15025.30	8428.50	7773.80	8055.50	8277.00	8055.90
5	5357.70	14496.80	8564.30	7832.50	8416.90	8436.40	7971.70
6	5234.20	13933.10	8567.00	7783.70	8464.50	8397.20	7349.00
7	5171.60	14201.10	8361.80	7290.30	8559.40	8053.10	7189.40
8	4914.30	13334.40	8151.90	7313.60	8597.80	7772.10	7476.50
9	4816.70	12316.00	7962.60	7563.10	8110.10	7687.30	7169.70
10	4753.00	12053.10	7775.70	7323.70	7966.40	7187.40	6892.30
11	4749.50	12984.50	7686.80	6870.90	8215.90	7378.80	6846.90
12	4098.50	12775.80	7625.20	7091.90	7850.00	6869.30	6077.40
13	4428.50	12227.20	7431.30	7022.40	7891.40	6976.10	7498.30
14	4353.70	11843.10	7369.30	6825.00	7368.70	6609.40	7131.90
15	4159.70	11754.00	7077.50	6703.80	7813.00	6422.60	6487.00
16	4504.80	11454.00	6672.80	6461.30	7380.40	6111.40	6639.10
17	4446.40	10971.10	6570.80	5976.70	7665.20	5956.40	6378.50
18	4513.40	10964.90	6318.30	5711.80	6845.20	6074.00	5781.90
19	4354.20	10840.40	6429.60	5763.20	6639.80	5779.30	6623.60
20	4389.20	10565.20	6206.80	5853.60	7099.10	5654.90	5833.10
21	4138.90	10389.30	6268.20	5371.60	6221.50	5659.00	5633.70
22	4358.70	9254.70	5702.50	5225.20	6687.00	5088.10	5007.00
23	4216.30	9449.50	5741.00	5040.60	6081.60	5381.90	5121.00
24	4137.80	8874.40	5553.90	4911.40	6142.80	5205.30	5751.50
25	4226.70	8342.40	5969.90	4785.70	5848.50	4885.00	5499.60

Rep # / Sub #	22	23	24	25	26	27	28
26	3882.10	8044.00	5578.70	4704.60	5648.70	4570.80	5163.70
27	3902.10	7400.10	5077.40	3872.50	5399.10	4616.00	5491.60
28	3724.30	7955.00	5267.30	4220.80	5653.80	4573.20	5130.60
29	3629.70	7688.40	5114.00	4177.20	5405.10	4370.70	4095.40
30	3761.00	7565.70	4991.80	4221.20	5598.80	4305.20	3930.30
31	3641.00	7320.80	5026.30	4054.50	4923.40	3812.90	4529.40
32	3579.30	7222.50	4936.30	3842.20	4831.60	3837.80	4235.50
33	3323.60	6987.50	5057.40	3615.40	4729.70	3853.30	3963.80
34	3474.60	6875.40	4835.70	3463.70	4841.20	3522.30	3773.70
35	3461.90	6796.40	4869.10	3294.60	4966.30	3147.30	3681.10
36	2898.50	6285.20	4690.60	3181.70	5169.60	3272.90	3556.30
37	3394.50	6308.30	4781.00	3241.30	4850.70	3144.70	3987.60
38	3135.60	6255.90	4387.50	3178.00	4588.90	3145.50	3793.90
39	3088.60	6096.90	4651.40	3130.90	4992.30	3536.80	3558.60
40	3010.60	5684.60	4888.20	2753.50	4376.50	3582.50	3682.70
41	3356.50	5979.90	4709.90	3014.30	4499.90	3375.60	3051.30
42	3180.50	5652.20	4561.10	2816.10	4446.20	3075.40	2831.10
43	2970.30	6168.00	4637.20	3076.40	4345.40	3179.40	2875.80
44	2823.70	6160.30	4554.60	2953.40	4499.30	3322.30	3331.90
45	2758.90	5427.20	4451.60	2787.70	4330.00	3581.10	3375.00
46	2874.60	5704.90	4312.60	2854.00	4262.40	3039.80	3258.30
47	2784.60	5277.00	4333.30	2615.60	3799.00	3311.40	3641.80
48	2679.70	5717.40	4396.50	2989.20	3554.70	3441.40	2742.10
49	2680.50	5431.30	5064.80	2888.50	3421.50	3467.30	3218.90
50	2851.30	4714.10	4743.30	2691.50	3803.80	3758.30	3759.60
Peak	5357.70	15683.40	8567.00	8037.60	8597.80	8436.40	8650.60
AVG	3924.31	9242.04	5985.09	4983.21	6091.46	5184.49	5280.23

