THE EFFECTS OF A PRE-COOLING ICE SLURRY ON REPEATED SPRINT ABILITY IN RECREATIONALLY ACTIVE MALES

By

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A Thesis submitted in Partial Fulfillment of
the Requirements for the Degree of Master of Science in Exercise Science
to the office of Graduate and Extended Studies of
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ABSTRACT

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Abstract

The ability to produce consistently high average sprint time over a series of sprints separated by less than or equal to 60 seconds of recovery is vital for sports. Muscle and core temperature is a major contributor to fatigue. Precooling has shown to be and effective means of lower the body's core temperature. Purpose: The aim of this study was to look at the effect of an ice slurry beverage in a precooling protocol on peak sprint time, mean sprint time, RPE and fatigue index during a repeated sprint protocol (5 x 40m shuttle sprints with 30s of passive recovery). Fifteen healthy recreationally active °college aged 18- 24 males. A precooling protocol of 7.5g/kg of bodyweight either water or ice slurry administered over a 30 minute period in ten minute intervals. Following the precooling protocol subjects completed a 5x40m sprint protocol with 30s of passive recovery. RPE, core temperature and sprint time were all recorded after every sprint. There was no significant difference in sprint times ($p= 0.750$), RPE ($p = 0.588$) and core temperature ($p = 0.908$). There was a significant difference in pre- cooling core temperature between conditions ($p = 0.02$). Precooling protocol consisting of an ice slurry approximately 1°C was effective at lowering core temperature vs control condition. This did not yield any significant difference in sprint time, RPE or core temperature during the sprint protocol. Additional research is needed to exhibit the benefits of precooling during repeated sprints.

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Introduction

Sprint durations lasting less than or equal to ten seconds and brief periods of recovery are common in most team sports. The ability to produce consistently high average sprint time over a series of sprints separated by less than or equal to 60 seconds of recovery is vital for sports such as soccer. This has been termed as repeated-sprint ability (Girard et al 2015). Although sprint type activities only account for approximately 10% of the total distance covered in a game (C. Carling et al.,2011), improving repeated sprint ability should result in the improvement of physical performance in team sports like soccer (Bishop, D. J et al 2011). According to Mohr (Mohr et al, 2003) players on average perform 150 to 250 brief bouts of high intensity activity during a game. These brief bouts occur during crucial moments of the game for example chasing another player or scoring a goal. Players who can maintain a relatively high sprint speed throughout many bouts are more likely to perform better for an extended period of time. Motion analysis data has shown not only decrease of distance covered in the latter half of the game but also a decrease in mean speed at which the athletes moves. The amount of decline is also determined by the skill level of the athlete (C. Carling et al. 2011). This indicates an accumulation of fatigue during the later half of the game (stolen et al., 2005). According to Carling (C. Carling et al.,2011) bouts of high intensity in soccer games are usually paired with an active recovery period lasting less than 21 seconds of jogging or walking.

Understanding the specific movement patterns of a sport and the duration of work to rest periods allows for an understanding of the contributions of the energy systems. Oxidative phosphorylation contributes only less than 10% to total energy expenditure during a short sprint. When sprints are repeated the level of contribution from aerobic metabolism may increase to as much as 40% of the total energy supply during the final repetitions of repeated sprint training (Girard, O et al., 2011). Repeated sprint activities are associated with short duration sprints and short recovery periods. During a short bout of exercise there will be heavy dependence on phosphocreatine (PCr) degradation. In the period of rest following the bout there will be resynthesis in PCr. However, during the short rest intervals of repeated-sprint training there will be an incomplete resynthesis in PCr. This causes the increase in contribution from aerobic metabolism (Moir, G. L. 2015).

During repeated sprint activities fatigue is recognized by the decrease in peak power and decrease in mean or maximal sprint speed over a period of several sprints (Girard, O.2011). Muscle and core temperature have a noticeable effect on exercise and sport performance. Temperature of muscle and core can have different effects depending on the mode and duration of the exercise. Elevated muscle temperature enhances sprint performance after an active or passive warmup (Drust et al, 2005). Rising of muscle temperature can increase single sprint performance by possibly increasing PCr utilization during prolonged submaximal exercise. However, there will be an accumulation of lactate, elevation of the muscle temperature and core body temperature. An elevation in core body temperature may lead to increase in central nervous system fatigue and cardiovascular strain causing a decline sprint speed even after the first bout (D. Wendt et al 2007).

Many team- sports require sustained exercise performance in mid to high ambient temperatures during training and competition. Exercising or performing under high ambient temperatures or continuous sustained exercise results in a noted increase in core (T_{core}) and skin (T_{skin}) temperatures. As temperature rises, the metabolic and cardiovascular load increases and quickens neuromuscular fatigue (R. Duffield, 2007). It has been proposed that there is a critical body temperature that triggers voluntary fatigue in subjects regardless of different starting temperatures and the athlete's ability to regulate heat (D. Wendt, 2007).

Cooling methods have been not only utilized in high ambient temperature environments but also in thermo-neutral environments. During prolonged exercise the increase of body temperature is proportional to the rise of metabolic rate and demand of exercise. Regardless of heat acclimation or training state of the athlete, there is a common absolute heat storage limit. Given that there is a limit in heat storage capacity it would be advantageous to begin exercise at the lowest body temperature possible (F. E. Marino, 2002). A common method of cooling frequently investigated to improve sport performance is pre-cooling. Pre-cooling is used by many athletes and coaches to reduce body temperature prior to exercise by decreasing the onset of heat stress to improve performance (Siegel, R et al.,2012).

There are several common protocols of pre-cooling such as cooling packs and vests, cold room or air cooled, water application or cold water immersion and cold drinks. Regardless of the method the time prior to exercise and the length of time it takes to complete the protocol and achieve sufficient body cooling seems to be the most important factors. Factors like practicality of the protocol prior to an event or practice become more important when selecting a protocol (F. E. Marino, 2002).

Cooling packs and vests are easy to use on the field and are convenient for the athlete but also have potential disadvantages. Many vests and packs are not tailored for the specific athlete and may not offer proper heat transfer. Discomfort from the size and weight of the vest must also be considered and the cold temperature of the vest may cause thermal discomfort to the athlete. Ice vest and packs mainly cause a decrease in skin temperature (T_{skin}) which leads to skin vasoconstriction. Vasoconstriction reduces blood flow to the skin thus reducing the exchange of heat between the athlete and the cooling vest or pack. A proper cooling level or power will need to be established to produce the best result (N. Bogerd, 2010).

Cold air exposure is among the least practical protocols for field use as studies using this method indicate that cooling body temperature on average ranges from 40 to 130 minutes prior to exercise. This time can include a rewarming period to reduce thermal discomfort and shivering (F. E. Marino et al., 2002). Although cold air exposure has demonstrated to have a beneficial effect on performance, application of this protocol would be difficult in a sport setting being as time and proper facilities are required for this method to be effective.

According to Wegmann (M. Wegmann *et al.*, 2012) cold water or air applications has been shown to have the lowest percentage of improvement when compared to other protocols of pre-cooling. According to Siegel (Siegel et al., 2012) ice slurry ingestion did yield a higher core temperature of (0.28 ˚C) more compared to cold water or air. Ice slurry ingestion does not cause a significant decrease in skin or muscle temperature. An increase in skin and muscle temperature followed by a warm up and a decrease in starting core temperature prior to exercise allows for a theoretical maintenance of repeat-sprint performance after ingesting an ice slurry. Not requiring special equipment or facilities, ice slurry ingestion is the most practical means of pre-cooling (F.E Marino et al 2002)

Different methods of pre-cooling have been used to mitigate the effects of heat related fatigue. According to Wegmann (M. Wegmann et al., 2012), ice slurry yielded the highest percentage of improvement (15% relative). However, these effects were obtained in environments with high ambient temperatures or on a cycle ergometer. Limited studies have examined the relationship between repeated-sprint (running) ability and precooling in non-acclimatized athletes in thermo-neutral temperature (> 23˚C). No substantial effects on performance has been observed on heat acclimated athletes from precooling (Brade, C. J et al 2013). However, few studies have assessed the effects of pre-cooling methods such as ice slurry and water in a thermo-neutral ambient temperature on repeated sprint (running) performance.

Purpose

The purpose of this study was to investigate the effects of a precooling ice slurry on repeat sprint performance on non- acclimatized individuals. in a thermo-neutral indoor environment. The following variables were be collected for analysis mean sprint time, peak sprint time, and fatigue was measured using percent decrement. Additionally, physiological variables such as, rating of perceived exertion, and core temperature were also measured.

Null Hypothesis

There will be no statistically significant difference between the control, tepid water, and ice slurry for baseline core temperature.

There will be no statistically significant differences between the control, tepid water, and ice slurry for mean sprint time.

There will be no statistically significant differences between the control, tepid water and ice slurry for peak sprint time.