Rep # / Sub #	29	30	31	32	33	34	35
1	6308.70	9102.50	7120.50	7833.20	5437.90	8493.80	8259.20
2	6973.30	9766.00	7862.30	9178.60	6050.80	9372.20	8509.00
3	6978.40	9972.20	7168.70	8957.30	6543.20	9555.80	7897.60
4	6918.70	9882.60	7487.40	8825.40	6852.30	9172.20	7866.50
5	6855.00	9884.60	7295.50	8603.80	6788.80	8986.10	7794.30
6	6987.30	9907.00	6879.40	8210.40	6142.10	8875.10	7279.30
7	6691.00	9823.00	6670.50	7935.70	6169.60	8466.70	7069.70
8	6200.90	9295.80	6954.50	7701.60	6423.80	8565.90	7049.40
9	6425.70	9269.50	6835.10	7855.30	6241.70	8112.80	6761.10
10	6471.00	9040.80	6663.10	7780.80	6010.80	8187.60	6512.30
11	6048.80	8453.10	6679.00	6841.50	5970.80	7953.10	6187.70
12	6163.90	8865.10	6680.60	6894.00	6425.20	7818.90	6119.70
13	5978.50	8694.20	6526.30	6513.40	6013.50	7661.90	5843.80
14	5611.10	8328.70	6652.40	5880.10	5666.10	7322.90	5683.70
15	5438.10	7669.80	6438.20	5544.10	5732.40	6885.50	5457.50
16	5071.00	7558.70	6052.20	4775.90	5624.70	6742.20	5396.50
17	5065.80	7360.40	6068.40	5344.50	5798.70	6498.20	5092.00
18	5090.60	6967.50	6021.30	4219.30	5186.40	6096.40	4990.30
19	5186.80	6794.00	6144.40	4910.10	5353.50	6174.80	4865.60
20	4147.60	6902.90	5694.10	4333.40	4859.50	5875.60	4575.10
21	4645.80	6676.70	5833.90	3633.40	4869.30	5990.30	4481.50
22	4583.50	6354.00	5661.30	3964.30	5147.00	5558.00	4306.80
23	4386.30	6176.70	5535.50	3906.50	4899.30	5444.40	4223.60
24	4286.50	6225.70	5128.90	3652.10	4872.70	5314.70	4035.80
25	3987.20	5869.00	5228.80	3577.80	4868.90	5105.80	3722.90

Rep # / Sub #	29	30	31	32	33	34	35
26	3790.00	5988.40	4972.80	3389.30	4488.00	5144.30	3698.90
27	3294.80	5819.80	5052.70	3853.00	4602.50	4926.10	3467.90
28	3352.60	5450.90	4806.20	3408.20	4946.30	4958.10	3362.40
29	3349.20	5172.10	4586.30	2696.20	4701.40	4931.20	3322.40
30	3686.50	4879.20	4579.30	3211.90	4542.40	4675.20	3073.30
31	3349.00	4711.90	4336.40	3047.40	4365.70	4407.80	2863.70
32	2977.20	4643.30	4380.30	3302.70	4319.10	4181.30	2839.30
33	2816.60	4284.70	4142.00	2343.80	4097.10	3948.80	2679.40
34	2502.30	4112.80	4450.00	3672.30	3904.50	3661.80	2827.60
35	3196.10	4405.80	3960.80	3056.50	4069.00	4062.00	2597.40
36	2750.40	4038.70	4083.70	3124.60	4022.60	4067.30	2539.60
37	2781.40	3957.80	3792.00	3001.80	3640.60	3939.70	2335.10
38	3164.90	3807.70	3823.10	2564.20	3652.60	3797.70	2312.20
39	2701.20	3764.50	3590.70	2401.10	3355.10	3636.30	2303.50
40	2589.20	3965.60	3535.80	2502.70	3507.70	3336.40	2335.00
41	2900.20	3592.40	3439.70	2844.60	3155.70	3284.80	2172.70
42	2173.90	3461.70	3104.60	2798.80	3426.30	3276.00	2269.40
43	3053.60	3093.00	3205.90	2680.20	3047.10	3189.50	2232.40
44	2557.60	2836.10	2939.20	2332.20	3219.60	3300.90	2233.40
45	2860.50	3512.90	3216.50	1951.10	3035.90	2861.50	2155.10
46	2589.20	3133.40	2729.80	3289.00	3424.50	3050.20	2240.80
47	2580.20	3386.00	3045.00	1905.50	3001.80	2994.90	2055.40
48	2664.50	2920.50	2854.10	2406.60	3228.50	2855.70	2233.60
49	2093.50	3219.00	2869.50	2937.80	2827.00	2568.30	1969.20
50	2393.70	2906.80	2747.80	2529.90	3060.20	2655.60	2100.20
Peak	6987.30	9972.20	7862.30	9178.60	6852.30	9555.80	8509.00
AVG	4293.40	6118.11	5110.53	4562.48	4751.80	5558.85	4284.02

Maximum Work (ft·lb) - PL

Rep # / Sub #	1	2	3	4	5	6	7
1	4486.50	4778.80	7207.50	6780.90	9063.00	5606.30	4347.10
2	4348.80	5633.80	6684.60	6316.30	9940.70	7734.30	5339.90
3	4472.30	4981.30	7092.50	5925.40	9850.70	8147.00	5049.70
4	4607.80	5453.10	6600.60	6517.40	9824.50	7899.80	4938.10
5	4178.60	5173.10	6563.00	6215.20	9718.10	8058.10	4626.80
6	4487.40	5388.90	6415.60	6389.40	9657.90	7633.20	4540.00
7	4253.50	5139.30	6018.10	5974.30	9598.70	7349.50	4689.30
8	4230.70	5065.10	6452.60	6657.40	8766.00	6648.70	4582.40
9	3971.80	5050.10	6080.80	6684.50	7860.60	6889.20	4186.10
10	4358.90	4941.60	5512.00	6474.90	8972.20	6636.40	4251.40
11	4293.50	4964.60	5506.50	6739.20	8341.20	6392.20	4572.10
12	4108.80	4741.60	5311.30	7351.80	8377.70	7178.90	3928.20
13	4042.20	4689.70	4992.90	6806.70	8276.10	6379.00	4608.60
14	3946.60	4612.40	4689.10	7186.10	7011.70	6630.70	4332.20
15	3525.10	4281.70	5000.70	6833.60	7665.00	6556.90	4772.20
16	4081.00	4309.40	3790.40	6799.20	7929.80	6647.90	4347.40
17	4121.70	4209.90	4626.00	7032.40	7441.40	6997.60	4223.40
18	4192.90	3942.00	4725.20	7055.20	7542.70	6299.60	4090.40
19	4234.40	4355.50	4514.70	6710.20	7437.70	6062.00	3951.70
20	3938.90	4209.60	4215.30	6503.40	7591.50	5601.70	4581.50
21	4117.50	3825.70	4130.80	6729.10	7029.20	5800.10	4098.00
22	3785.70	3763.20	4295.70	6426.80	6775.00	5802.80	3981.10
23	3864.30	3670.10	4034.60	6682.10	7714.40	5620.10	3821.60
24	3708.10	3695.40	4603.30	6484.40	7325.00	4996.10	3857.40
25	3539.40	2976.50	4180.30	6447.90	7065.80	4263.20	4321.30

Rep # / Sub #	1	2	3	4	5	6	7
26	3625.30	3319.30	4166.00	6392.90	6543.50	5146.00	4044.70
27	3769.80	3124.40	3485.00	6386.30	6256.00	4569.10	3941.30
28	3569.70	3162.60	4545.50	6312.50	6594.80	4563.20	4012.10
29	3219.00	3079.00	4219.50	6136.30	6283.40	4985.00	3929.40
30	3337.70	3068.20	4396.40	6261.20	6001.00	4830.30	3931.70
31	3553.50	3201.60	4275.10	6420.80	5277.10	4480.60	3932.60
32	3187.00	2721.50	3890.80	6402.20	5276.40	4030.50	3828.40
33	3490.30	2881.10	3813.60	6229.60	5372.80	4530.20	4200.30
34	3037.30	2684.40	4301.90	6039.60	4866.40	4370.70	4077.40
35	3485.70	2596.30	4299.90	5984.20	5046.20	3961.30	3967.60
36	3292.40	2995.40	4293.60	6292.50	4885.60	3630.10	3846.90
37	3350.50	2610.90	3913.50	5801.10	4677.70	3982.90	3907.70
38	3240.30	2560.20	3933.40	5617.00	4939.50	3662.90	3750.30
39	3111.60	2501.70	3806.60	5907.50	4707.90	4239.70	4102.60
40	2750.60	2521.70	3553.60	5784.70	4781.80	4417.50	3567.20
41	2876.00	2644.60	4030.30	5452.00	4204.60	4091.70	3727.40
42	3037.70	2453.60	3394.40	5590.80	4217.10	3903.10	4132.10
43	3163.40	2467.70	4213.40	5884.50	4107.10	4134.50	4278.10
44	3109.50	2378.70	3838.60	5717.60	4056.90	4406.20	3993.50
45	3174.50	2485.80	3806.60	5638.00	4016.00	3632.10	4102.80
46	3088.70	1978.60	3553.60	5046.00	4121.50	4003.90	3971.80
47	2685.70	2448.60	4030.30	5517.80	3996.30	3783.50	3973.40
48	2703.90	2111.80	3394.40	5234.40	3853.50	3634.70	3936.40
49	2857.10	2218.70	4213.40	5199.80	3940.20	3345.70	4103.80
50	2869.20	2360.50	3838.60	5608.50	4128.60	3371.30	3697.40
Peak	4607.80	5633.80	7207.50	7351.80	9940.70	8147.00	5339.90
AVG	3649.66	3608.59	4649.04	6251.63	6578.57	5350.76	4179.90