There will be no statistically significant differences between the control, tepid water and ice slurry for sprint core temperature.

There will be no statistically significant differences between the control, tepid water and ice slurry for rating of perceived exertion.

Limitations

1. The participants in the study dietary and exercise regimen were not regulated.
2. There is a possibility that the participants did not complete the sprint bouts with maximum effort.
3. Participants could have possibly paced themselves throughout the whole trial.

Delimitations

1. Participants in the study were 18- 24 years' old.
2. Participants were free of musculoskeletal injuries and / or surgeries 6 months prior and were all recreationally active.
3. All participants were students of East Stroudsburg University.

Operational Definitions

Pre- cooling – method of reducing body temperature before exercise.

Thermo - neutral temperature - (16- 23˚C)

Repeated Sprint- Short duration sprints of <10 seconds with interspersed recovery periods of (<60 seconds)

Ice Slurry- a beverage containing a mixture of ice, water.

Tepid Water – A mixture of cold and hot water rendering a temperature of 37 – 39˚C .

CHAPTER II

Literature Review

The purpose of this chapter is to highlight all of the important background data related to pre-cooling and repeat sprint ability. Specifically this chapter will focus on repeated sprint ability, mechanisms of fatigue, temperature, pre-cooling.

Regardless of the type of sport directly or indirectly, the ability to produce maximal short term effort is vital in many competitive sports (O. Girard et al., 2015). The ability to produce high average sprint performance over a series of sprints less than 10 seconds with less than or equal to 60 seconds of recovery has been termed repeated sprint ability (RSA). Most competitive sports require completion of these tasks during warm to hot ambient temperatures (25-45 ºC) (Duffield et al. 2007). Exercising in environments like these leads to an increase in the body core’s temperature, potentially decreasing performance (Wegmann et al. 2012). This is usually exhibited by a decreased time to exhaustion and or longer time – trial completion time (O. Girard et al., 2015). When an athlete’s core temperature is cooled prior to exercise or competition the performance decrement is counteracted (Bogerd et al. 2010). Pre- cooling is a method of reducing pre – exercise skin and or core body temperature (Duffield et al. 2007). There are several proposed mechanisms as to how precooling reduces heat stress and delays thermally induced fatigue. Many studies have shown beneficial effects of pre-cooling with a meta-analysis (Wegmann et al. 2012) finding a 4.9% increase on average in performance in the studies analyzed. Studies have shown a large effect in endurance based exercise and also to intermittent and repeated-sprint exercise to a smaller degree. Several authors have demonstrated a large reduction of peak and mean sprint power output in the heat leading to the increase in core temperature causing a decrease in performance (Girard et al., 2011), (Drust, Bishop et al., 2005)

Repeated sprint ability in sport

Repeated sprint ability is characterized as short duration sprints (less than ten seconds) interspersed with recovery periods of less than sixty seconds. The ability to recover and produce consistent sprint performance is an important fitness requirement for field team sports (Girard et al 2015). Repeated sprint ability is important in team sports but protocols and tests must accurately depict real in game movement patterns (C.Carling et al., 2012). Match analysis of soccer players has demonstrated varying movement patterns, speeds, sprint bout, recovery times and mode of recovery between them for the different positions played and level of skill (C. Carling et al 2012). On average players perform 150 – 250 bouts of high intensity activity less than ten seconds long (Mohr et al, 2003). Recovery between these bouts consisted of primarily walking. It is thought that repeated sprint ability can determine the final outcome of the game by influencing the ability to win possession of the ball or concede goals (Girard et al). Studies by Mohr et al, (2003) have shown that even when skill level is accounted for, high intensity activity decreases significantly during the second half of a soccer game suggesting a development of fatigue throughout the game.

Repeated sprint ability is measured using a variety of different testing methods and systems like shuttle runs, sprints, bikes and treadmills (Glaister et al., 2008). According to Shalfawi (Shalfawi, S. A. I. et al., 2012) most running repeated sprint measurements are done using photocell timing gates. The Brower Speed Trap II running speed timing system is among the most well documented in the literature (e.g. Caldwell & Peters, 2009; Coh, Milanovic, & Kampmiller, 2001; Ebben, 2008; Ebben, et al., 2008; Wisloff, et al., 2004). According to Shalfawi (Shalfawi, S.A. I. et al., 2012) the Brower Speed Trap II running timing system has been determined to be reliable measure of running sprint speed.

Mechanisms of Fatigue

Fatigue during repeated-sprint activity is characterized by a decrease in sprint time between bouts in a single session or a decrease in peak/mean power output (Bishop et al 2011). There are many contributing factors to fatigue during repeated sprint exercises such as phosphocreatine resynthesis (PCr) and H+ accumulation to fatigue from heat strain. A brief recovery time associated with repeated sprint exercises only allows a partial restoration of PCr which may be a determinant of sprint performance (B. Dawson et al.,1997). Repeated sprint performance may be improved by training protocols that increase rate of PCr degradation. Training methods such as 6 x 12 second bouts of sprint training with 60 second rest intervals have shown an improvement in the rate of rephosphorylation (D. Bishop et al.,2008). PCr is an important fatigue factor in repeated sprint ability during protocols with shorter rest intervals. During protocols with rest intervals of less than sixty seconds there is an incomplete resynthesis of PCr and more reliance in anaerobic glycolysis which explains a high accumulation lactate (TheBault N. et al).

The initial contribution of PCr is high during repeated sprint exercise but as rest intervals decrease and the number of bouts increases per a session there is an increase reliance in anaerobic glycolysis leading to the buildup of lactate (TheBault N. et al). In a previous study (Spencer et al, 2008) there was significant increase in lactate accumulation in the active recovery group study compared to the passive recovery group. The mode of recovery according to Mohr (Mohr et al, 2003) is typically active in nature consisting of walking or a light jogging during in game. Fatigue from lactate accumulation is associated with increase in acidosis from H+ in blood and muscle leading to the decrease in ATP from anaerobic glycolysis (Bishop et al, 2011).

The exact mechanism of fatigue caused by heat isn't exactly known. A possible cause of fatigue is caused by high muscle temperature. This may alter or damage structural proteins disrupting electrolyte distribution and mitochondrial respiration. It was also found that increase core temperature for a long duration increases central nervous system fatigue. This is caused by the increase in inhibitory signals by the hypothalamus. This alteration in muscle structure may also affect cardiac muscles and can influence the contractility of these muscles reducing stroke volume. This decrease in stroke volume results in ultimately a decrease in cardiac output. Another possible contributor to the decrease in stroke volume is the change in blood volume delivered back to the heart. The increase in core temperature had a direct correlation with the increase in heart rate (Gonzalez- Alonso et al 1999). The increase in heart rate and intern decrease in stroke volume may be caused by the decrease filling time during diastolic filling. It was discussed by(Nybo et al 2008) that an actual increase in performance can occur from a temporary increase in temperature in outer limbs. Stroke volume decreases by the increase in exercise volume, body position and heat stress. With the increase in heat stress, there is more blood perfusion towards the skin. During these conditions stroke volume is severely affected increasing fatigue accumilation.

Ambient Temperature

Core temperature has a noticeable effect on exercise and sport performance (B. Drust). Stress from heat is typically associated with a decreased time to exhaustion or longer completion of a time trial (O. Girard et al). Heat from skeletal muscle triggers major physiological mechanisms to dissipate heat to the skin and then to the outside environment. During exercise this process reverses, and heat transfers from muscle to blood and ultimately to the core. There are several mechanisms by which heat can be gained or loss: metabolism, radiation, conduction, convection and evaporation. Heat regulation and transfer is determined by a temperature gradient. During exercise sweat glands secrete sweat to the skin’s surface. This promotes heat loss by evaporating the water content from the sweat. The environment has a large effect on the rate of sweat loss and evaporation. In an environment with a temperature greater than or equal to 36º C the body gains heat by radiation and convection during rest. (Wendt et al. 2007).

Aerobic Fitness

Aerobic fitness has also been a determinant of thermoregulatory capacity (Hayes et al. 2014). Benefits acquired from aerobic fitness yield positive results for thermoregulation. Body composition plays a major role in heat production and thermoregulation. Athletes with a leaner body composition store more water by virtue of their lean body mass and low fat content. This increased muscle mass also coincides with increase glycogen stores and the water associated (Mora- Rodriguez et al 2012). Surface to mass ratio is another factor. This refers to the ratio of total skin surface area and total mass in an individual. Total mass acts like a “sink” to store heat during exercise. More body mass entails more stored body heat (Havinth et al 1998). Sweat is the primary mode of thermoregulation during exercise (Wendt et al. 2007). A smaller skin to mass ration means the rate of heat dissipation may be more difficult with higher mass but less skin surface area.