Rep # / Sub #	8	9	10	11	12	13	14
1	8023.60	9007.20	5746.80	4798.80	6906.40	5327.70	8521.90
2	8888.60	10872.60	6761.70	6776.50	7457.90	6370.10	9759.50
3	8538.50	10254.20	6740.70	6731.80	7496.60	5848.10	9872.80
4	8463.10	9442.00	7225.40	6294.10	7455.20	6666.00	9534.50
5	8590.80	8236.20	6837.10	6939.90	7353.20	6832.30	9684.10
6	8572.90	8964.70	7380.70	6164.00	7159.60	6779.80	9379.50
7	8214.80	9258.90	7130.20	5279.50	7206.20	6643.60	9569.90
8	7894.30	9381.30	6880.90	4966.30	7080.30	6127.00	8800.00
9	8106.70	8835.30	5735.80	6019.20	6786.60	6229.80	8756.90
10	7696.20	8318.80	6424.20	5786.00	6755.90	6326.10	8676.30
11	7643.90	8422.10	6723.70	5122.90	6793.60	6052.20	8515.00
12	7305.10	8106.70	6001.40	5672.80	6525.70	6078.00	8804.80
13	7250.00	7778.50	6057.60	5328.30	6382.10	5807.10	8236.30
14	7000.80	8450.10	6356.70	4758.70	6314.80	5546.70	7857.90
15	6983.00	7564.90	6592.40	4165.70	6208.70	5586.90	7790.70
16	6740.00	7471.60	5405.80	5034.00	5956.10	5581.20	7549.50
17	6326.30	7224.10	5787.40	5355.10	5778.80	5498.30	6929.80
18	6146.10	7997.70	5612.60	5394.40	5455.10	5225.20	6609.00
19	5813.10	7057.60	5022.20	4563.50	5358.10	5246.90	7353.40
20	5815.00	6778.60	6237.20	5352.90	5246.40	5017.90	6693.20
21	6069.10	6741.30	5408.00	4845.00	5155.70	5204.80	6623.70
22	5741.60	6666.00	5583.10	4618.90	5175.00	4633.70	6559.50
23	5304.70	6121.10	5716.00	4700.10	4878.50	4664.60	6316.60
24	5217.40	5521.70	5536.20	4257.60	4868.00	5187.30	5918.70
25	5116.10	5956.60	5575.10	5125.70	4807.00	4802.10	5732.50

Rep # / Sub #	8	9	10	11	12	13	14
26	5421.90	5540.50	5307.80	5393.30	4565.60	4638.10	5715.50
27	4909.70	5706.50	4835.90	4638.10	4519.10	4774.00	5824.90
28	4807.10	6354.70	5417.80	5463.20	4524.40	4459.80	5227.80
29	4670.50	5530.10	4643.70	4653.50	4428.50	4342.00	5228.30
30	4515.90	5680.60	3883.10	4051.90	4199.60	4600.20	5434.40
31	4654.90	4944.20	4662.80	4059.10	3876.90	4131.60	5176.40
32	4595.00	5314.90	4168.80	4167.20	4023.60	4081.90	5176.90
33	4103.20	5130.50	3937.40	3824.90	3970.70	4109.60	5093.50
34	4371.70	5235.40	4221.60	4310.00	3898.80	4460.00	5107.20
35	4440.90	4953.60	3839.30	3765.50	3729.60	3649.30	5574.70
36	4257.30	4972.10	4229.20	3649.80	3648.80	4430.30	5256.80
37	4085.50	5199.80	3288.10	3705.30	3724.30	4027.70	4500.30
38	4207.60	4310.00	4501.80	4285.90	3645.60	4384.30	4771.90
39	4198.90	4795.10	3666.30	3381.50	3440.70	4071.40	4423.70
40	3985.00	4043.50	3934.80	3046.40	3266.90	4236.30	4683.20
41	3529.30	4291.20	3763.20	3733.70	3173.00	3922.90	4279.80
42	3933.00	4352.90	3738.40	3580.50	3313.10	3821.00	5060.30
43	3527.60	4904.10	4155.30	3954.30	3338.10	4266.60	5295.50
44	3398.00	3937.60	4150.00	3984.90	3378.30	3333.30	4962.50
45	3937.10	3625.30	3991.70	3494.10	3170.60	3760.90	4719.70
46	3971.70	3769.50	4224.20	3661.20	3139.50	3625.30	4322.80
47	3744.40	3149.00	3572.80	4193.10	2972.70	3247.10	4542.50
48	3403.90	4226.80	4028.20	4050.90	3017.90	4090.60	4282.10
49	3424.20	2731.80	3973.10	4074.60	2849.90	3762.20	4636.30
50	3792.80	2999.40	4103.10	3689.60	2907.00	3522.00	4758.30
Peak	8888.60	10872.60	7380.70	6939.90	7496.60	6832.30	9872.80
AVG	5626.98	6322.58	5174.35	4697.28	4945.69	4900.64	6482.03