Movement Efficiency

Efficiency of a movement increases with prolonged training. Efficiency of running is defined by running economy This is primarily caused by fiber type adaptations. Trained athletes have a higher density of type 1 fibers compared to a non-trained athletes which are more metabolically efficient than type II fibers. It has been found that aerobically fit individuals experience greater core body temperature changes during high intensity bouts of exercise (smolijanic et al 2014) compared to unfit groups when matched for body morphology. During moderate intensity the effect is inverted favoring aerobically fit athletes and sweat response is often delayed during the onset of exercise. During moderate continuous exercise sweat response is often delayed longer for untrained than trained individuals. This is usually caused by the lower plasma volume found in untrained individuals. This has little effect on excessive heat accumilation and does not hinder heat equilibrium of dissipation and accumilation. Although during high intensity bouts coupled with short resting periods heat may accumulate and fatigue may accrue rapidly (Mora-Rodriguez et al 2012). Gait pattern of running differs greatly from walking. During human bipedal walking there is a constant alternation between potential and kinetic energy. Walking is done by vaulting over still limbs and turning gravitational potential energy into forward kinetic energy. During running limbs are primarily used as springs used to store and return muscular elastic energy. Muscles in the limbs conserve elastic energy, meaning the primary consumption of muscles during locomotion is the support of the individuals body mass. It can be deduced that the force used to support body mass is the primary determinant of metabolic cost of running (Farley et al 1992).

Airflow

Convection is another important factor of thermoregulation. Proper air flow is required to allow the sweat to evaporate properly into the surrounding environment (Mora- Rodriguez et al 2012). One study concluded that without proper airflow rehydration had nearly no effect on core temperature. This leads to a concern for individuals exercising indoors (Mora- Rodriguez et al 2007). It is even suggested that airflow may reduce thermal strain even in hypo hydrated individuals (Cheuvront et al 2004). Rehydration is effective only coupled with proper airflow in the exercise environment (Mora- Rodriguez et al 2007). Sweating is vital for cooling by means of evaporation. If airflow at minimum does not resemble outside conditions, sweat drips rather than evaporates resulting in no heat loss and heat accruing rapidly. At relative exercise intensities higher trained individuals train at an absolute higher workload than untrained individuals. Trained individuals for example may run at a faster pace and may experience more airflow. This is known as the differential air flow effect and should be considered in future studies (Mora- Rodriguez et al 2012).

Pre- cooling

Pre- cooling is a common method used by many athletes. The purpose of pre-cooling is to reduce the body temperature prior to exercise or competition. This will reduce heat stress and improve athletic performance (Wegmann et al. 2012). Heat from the environment or generated by the athlete causes increased core and skin temperature causing increased cardio-vascular and metabolic loads in addition to neuromuscular and endurance fatigue (Duffield et al). There are several effective methods of pre – cooling such as ice vests, ice packs, water immersion, air- cooling or cold drinks (Siegel et al). Selecting the most optimal pre- cooling method depends heavily on the circumstances of the ambient temperature, protocol, type of sport and many other factors (Wegmann et al., 2012).

Ice vests are among the most researched methods of pre-cooling. They have been found to be effective most with a mixed method. Typically paired with ice slurry ingestion approach with several cooling sites on the body (O. Girard et al., 2015). According to Marino (F.E Marino et al., 2002) ice vest cooling has been shown to reduce physiological and psychophysical pain and improve endurance performance on a cycle ergometer. In addition, Duffield (Duffield et al., 2003) has found a decrease in perception of participant’s thermal load. Ice vest or cooling jackets require ample time to prepare and cool athlete, prior to the event. Making it difficult to use them practically prior to an athletic event (Ross et al., 2013).

In addition to Ice jackets, water immersion is another common method of precooling. Marino (F.E. Marino et al., 2002) proposes a gradual decrease in water temperature during water immersion to ensure no physical discomfort. It is for this reason that water immersion precooling methods are the longest duration. Second only to air cooling in duration, water immersion is not a very practical means of precooling prior to an event or game (Wendt et al.,2007). Even with this disadvantage water immersion does have some significant advantageous. According to Wegmann (Wegmann et al.,2012) water immersion methods lead to rapid and large reductions of body core temperature. Another advantage is the rate of heat loss to water is two or four times greater than to air at the same temperature. This allows the skin to remain generally around water temperature creating a more uniform skin temperature (F.E. Marino et al., 2002). This rapid and large decrease in both core and skin temperature allows for a more positive perception of effort possibly enhancing willingness to maintain maximal effort sprints. Water immersion has been shown to improve subjective perception of recovery during a 5 x 40m repeated sprint protocol (Cook, Beaven, 2013). A possible factor in this is the common drop of core temperature after the precooling phase and before the onset of exercise (F.E. Marino et al.,2002). Although this method of precooling is effective, practicality and deciding on duration and temperature of water are always variables to consider when deciding a whole body precooling method (Wegmann et al.,2012).

Air cooling is a method that has been shown to greatly improve endurance based sport and training (Wegmann et al., 2012). Air cooling like water immersion also causes drop in core temperature after the precooling phase prior to the onset of exercise (F.E. Marino et al., 2002). Although air cooling has some similar advantages as water immersion with Wegmann (Wegmann et al., 2012) finding a 10.7% effect size being second only to cold drinks which had a 15% effect size. Air cooling is a far less practical means of cooling, requiring steady environmental conditions in an enclosed environment.

Variables like cost and time are major factors preventing practical use prior to an event or practice. Ice Slurry beverages seems to be the most practical means of precooling. Ingestion of an ice slurry does not have a direct cooling effect on the musculature unlike other precooling interventions and has major positive effects on performance similar to water immersion (Siegel et al.,2012). According to the results from Beaven (Beaven et al.,2018) ice slurries alone caused a minor decrease in initial sprint speed but increased fatigue resistance in a 5x 40m repeated sprint protocol. Ice slurry precooling method offers high practicality, convenience and a low time - to - effect.

Chapter III

Methodology

Subjects

This study was approved by the Institutional Review Board of East Stroudsburg University. Participation was voluntary and each participant underwent an orientation with written informed consent. The purpose of this study was to investigate the effect of an ice slurry precooling protocol on peak sprint time, mean sprint time, RPE , core temperature and fatigue index during a repeated sprint protocol (5 x 40m shuttle sprints with 30s of passive recovery). Thirteen healthy recreationally active college aged 18- 25 males volunteered to take part in the study. Table 1 below represents the characteristics of the participants (n = 13).

Table 1

Characteristics of the study participants

Characteristics (N= 13)	Mean ± SD	Minimum	Maximum
Age (years)	21.8 ± 2.0	19	25
Height (cm)	176.3 ± 6.4	165	185
Weight (kg)	82.7 ± 15.4	60.2	108.6

Protocol Overview

The repeated-sprint protocol was adapted and utilized by Impellizzeri et al. The participants attended a total of four sessions : (1) Orientation, consent form and familiarization protocol , (2-4) Randomized trials consisting of either Control, Water, Ice slurry. Control trial consisted of no consumption of any beverage. A Water trial consisting of consumption 7.5g/kg of mass of tepid water at approximately 37 degrees Celsius. The final trial consisting of the consumption of an ice slurry 7.5g/kg of mass. All subjects were required to complete all sessions in a randomized order with at least 3 days interspersed between trials. During each session excluding the first session all subjects were required to wear athletic clothing and were asked to either refrain from exercise for the past 24 hours prior to the session and had to be 3 hours post absorptive. Height and weight were all collected and recorded. During sessions (2-4) subjects were asked to be 3 hours post absorptive. Participants either refrain from consuming any beverage, water (7.5g per a kg of body mass) or slurry (7.5g per a kg of body mass) during the first 30 min of the session. Core temperature was measured using a tympanic thermometer every 10 minutes during the pre-cooling period. After 30 min precooling period subjects warmed up and began the repeated sprint protocol of 5 x 40m shuttle sprints with 30s of passive recovery between each sprint. RPE and Core temperature were measured after every sprint. Peak and mean sprint time were recorded and power output and percent decrement score were calculated. Trials were completed with a minimum of 3 days in-between sessions.

Session 1	Session 2-4
•Orientation •Consent •Familiarization trial	Control (no beverage) Water beverage Slushy beverage

Figure 1. Session Overview

Protocol Procedures

Session 1 participants reviewed and signed an informed consent document. Subjects were also informed on the purpose of the study and all procedures. Subjects were allowed to ask questions about any requirements that they were required to do. A Physical Activities Readiness Questionnaire (PAR- Q) was filled out by subjects to ensure that they did not have any prior conditions preventing them from participating. If any participants answered “yes” to any questions on page one, the subject was not allowed to participate. Subjects were also given written instructions for the following sessions which included procedures and requirements of the patient for remaining sessions. Subjects were asked to abstain from vigorous activity and caffeine 24 hours prior. All subjects were 3 hours post absorptive prior to every session. Demographic data of the subjects were collected which included age (years), height (cm) and body mass (kg).

Familiarization Trial

Session 1 also consisted of the familiarization trial. Participants were allowed to ask questions at any point during the trial to ensure complete understanding of the protocol. Participants were asked to complete a short dynamic warm up. The warm up consisted of a minimum of two lap jog totaling of 400 meters around an indoor track, this was coupled with short dynamic warm up assigned by the tester. The warm up consisted of various assigned warmup exercises such as lunges, leg swings, knee hugs, back pedaling, side shuffling and karaoke. Subjects were also allowed to do their own exercises. Those exercises had to be repeated for every subsequent trial. Following the warmup subjects began a trial of 3 maximum sprints. Measurements were required for the following trials to assure that subjects completed the sprints at a time of at least 90% of their maximum sprint time. If times were not met participants were asked to attend the session at the following week to ensure no pacing strategy. Timing gates were setup 40 meters apart with cones indicating to the subject how far. Subjects were instructed to be one meter from the starting timing gate and initiated protocol on three second countdown. Subjects had 30 seconds of passive recovery in between every 40-meter sprint. Rate of Perceived Exertion (RPE) and core temperature were recorded after every sprint. RPE was measured using the RPE (6-20) Borg Scale and core temperature was measured using an ear thermometer.

Experimental Trials

Sessions (2-4) consisted of experimental trials. All subjects were randomized and counterbalanced when assigned to a testing group in a specific order. Subjects arrived at the same time as their familiarization trial on the day of testing. Participants were asked to not engage in strenuous exercise prior to trials, to wear proper attire and to be 3 hours post absorptive. Once arriving to the lab participants were given a beverage or not according to a random protocol they were assigned. Participants were given 7.5g of water or ice slurry per a kg of body mass or nothing to consume during the 30-minute pre-cooling phase. They were also asked to remain seated and relaxed during entire pre-cooling phase. Core temperature was measured and recorded every 10 minutes during this phase. Following this phase the participants began their warm up of a minimum of two laps around an indoor track totaling 400 meters and the tester assigned a dynamic warm up. Warm up consisted of various assigned warmup exercises lunges, leg swings, knee hugs, back pedaling, side shuffling and karaoke. Participants were also allowed to do their own exercises. All exercises and routines that were used from the familiarization trial were repeated for experimental trials. Core temperature was then measured post warm up. The participants began the protocol one meter from the first timing gate with a three second countdown to begin the first sprint. Subjects began the protocol of 5 x 40m sprints that was used during the familiarization trial. Subjects were given 30 seconds of passive recovery in-between sprint bouts. During recovery time RPE was measured using the (6-20) Borg Scale and core temperature was measured using an ear thermometer.

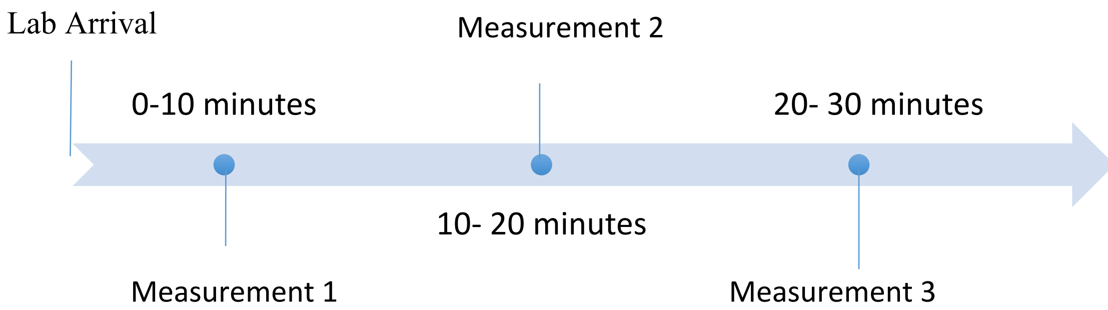

Figure 2. Precooling Protocol Overview

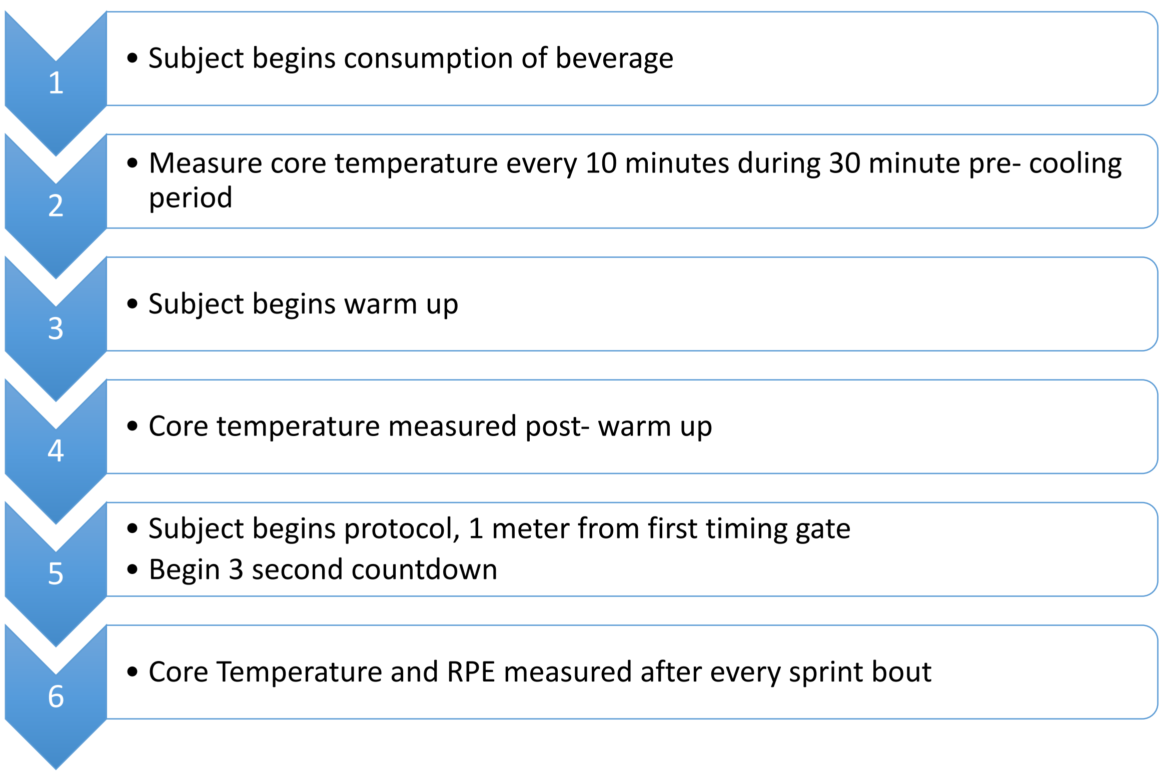

Figure 3. Sprint Protocol Overview

The inclusion criteria for this study consists of at least being recreationally active defined as participating in less than or equal to twice a week of aerobic activity for a total of 80 minutes at a moderate intensity. Participants were also free of any metabolic or heat related illnesses. Participants were also free of lower limb injuries within 6 months.

Statistical Analysis

Statistical analysis was performed using SSPS Version 24 for windows (SPSS., Chicago, IL). The means and standard deviation was calculated for all variables that were recorded during testing. A univariate analysis of variance (ANOVA) was used to determine a significant difference in baseline core temperature and sprint time. A two way ANOVA was done for sprint core temperature and RPE. A Bonferroni *post hoc* analysis was done for precooling temperature, sprint core temperature, RPE and sprint time to determine which conditions had a significant differences from another. Statistical significance was determined using a p-value of $p < 0.05$.

Chapter IV

Results

The primary purpose of this study was to investigate the effects of precooling (Ice slurry, water) on a repeated sprint running protocol: 5 x 40m on non-acclimatized individuals in thermo-neutral indoor conditions. This chapter presents data on the following: Mean baseline core temperature, mean sprint time, peak sprint time, sprint core temperature, sprint RPE, fatigue (% decrement).

Descriptive Analysis

The initial two – way ANOVA results for baseline precooling temperature was used to determine whether or not there was a significant difference in precooling temperature between any of the conditions. Table 2 below reveals the mean (SD) and change in temperature for each condition during the baseline precooling protocol. The mean and standard deviation for control, water and Ice Slurry w 36.68 ± 0.34, 36.62 ± 0.24 and 36.35 ± 0.29 respectively. There was a significant difference in baseline precooling core temperature between the control and ice slurry precooling protocol. Table 3 below shows the mean sprint time for each sprint for each condition. The three-way ANOVA did not reveal any significant difference in any mean sprint times for any condition. The mean sprint time for control , water and ice slurry were 5.83 ± 0.53, 5.77 ± 0.49 and 5.78 ± 0.44 seconds respectively. Table 4 below shows the peak sprint time average for all participants by condition. Peak sprint time like mean sprint time did not differ much among each subject. Peak sprint time was measured by choosing the fastest time for each subject. The mean peak sprint time for control was 5.69 ± 0.48, 5.66 ± 0.48 and 5.69 ± 0.44. Table 5 below shows the mean Rate of Perceived Exertion of all the participants for each condition. Rate of Perceived Exertion was recorded using the Borg's scale 6 – 20. The mean RPE for control, water and ice slurry 11.79 ± 3.18, 11.69 ± 3.33 and 11.32 ± 2.90. The three – way ANOVA did not find any significant difference between any condition. Although there wasn't a significant difference between RPE, there was a slight correlation showing the ice slurry condition being the lowest recorded RPE out of all the conditions.