Rep # / Sub #	15	16	17	18	19	20	21
1	6050.80	4821.90	4872.60	6162.10	7380.60	4062.70	5942.00
2	6217.90	6037.40	5241.70	6998.90	7727.40	4632.80	6960.80
3	6236.90	5988.40	5172.50	6578.90	7852.10	4630.30	7051.40
4	6139.10	5751.40	5107.90	6665.80	7883.70	4645.10	7279.40
5	6096.10	6043.70	5036.90	7223.30	7730.50	4303.90	7615.70
6	5872.40	5261.90	4905.80	6207.10	7854.10	4020.70	7307.00
7	5743.90	5500.30	4500.20	7091.80	7658.60	4085.10	7267.30
8	5704.60	4885.50	4675.70	7416.10	7543.80	3902.90	7558.30
9	5610.10	5221.90	4609.80	6602.00	7022.40	3979.50	7632.30
10	5530.50	4955.50	4489.90	6612.20	7157.80	3815.20	6943.10
11	5090.70	4692.60	4182.50	6131.20	6974.00	3491.40	6845.00
12	4895.50	5063.40	4351.50	6287.00	6682.10	3317.70	6884.80
13	5312.60	5072.10	3998.60	5992.80	6606.00	3452.00	6542.50
14	5121.50	4783.50	3838.60	6131.60	6535.00	3208.50	6513.70
15	4787.80	4447.40	3754.20	6280.30	6518.00	2932.50	7211.40
16	4994.30	4220.80	3601.90	6602.40	6069.70	2926.40	6512.30
17	4917.90	4253.20	3499.80	6190.50	6052.20	2897.60	6646.20
18	4714.20	4341.60	3414.30	5587.20	5661.10	2928.70	6480.40
19	4680.00	3722.80	3317.50	5803.80	5854.80	2713.50	5893.90
20	4610.00	3784.10	2765.70	5549.10	5284.70	2718.20	6064.40
21	4592.70	3514.60	3061.10	5759.20	5713.80	2636.10	5860.20
22	4338.70	3894.80	3180.60	5391.30	5412.80	2905.60	5728.30
23	4357.90	3739.10	3018.70	5645.80	5260.00	2272.00	5809.50
24	4222.40	3859.70	3126.80	5604.90	5070.80	2560.90	5169.40
25	4135.70	3317.60	2614.00	5688.00	5088.80	2290.40	5492.80

Rep # / Sub #	15	16	17	18	19	20	21
26	3962.40	2997.40	2340.00	5298.10	4915.90	2518.30	5349.00
27	4101.70	2981.40	2576.60	5286.00	4933.10	2383.80	4415.60
28	4023.20	2845.50	2104.00	4536.80	4614.40	2322.70	4252.70
29	3895.10	2996.10	2198.80	4851.20	4510.90	2244.40	4185.70
30	3481.50	2952.80	1907.20	4608.30	4432.90	2455.50	4778.70
31	3887.70	2853.20	2160.20	4680.90	4384.90	2511.00	4526.50
32	3609.70	2826.40	2353.10	4665.20	4144.60	2431.20	3935.70
33	3505.50	2366.00	2310.90	4359.00	4464.00	2482.90	4401.70
34	3751.70	2747.20	1974.50	3893.00	4327.40	2290.30	4328.20
35	3565.50	2471.40	2299.90	4342.80	4337.50	2293.40	3726.80
36	3723.20	2759.10	2208.20	4691.00	3912.90	2268.20	3797.90
37	3963.50	2606.20	2053.10	4468.60	3944.20	2405.10	4023.80
38	3671.20	2549.20	2112.20	4356.50	4059.10	2325.20	3918.10
39	3283.50	2799.00	2300.00	4340.30	3643.00	2185.10	4234.30
40	3700.80	2371.50	2148.70	4296.50	3353.80	2559.10	3556.10
41	3944.40	2896.60	2047.60	3991.80	3379.40	2173.80	3684.30
42	3854.20	2448.40	1958.40	3428.30	3529.60	2187.70	3775.50
43	3297.80	2668.40	2057.00	3705.70	3699.60	2041.00	3835.20
44	3342.50	2813.30	1861.60	3565.70	3229.90	1959.30	2953.10
45	3323.20	2595.70	2229.70	3832.60	3274.70	2229.20	3414.00
46	3659.00	2693.00	2165.80	3590.30	2624.10	2084.60	3326.90
47	3052.10	2357.70	2018.70	3542.90	3514.30	2036.30	2719.00
48	2604.00	2304.40	1614.90	3486.30	2946.60	2167.30	3397.30
49	2954.90	2641.00	2270.40	3610.90	3099.80	2126.70	3619.70
50	3046.10	2482.30	1778.50	3456.30	2615.50	2018.50	3121.20
Peak	6236.90	6043.70	5241.70	7416.10	7883.70	4645.10	7632.30
AVG	4383.57	3683.97	3067.78	5221.77	5209.74	2840.61	5249.78