Table 2

Baseline Core Temperature Measurements

	Condition								
	Control			Water			Ice Slurry		
Time (min)	Mean (˚C)	SD (±)	Δ Temp (˚C)	Mean (˚C)	SD (±)	Δ Temp (˚C)	Mean (˚C)	SD (±)	Δ Temp (˚C)
10	36.68	0.34	-	36.72	0.24	-	36.65	0.19	-
20	-	-	-	36.71	0.19	0.01	36.51	0.27	0.14
30	-	-	-	36.68	0.25	0.03	36.38	0.31	0.13
Total	36.68	0.34	-	36.62	0.24	0.04	36.35	0.29	0.27

Note * = Significant difference in temperature in Control compared to Ice slurry. $p < 0.05$

Table 3

Mean Sprint Time Results

	Condition					
	Control		Water		Ice Slurry	
Sprint	Mean (s)	SD (±)	Mean (s)	SD (±)	Mean (s)	SD (±)
1	5.83	0.55	5.83	0.48	5.83	0.45
2	5.82	0.56	5.72	0.47	5.73	0.43
3	5.88	0.57	5.74	0.49	5.78	0.46
4	5.84	0.49	5.77	0.49	5.79	0.45
5	5.78	0.48	5.77	0.51	5.76	0.40
Total	5.83	0.53	5.77	0.49	5.78	0.44

Table 4

Peak Sprint Time Results

	Condition		
	Control	Water	Ice Slurry
Mean (s)	5.69	5.66	5.69
SD (±)	0.48	0.48	0.44

Table 5

Rate of Perceived Exertion Results

	Condition		
	Control	Water	Ice Slurry
Mean	11.79	11.69	11.32
SD (±)	3.18	3.33	2.90

Ambient Temperature

Ambient temperature was measured using a weather station. All measurements were taken prior to the sprint protocol. All ambient temperature measurements are displayed below on table 6. Temperature measurements were consistent throughout all the repeated sprint protocols. Water had the highest average recorded humidity at

61.69% while the lowest average recorded humidity was Ice which was 50.54% humidity. All ambient temperatures were generally the same. There was some variation in humidity but not a noticeable difference with generally most trials measuring the same.

Table 6
Ambient Temperature Measurements

	Condition		
	Control	Water	Ice Slurry
Temperature (°C)	20. 48	20.77	20.87
Humidity (%)	51.77	61.69	50.54

Baseline Precooling Results

Baseline core temperature was measured every 10 minutes during the precooling protocol. Precooling protocol was a control condition, water condition which only consisted of tepid water and ice slurry condition consisting of an ice slurry containing only water and ice. Table 7 below displays the means of all subjects baseline core temperature by time interval and total baseline core temperature across all conditions. The baseline core temperature for control condition was 36.68± 0.34 ˚C. The mean baseline core temperature for water condition was 36.62± 0.24˚C. In contrast the ice condition had an average 36.35± 0.29 ˚C. Only one core temperature measurement was recorded for the control condition during the precooling protocol. Water condition shows a slight decrease in temperature over time whereas ice shows a significant decrease over time. The ice slurry precooling protocol resulted in a significant difference between the control condition and the ice slurry condition. The results of a the three way ANOVA displayed in Table 8 showed a significant difference in baseline core temperature (P= 0.021; f = 4.287). This significant difference between control and ice condition can be displayed below on Figure 4.

Table 7

Mean (SD) baseline precooling core temperature values for all conditions

	Conditions					
	Control		Water		Ice	
	Mean (˚C)	SD (±)	Mean (˚C)	SD (±)	Mean (˚C)	SD (±)
10 min	36.68	0.34	36.72	0.24	36.65	0.19
20 min	-	-	36.71	0.19	36.51	0.27
30 min	-	-	36.68	0.25	36.38	0.31
Total Mean	36.68	0.34	36.62	0.24	36.35	0.29

* Significant difference ice slurry condition ($p < 0.05$); ˚C = Celsius

Table 8

Baseline Precooling Core Temperature ANOVA Results

Tests of Between - Subjects Effects

Source	df	F	Sig.
Corrected Model	2	4.287	0.021
Intercept	1	614841.225	0
Condition	2	4.287	0.021
Error	36		
Total	39		
Corrected Total	38		

Note. * = Significance at 0.05 level

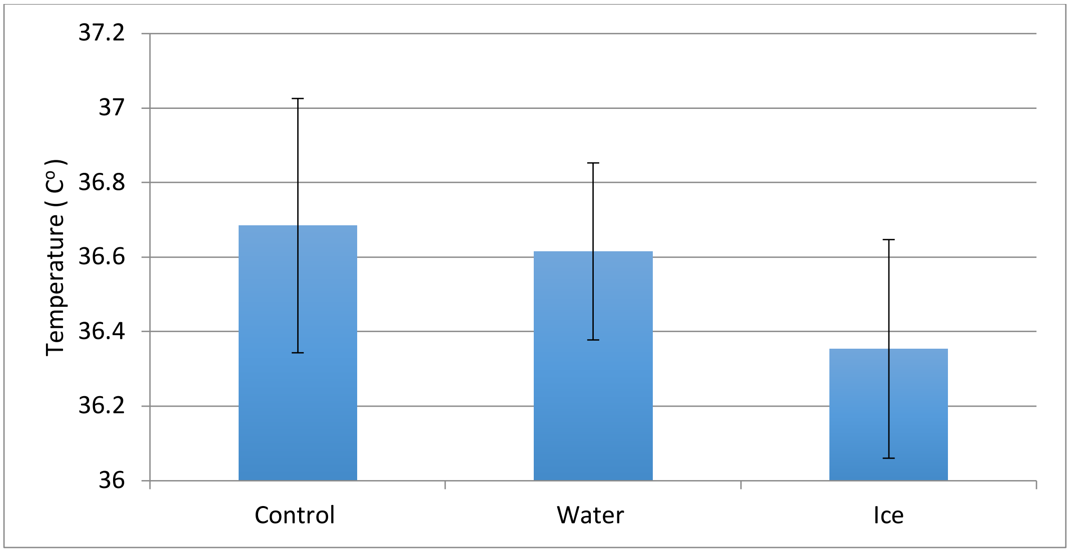

Figure 4. Mean baseline core temperature by condition

Sprint Protocol Results

There was no significant difference in sprint core temperature between any condition during the sprint protocol ($p = 0.908; f = 0.097$) which is displayed below on table 10. The mean sprint core temperature for control was 36.27 ± 0.44℃. The mean sprint core temperature for water was 36.25 ± 0.33℃. The mean sprint core temperature for ice slurry condition was 36.24 ± 0.37℃. Figure 5 below displays the mean sprint core temperature for each condition. Mean sprint core temperature was virtually the same across all conditions.

The ANOVA results for sprint time displayed below on table 7 showed no significant difference in sprint time between any condition ($p = 0.750; f = .288$). The mean sprint time for control was 5.83 ± 0.53s. The mean sprint time for water was 5.76 ± 0.47s. The mean sprint time for the ice condition was 5.79 ± 0.43s. Figure 6 below displays the mean sprint times by conditions. There was no significant difference in RPE between any condition (p = 0.588;f = 0.533) which is displayed below on Table 11. The mean RPE for control was 11.8 ± 3.2. The mean RPE for water was 11.7 ± 3.3. The mean RPE for Ice slurry was 11.3 ± 2.9. Figure 7 below displays all the mean RPE values of all subject by condition. The averages in Table 9 are post-dose (post precooling consumption) and were measured after every sprint bout. The measurements in Table 9 are averages of all the variables measured by condition. Like stated previously there was no significant difference between any of these variable among all conditions. There was a slight correlation found with RPE. Ice slurry condition had the lowest RPE value compared to control and water condition.

Table 9

Mean (SD) values for all conditions of all subjects per a variable

	Condition					
	Control		Water		Ice	
	Mean	SD (±)	Mean	SD (±)	Mean	SD (±)
Core Temp (°C)	36.27	0.44	36.25	0.33	36.24	0.37
Sprint Time (s)	5.83	0.52	5.76	0.47	5.79	0.46
RPE	11.7	3.1	11.7	3.3	11.3	2.9

Note. No statistical significance was found at the level of p < 0.05.