Rep # / Sub #	22	23	24	25	26	27	28
1	5099.50	11952.30	6538.90	7220.60	7594.40	6179.00	6901.90
2	5950.00	14910.30	6703.40	8034.00	9104.50	7142.40	7869.80
3	5751.30	15645.30	7259.10	8383.80	8768.00	7601.80	8138.30
4	5827.50	15237.70	7248.40	8065.80	8463.50	7730.60	8617.00
5	5476.80	14856.90	7028.70	8014.10	8543.60	8008.80	8332.90
6	5127.30	14988.60	6952.40	7865.80	8678.00	8072.00	8018.80
7	5077.20	13937.20	6687.20	7889.30	8517.60	8069.30	7819.90
8	4623.30	13548.70	6879.40	7580.90	8695.40	7896.60	7845.50
9	4688.70	13238.50	6378.60	7062.30	8790.00	7881.00	7584.60
10	4914.80	12667.30	6270.30	7159.70	8417.20	7627.40	7903.50
11	4911.00	12799.80	6499.60	6880.70	8371.30	7306.20	7125.50
12	4742.30	12516.80	7285.20	7039.00	8351.40	7370.60	7714.80
13	4808.00	12322.00	6751.00	6808.50	8269.60	6856.40	6982.50
14	4545.10	11717.90	6413.10	6750.50	7906.90	6877.10	6912.50
15	4525.60	12193.20	6419.80	6537.70	8280.60	6522.30	6544.80
16	4392.40	11849.90	6170.20	6258.70	7934.60	6592.10	6709.70
17	4242.30	11756.00	6075.00	6378.70	7469.50	6108.20	6424.40
18	4138.10	10987.40	6153.60	5894.70	7315.60	6020.90	6663.60
19	3962.30	10910.50	5422.50	5812.50	7129.60	6043.70	6539.80
20	3772.50	10968.20	4993.10	5620.90	7254.50	5782.80	5418.90
21	3971.30	10661.90	5784.40	5320.90	7107.90	5230.60	4834.00
22	3521.60	10012.30	5300.70	4590.80	7128.70	4969.90	5096.90
23	3878.80	9624.70	5173.20	5198.00	6460.00	5050.40	5082.00
24	3476.10	9367.20	5368.10	5048.30	6470.20	4977.30	5501.60
25	3769.90	9371.70	4787.90	4804.60	6766.90	4651.60	4909.10

Rep # / Sub #	22	23	24	25	26	27	28
26	3306.20	8530.30	4725.30	4696.80	6791.60	4352.90	4881.10
27	3458.60	7933.30	5486.40	4442.60	6095.00	4260.10	4343.80
28	3367.40	7825.80	4237.00	4463.60	5745.50	4647.30	4736.00
29	3323.10	7662.30	4648.00	4192.40	6351.00	4073.90	4267.50
30	3151.70	7571.20	4466.00	4261.50	6176.70	3711.10	3997.70
31	2794.10	7355.30	5017.60	4167.20	5729.80	3921.10	4637.30
32	2860.40	7334.00	4072.50	3869.40	5626.60	3586.60	3817.60
33	3116.40	6864.70	4262.10	3509.30	5831.00	3146.00	3689.90
34	3227.40	6197.70	4206.90	3434.70	5877.40	3509.60	3590.10
35	3099.60	6163.00	3974.50	2976.30	5223.30	3522.10	3753.60
36	3054.40	6282.10	4389.10	3547.60	5518.10	3757.30	3245.30
37	2402.60	6226.80	3789.10	3320.90	5714.50	3163.50	3854.60
38	2547.40	6339.10	4635.40	3749.10	5500.50	3542.20	3193.40
39	2620.90	6333.00	3614.00	3491.50	5142.90	3151.80	3320.70
40	2699.80	6150.00	4748.80	3363.00	5609.00	2708.90	3122.40
41	2654.60	5546.30	3952.70	3356.10	4790.80	3101.30	2730.10
42	2645.60	5384.90	5078.10	3279.00	5274.60	2765.40	2634.80
43	2581.10	5210.40	3873.70	3073.50	4546.10	2736.10	2558.30
44	2467.50	5474.50	4085.90	3183.90	5066.10	2926.50	2810.50
45	2244.20	4867.90	3137.60	2814.50	5097.30	2825.40	2341.90
46	2090.80	5141.30	3808.90	2868.70	4708.60	2610.70	2540.40
47	2186.40	4931.20	3890.40	2881.60	4688.20	2835.70	2582.20
48	2208.00	5484.10	3857.00	2810.60	5145.20	2556.00	2697.60
49	2144.80	5090.40	4913.60	2861.20	4739.00	2653.50	2525.90
50	1852.00	4820.80	4126.70	2950.20	5029.90	2360.20	2645.40
Peak	5950.00	15645.30	7285.20	8383.80	9104.50	8072.00	8617.00
AVG	3665.97	9295.25	5270.82	5075.72	6676.16	4979.88	5120.21