Table 10

Sprint Core Temperature ANOVA Results

Test of Between- Subjects Effects

Source	df	F	Sig.
Corrected Model	14	0.432	0.963
Intercept	1	1714411.381	0
Condition	2	0.097	0.908
Error	180	0.149	
Total	195		
Corrected Total	194		

Note. * = Significance at 0.05 level

Table 11

Sprint Time ANOVA Results

Test of Between - Subjects Effects

Source	df	F	Sig.
Corrected Model	14	0.114	1
Intercept	1	27509.423	0
Condition	2	0.288	0.75
Error	180		
Total	195		
Corrected Total	194		

*Note. * = Significance at 0.05 level*

Table 12.

Rate of Perceived Exertion ANOVA Results

Test of Between - Subjects Effects

Source	df	F	Sig.
Corrected Model	14	8.297	0
Intercept	1	4141.551	0
Condition	2	0.533	0.588
Error	180		
Total	195		
Corrected Total	194		

*Note. * = Significance at 0.05 level*

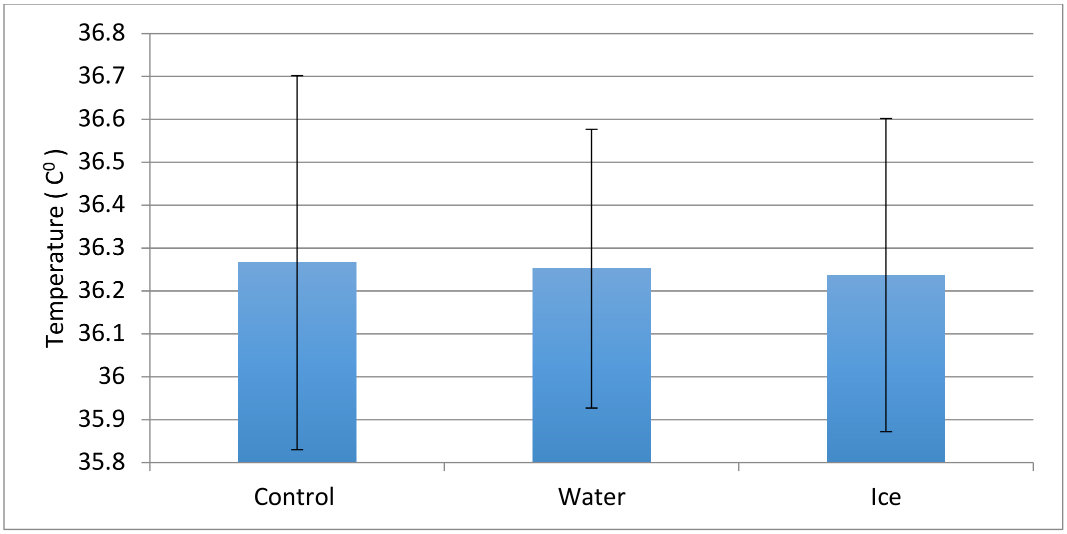

Figure 5. Mean Sprint core temperature by condition

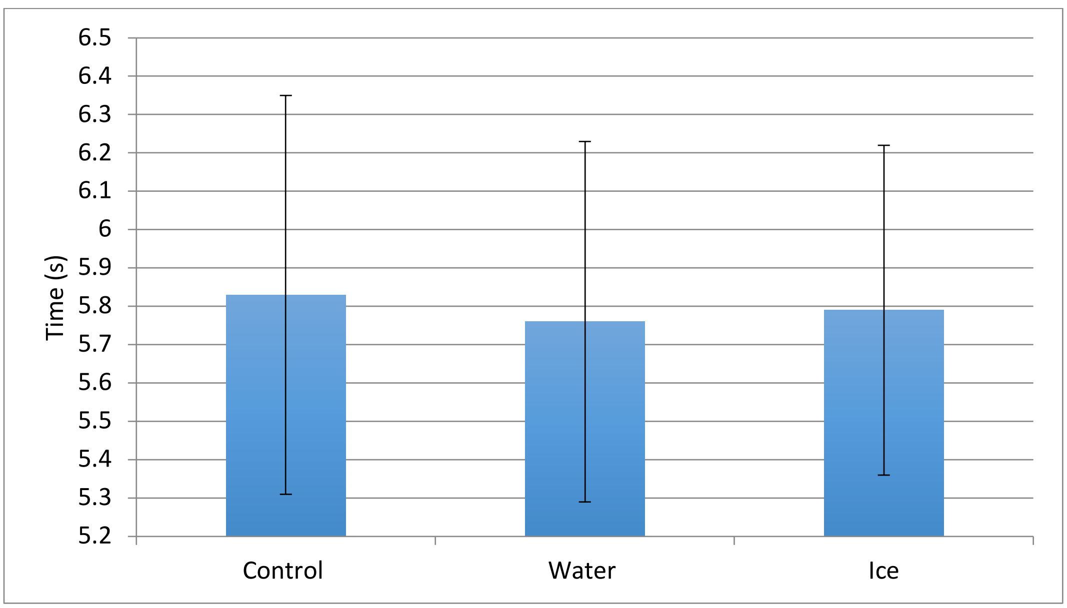

Figure 6. Mean Sprint time by condition

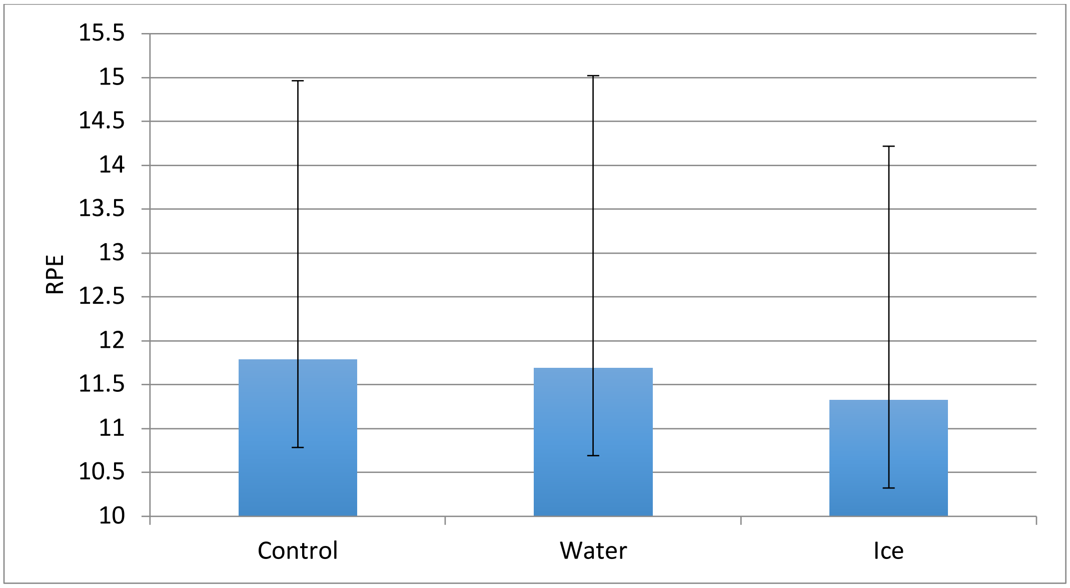

Figure 7. Mean Rate of Perceived Exertion by condition

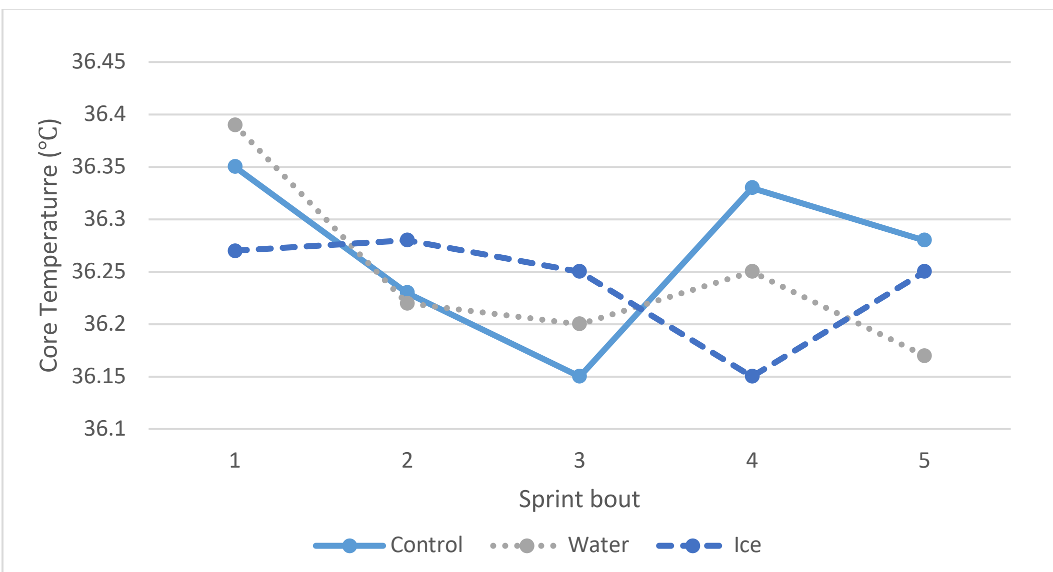

Figure 8. Mean core temperature by sprint bout

Figure 8 displays the mean core temperature of all the subjects for each sprint bout of all condition. Water both had the highest average core temperature (36.39 ± 0.24) for the first sprint, and the lowest recorded 5th sprint temperature of (36.17 ± 0.37). Ice condition had the lowest starting temperature (36.27 ± 0.39), but did not have the lowest recorded temperature for the last sprint (36.25 ± 0.44). Control condition had an average first sprint core temperature of (36.35 ± 0.49), control condition also had the highest 5th and final sprint core temperature of (36.28 ± 0.44).

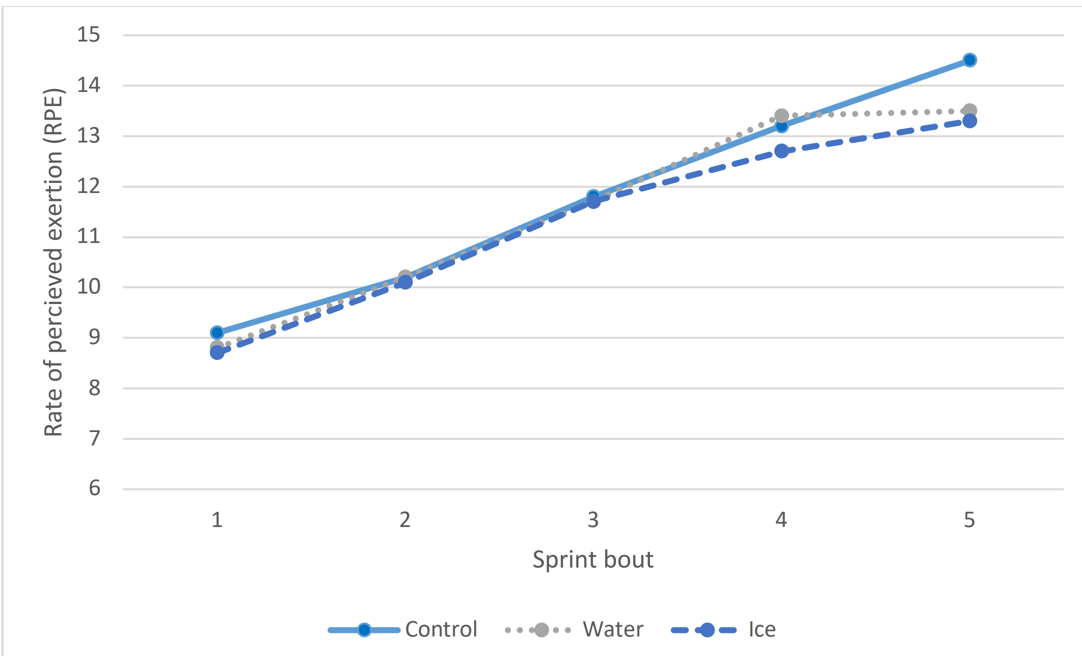

Figure 9. Mean RPE by sprint bout

Figure 9 shows the average RPE of all subjects for each sprint bout of all condition. Control had both the highest RPE average for both the first and last sprint of (9.1 ± 2.36, 14.5 ± 2.86). Water had an average RPE of (8.8 ± 2.42) for the first sprint and an average of (13.5 ± 2.93) for the final sprint. Ice condition did have the lowest recorded RPE for the first and last sprint (8.7 ± 1.49, 13.3 ± 2.93).

Table 13

Peak and Mean Sprint Time Results

	Condition					
	Control		Water		Ice Slurry	
Participant	Peak	Mean	Peak	Mean	Peak	Mean
1	5.11	5.20	5.08	5.16	5.24	5.29
2	5.77	5.87	5.77	5.90	5.82	6.01
3	5.49	5.63	5.58	5.70	5.66	5.72
4	5.35	5.42	5.29	5.39	5.33	5.42
5	6.11	6.48	5.68	5.79	5.61	5.80
6	6.77	6.93	6.85	6.90	6.78	6.83
7	5.40	5.64	5.54	5.60	5.58	5.69
8	5.71	5.79	5.75	5.89	5.78	5.84
9	5.48	5.54	5.34	5.47	5.35	5.48
10	6.49	6.62	6.34	6.49	6.37	6.44
11	5.49	5.62	5.41	5.49	5.50	5.65
12	5.50	5.60	5.67	5.83	5.55	5.64
13	5.35	5.44	5.23	5.30	5.41	5.48

Note* Figures were rounded to two significant figures.

Table 14

Peak Sprint Time (Percent Decrement)

	Condition		
Participants	Control	Water	Ice Slurry
1	5.11 + 1.80	5.08 + 1.65	5.24 - 1.07
2	5.77 + 1.69	5.77 - 2.46	5.82 - 3.29
3	5.49 - 2.55	5.58 - 2.37	5.66 - 1.06
4	5.35 - 1.27	5.29 - 1.85	5.33 + 1.68
5	6.11 + 3.62	5.68 - 1.87	5.61 - 3.53
6	6.77 - 2.30	6.85 - 0.67	6.78 - 0.77
7	5.40 - 4.40	5.54 - 1.19	5.58 + 1.97
8	5.71 - 1.40	5.75 - 2.40	5.78 - 0.96
9	5.48 - 1.02	5.34 - 2.35	5.35 + 2.50
10	6.49 - 2.06	6.34 + 2.40	6.37 + 1.13
11	5.49 + 2.40	5.41 - 1.44	5.50 + 2.80
12	5.50 + 1.81	5.67 + 2.79	5.55 + 1.55
13	5.35 + 1.68	5.23 + 1.40	5.41 - 1.29

Note * Figures were rounded to 2 significant figures

Table 13 above shows the mean peak and mean sprint time for each subject. Several participants listed in table 13 increased in speed over time during the trial. This explains the close values between peak and mean sprint time. Table 14 shows the peak with percent decrement. The change in the time showed on table 14 indicates either an increase or decrease in sprint time. Subject 5 showed the greatest change in sprint time for the control condition. Subject 3 and 10 showed the greatest change for the water condition. Subject 5 again showed the greatest change in sprint time during the ice condition and was among six other subjects which experienced a progressive decrease in sprint time during the 5 sprint bouts. Subject 9 experienced the smallest change in time during the control condition. Subject 6 had the lowest change in sprint time during the water condition and subject 1 had the lowest change in sprint time during the ice condition.

Percent Decrement = (100 × (total sprint time ÷ ideal sprint time)) − 100

where Total sprint time = Sum of sprint times from all sprints.

Ideal sprint time = The number of sprints × fastest sprint time. (Glaister et al 2008)

Chapter V

Discussion and Conclusion

The purpose of this study was to investigate the effect of an ice slurry precooling protocol on peak sprint time, mean sprint time, RPE, core temperature and fatigue (% decrement) during a repeated sprint protocol (5 x 40m shuttle sprints with 30s of passive recovery). Thirteen healthy recreationally active college aged 18- 24 males volunteered to take part in the study.

Precooling Protocol

The main finding of this investigation was a significant difference in core temperature (P=0.021) between control and ice condition during the pre-cooling protocol. Repeated sprint performance saw no significant differences between control and ice conditions. There were also no significant differences between any condition for core temperature and RPE. Similar results were found in (Brade et al 2013) which also found a significant decrease in core temperature but also found no difference in sprint performance. The pre-cooling protocol for this study was ingestion of an ice- slurry for a total of 30 minutes in 10 minute increments with core temperature being measured every increment. Several studies have found ice slurry in combination with a cooling vest such as (brade et al 2014) significantly improved performance. Studies like this consisted of exercise protocols with total exercise duration lasting up to 30 to 40 minutes. Average exercise core temperatures for all conditions were virtually the same (36.2 °C) with minor variations (Control 36.27°C, Water 36. 25°C, Ice 36.24°C). A possible conclusion from this data is the precooling protocol was effective for only a short duration. Precooling with an ice slurry in conjunction with a cooling vest has been found to be effective with inclusion of cooling during the exercise protocol (Brade et al 2014, Bogerd et al 2013). The longer duration of low core temperature can possibly be attributed to the cooling during the exercise protocol maintaining the low core temperature throughout the protocol (Bogerd et al 2013). Ice slurry method has been found to be highly effective at dropping core temperature very rapidly compared to methods such as the ice vest or cold water immersion but without the reduction in skin temperature. This causes a rapid rise of core temperature compared to an ice vest or water immersion due to the high temperature gradient of core and skin temperature (James et al 2015). It may be suggested that precooling with only an ice slurry will elicit the greatest effect immediately prior to an exercise bout. The combination will lower not only core but skin temperature as well, increasing the total heat capacity of the body. The combination of an ice slurry and an ice vest would possibly lower core temperature for a greater amount of time.