Rep # / Sub #	29	30	31	32	33	34	35
1	6914.30	8323.50	7214.70	7710.80	5467.20	7758.30	8704.00
2	7268.80	9209.60	7673.90	9234.80	6852.30	8532.40	8417.10
3	7430.20	9284.90	7453.10	8691.60	4981.40	8528.70	7816.30
4	7354.20	9772.30	7532.50	8594.40	5596.80	8259.90	7584.90
5	7115.10	9279.80	7420.20	7610.20	4965.80	8013.80	7784.10
6	7202.90	9529.60	7464.30	8440.50	5747.60	7573.70	7619.90
7	7119.50	9289.70	7095.10	7987.70	5241.40	7115.60	7516.90
8	7001.80	9202.20	7164.30	7809.70	5608.40	7316.10	7488.30
9	6882.50	8891.70	7039.70	7188.90	5907.00	7072.20	7202.90
10	6439.30	8567.90	7099.80	6865.90	5045.90	6819.80	6947.50
11	6627.70	8459.40	6921.80	6844.20	5613.20	6606.50	6727.70
12	6275.50	8301.00	6719.90	6730.90	4492.20	6941.60	6581.40
13	6071.30	7873.70	6612.60	6728.60	5035.10	6854.60	6226.60
14	5973.40	7423.10	6479.40	6271.40	4226.90	6511.10	5929.40
15	5797.10	7300.40	6468.50	5331.20	4312.50	6345.70	5801.00
16	5380.70	7227.20	6298.50	4727.30	4735.50	6461.80	5585.70
17	5370.60	7403.50	6006.30	3866.10	4855.00	6249.40	5519.30
18	5345.30	7121.50	5981.20	3658.80	4202.30	6117.50	5292.20
19	5128.50	6564.20	5719.20	3896.00	3985.70	5990.00	5102.20
20	4767.70	6115.50	5668.60	3535.90	3864.60	5439.30	4709.40
21	4669.90	6856.40	5771.80	3664.60	3994.40	5359.30	4747.10
22	4538.30	6587.80	5936.30	3624.90	4755.60	5409.20	4435.90
23	4555.50	6120.80	5856.70	3420.80	4673.10	5232.90	4202.20
24	4270.80	5970.20	5468.90	3513.60	4478.30	4909.60	4196.40
25	4116.30	5790.20	5331.70	4124.10	4729.80	5338.10	3989.80

Rep # / Sub #	29	30	31	32	33	34	35
26	3755.00	5968.20	5028.50	3459.60	4534.10	5014.80	3878.30
27	3507.10	5491.40	5510.70	3574.10	4278.50	4808.50	3555.00
28	3585.20	5669.50	5122.20	2775.80	4765.80	4397.90	3604.60
29	3380.00	5192.50	4917.60	3134.80	3935.00	4210.40	3412.50
30	3573.20	5050.20	4831.10	3345.90	4636.30	4216.80	3142.00
31	3705.00	4828.20	4650.50	3544.00	4503.20	4462.80	3027.20
32	3541.20	4703.50	4472.80	2969.90	4192.80	4549.70	2862.70
33	3253.70	4526.50	4317.40	2382.10	3933.90	4360.10	2971.10
34	3158.20	4354.90	4261.20	2512.80	3625.10	4270.10	2711.00
35	3009.80	4087.90	4080.80	3003.00	3876.40	4412.00	2750.50
36	2724.30	4164.10	3880.20	3699.10	3684.10	4776.90	2581.30
37	3105.70	3716.40	3880.90	1962.90	3539.90	4120.20	2714.00
38	3115.10	4266.10	3850.10	3175.60	4176.90	4395.40	2570.20
39	2975.00	3804.60	4084.80	2733.10	3699.50	3996.70	2641.50
40	2398.40	3716.10	3395.00	2482.40	3504.10	3660.00	2464.00
41	3027.90	3620.30	3414.40	2171.30	3762.10	3840.00	2577.50
42	2844.80	3309.90	3382.10	2428.50	3833.90	3693.20	2487.70
43	3053.90	3064.70	3383.90	2258.30	3784.10	3423.00	2433.40
44	3112.60	3135.00	3279.10	2320.10	3787.50	3801.10	2442.40
45	2464.90	3183.70	3082.30	2807.00	3711.90	3394.50	2395.80
46	1953.90	3138.60	3069.90	3422.50	3843.90	3441.00	2426.10
47	2810.80	3083.20	2987.50	2184.70	3068.00	3366.30	2473.10
48	2405.30	3084.30	2985.90	2749.70	3014.00	3767.70	2369.60
49	2988.50	2886.30	2992.30	2355.90	3027.20	3790.60	2595.40
50	2111.80	2981.30	2915.50	2950.20	3013.30	3629.40	2503.70
Peak	7430.20	9772.30	7673.90	9234.80	6852.30	8532.40	8704.00
AVG	4503.57	5949.87	5243.51	4409.52	4381.99	5371.12	4514.38

VITA

EDUCATIONAL INSTITUTIONS ATTENDED AND DEGREES AWARDED

Dankook University	Bachelor of Science (2006) Physical Education

PROFESSIONAL APPOINTMENT

2011-2012	Graduate Teaching Assistant: University of Kentucky Department of Kinesiology and Health Promotion
2010	Physical Education Teacher: Angok Elementary School, Ilsan, Gyung-gi do, Korea
2009	Physical Education Instructor: Leadergym Private Institution, Seoul, Korea
2006-2008	Reserve Officers Training Corps (R.O.T.C), Platoon Leader, and Battalion Staff Officer: Korean Army
2002-2005	Ski Instructor: Dae myung Vivaldi ski resort, Hong-chun, Korea
2002-2005	Class Teaching Assistant as a volunteer: Dankook University Department of Physical Education

FELLOWSHIPS AND AWARDS

2011-2012	Lyman T. Johnson Academic Year Fellowship, University of Kentucky Graduate School and the Kinesiology and Health Promotion Graduate Program, 2011

TEACHING EXPERIENCE

2011-2012	Graduate Teaching Assistant, University of Kentucky Course: KHP106; Beginning Tennis, KHP 133; Intermediate Tennis
2010	Physical Education Teacher: Angok Elementary School Regular Physical Education Classes

2002-2005 Class Teaching Assistant - Volunteer, Dankook University
Course: Tennis I, II, Tennis Instruction, Ski Instruction

RESEARCH EXPERIENCE

2011 - Current Graduate Thesis, University of Kentucky Department of Kinesiology and Health Promotion – Nutritional Intervention Study with Human Subjects (Title; The Effect of Acute Beetroot Juice Supplementation on Muscle Fatigue in Knee Extensor Exercise)

2012 - Current Laboratory Assistant, University of Kentucky Department of Kinesiology and Health Promotion, Cardiovascular Physiology Laboratory - Wetlab Experience; Basic wetlab skills, Mechanical testing of arteries by wire myograph system-620M (DMT, Skejby Science Center, Aarhus, Denmark), Histology sections by Cryostat (Leica CM 1850), Measurement of pulse wave velocity by ultrasound Vevo- 2100 (VisualSonics, Inc.)

ABSTRACT

LEE, S. Y, Abel, M. G; Thomas, D. T; Symons, T. B; and Yates, J. W (February, 2013). The Effect of Acute Beetroot Juice Supplementation on Muscle Fatigue in Knee Extensor Exercise. The Southeast Chapter meeting of the American College of Sports Medicine

LEE, S. Y, Abel, M. G; Thomas, D. T; Symons, T. B; and Yates, J. W (May, 2013). The Relationship Between Acute Inorganic Nitrate Supplementation and Muscle Fatigue in Knee Extensor Exercise. The National meeting of the American College of Sports Medicine, Approved.

ORAL PRESENTATION

LEE, S. Y (October, 2012). The Effect of Acute Beetroot Juice Supplementation on Muscle Fatigue in Knee Extensor Exercise. University of Kentucky Kinesiology and Health Promotion Department Exercise Science Seminar series.

POSTER PRESENTATION

LEE, S. Y (February, 2013). The Effect of Acute Beetroot Juice Supplementation on Muscle Fatigue in Knee Extensor Exercise. The Southeast Chapter meeting of the American College of Sports Medicine, Greenville, SC.

LEE, S. Y (April, 2013). The Effect of Acute Beetroot Juice Supplementation on Muscle Fatigue in Knee Extensor Exercise. The Spring Research Conference, University of Kentucky Boon Center, Lexington, KY.

LEE, S. Y (May, 2013). The Effect of Acute Beetroot Juice Supplementation on Muscle Fatigue in Knee Extensor Exercise. The 60th Annual Meeting and 4th World Congress on Exercise is Medicine of the American College of Sports Medicine, Indianapolis, IN.

CERTIFICATIONS

- American Red Cross Adult/Child CPR/AED and First Aid Certification issued by Aug 18, 2011
- South Korea, Ministry of Education & Human Resources Development,
  Certified Teacher; K-12 Physical Education; No. 100635 issued by Feb 16, 2006