Exercise Protocol

A consideration for the results of the study is the amount of heat strain on the subjects from the exercise protocol. It is possible that even though core temperature did decrease during the precooling protocol. This was noticed in (Duffield et al 2007) during an intermittent sprint protocol consisting of 15m sprint bouts interspersed with sub-maximal exercise. This study consisted of 5x40m sprints with 30s of passive recovery. It is assumed that a greater sprinting distance and amount of sprints would increase heat strain significantly. It can be assumed an increased distance of forty meters would cause a greater physiological heat strain than fifteen meters. Although 40 meters would yield greater strain, five consecutive sprints may not allow a significant development of heat strain for a noticeable difference in performance. An important consideration is the difference between self- paced endurance protocol and a time-trial. Ice slurry intervention seemed to have little effect on perceived thermal strain with RPE averages being similar across all conditions. Studies like (Duffield et al 2010) noted that perceived thermal strain affect the voluntary exercise intensity. It may be possible that the reduction in exercise performance can be derived from sensory feedback of thermal strain.

Ambient environment

A considerable amount of energy is wasted through heat to the ambient environment. During exercise core temperature and skin temperature increases further decreasing the gradient between the subject and the environment (Ross et al 2013). The exercise protocol in this study was done in an indoor environment allowing consistent environmental conditions throughout the whole study. Effective heat dissipation only occurs when there is a properly high enough gradient to elicit heat loss from the body to the ambient environment. The consistent low ambient indoor temperature may have had a negative effect on performance. It is suggested in (Bongers et al 2014) that precooling and other cooling methods may only be effective in ambient temperature >30°C.

Fatigue

Fatigue in this study was calculated using the percent decrement formula. It was concluded by (Glaister et al 2008) that percent decrement formula gave the most accurate measure among other formulas and provided the best means of quantifying fatigue in this type of activity.

Percent Decrement = (100 × (total sprint time ÷ ideal sprint time)) − 100

where Total sprint time = Sum of sprint times from all sprints.

Ideal sprint time = The number of sprints × fastest sprint time. (Glaister et al 2008)

Percent decrement measurements in this study don't necessarily represent a steady decline in performance. Several subjects showed steady increase in performance during the (5x 40m repeated sprint protocol with 30 seconds of passive recovery). Regardless of the improved performance for several subjects in varying precooling conditions measurements of RPE still suggests accumilation of fatigue. Some subjects experienced a significant increase in power output during the final sprint. Subject 7 experienced a significant improvement in sprint time during the final sprint. Subject 7 had the highest percent decrement value but showed the greatest improvement throughout the sprint bouts. Subject 5 experienced their peak sprint time during their first sprint bout, and experienced their slowest time during the third sprint.

Practical Application

The ice slurry protocol is among the most practical and convenient methods of precooling. There was a significant difference in baseline precooling core temperature between the control and ice slurry conditions. Control and water conditions had a mean baseline core temperature of 36.68, 36.62℃ respectively with ice slurry condition being 36.35 ℃ respectively. This finding has a direct practical application to the development and implementation of precooling strategies. The results show some evidence of efficacy of an ice slurry protocol. Control and water condition had a mean RPE 11.79, 11.69 respectively with ice slurry condition being 11.39. Although there was no significant difference in RPE found in the ANOVA the addition of more subjects may have shown a significant difference. This exhibits evidence of a reduction in perceived thermal stress. Although some subjects in the ice slurry protocol did show improvement in sprint time, there was also improvement throughout all the conditions. This can be mitigated by the inclusion of additional sprints and the ignorance of the amount of sprints for the participant. The addition of a proper measurement of exercise strain and fatigue such as heart rate would aid in assuring this result. This finding can help increase the prevalence of an ice slurry protocol during an exercise regimen or sport game.

Future Recommendations

The purpose of this study was to investigate the effects of an ice slurry on a repeated sprint running protocol (5 x 40m, 30 seconds of passive recovery) on recreationally trained males. Participants were asked to abstain from caffeine and vigorous exercise 24 hours prior to each trial. Participants were asked also to be 3 hours post absorptive prior to each trial. Although some measures were taken to ensure consistency of results it is recommended that recording participant consumption outside of laboratory time could have led to more consistent results. A food diary and a more regimented eating plan and schedule may have mitigated this variable.

A total of 13 participants were recruited for the current study. The results did show some trends such as RPE. The amount of subjects recruited could have affected this result. Additional subjects may have resulted with a significant difference for rate of perceived exertion. There was some improvement in sprint time found in the ice slurry condition and other conditions. The addition of more subjects may have resulted in a significant difference in sprint time and or fatigue decrement.

The current study consisted of 5 x 40m sprint protocol with 30s of passive recovery. This protocol compared to other protocols found may not have induced enough heat accumilation to elicit fatigue for the participants. It would be recommended then to add more sprint bouts for the exercise protocol to induce more fatigue. Pacing with this sprint protocol is also something to consider. The participants knowing the protocol was only five sprints could have paced themselves during the initial sprints and later improved during the subsequent sprints. This would explain the actual improvement of sprint time during the later sprints during the exercise protocol. Future studies will have to consider withholding this information from the participant to ensure maximal effort through every sprint bout. Rate of perceived exertion is only one subjective measurement for fatigue. Proper measurement of the participants heartrate could have also shown possible pacing issues. It would have also been another metric in order to measure the degree of fatigue for the participants.

Conclusion

The purpose of this study was to investigate the effects of an ice slurry on a repeated sprint running protocol (5 x 40m, 30 seconds of passive recovery) on recreationally trained males. It has been shown in this study that an ice slurry precooling protocol is an effective means of lowering core body temperature prior to exercise and made a significant difference in baseline core temperature. Although precooling was effective at lowering core temperature it had virtually no effect on sprint measurements in this study. Several considerations include a lack of properly trained males, exercise protocol chosen and a thermal neutral environment. The lack of sprint trained males and low number of sprints with the inclusion of pacing may contributed to the improvement of sprint velocity during subsequent sprints. This has a caused the data to not show a proper decrement in fatigue and therefore are incapable of establishing if any affect occurred from the precooling protocol. The exercise protocol selected was a 5 x 40m sprint protocol with 30 seconds of passive recovery. This protocol although simulates an athletes distance and recovery time during a sport event, it may not have had such a great effect on core temperature to elicit fatigue. Lastly the ambient environment chosen was a thermal neutral environment of ~20 ℃ with ~ 55% humidity. This temperature and humidity combination may not have contributed enough to the increase of core temperature and thus did not show the beneficial effects of the precooling protocol selected. Ice slurry precooling protocol may still have beneficial effects to sport and exercise performance but more research is required.

APPENDIX A

East Stroudsburg University Institutional Review Board
Human Research Review
Protocol # **ESU-IRB-070-1819**

Date: **July 15, 2019**
To: **Matthew Miltenberger and Henry Castejon**
From: **Shala E. Davis, Ph.D., IRB Chair**
Proposal Title: **"Effects of Ice Slurry Beverage on Recreationally Active Adults during a Repeated Sprint Protocol"**

Review Requested:	Exempted	Expedited **X**	Full Review
Review Approved:	Exempted	Expedited **X**	Full Review

FULL RESEARCH

___ Your full review research proposal has been approved by the University IRB (12 months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your full review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your full review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit.

EXEMPTED RESEARCH

____ Your exempted review research proposal has been approved by the University IRB (12 months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your exempted review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your exempted review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit, if appropriate.

EXPEDITED RESEARCH

__X_ Your expedited review research proposal has been approved by the University IRB (12months). Please provide the University IRB a copy of your Final Report at the completion of your research.

____ Your expedited review research proposal has been approved with recommendations by the University IRB. Please review recommendations provided by the reviewers and **submit necessary documentation for full approval.**

____ Your expedited review research proposal has not been approved by the University IRB. Please review recommendations provided by the reviewers and resubmit, if appropriate.

Please revise or submit the following:

APPENDIX B

Informed Consent

Effects of Ice Slurry Beverage on Recreationally Active Adults during Repeated Sprint Protocol

1. Henry A. Castejon, who is a student in the Exercise Science Master's Degree Program, has requested my participation in a research study at East Stroudsburg University. The title of the research is: Effects of Ice Slurry Beverage on Recreationally Active Adults during Repeated Sprint Protocol.

2. I have been informed that the purpose is to examine the effects of ice slurry pre-cooling on a repeated sprint running protocol (5 x 40m, 30 seconds of passive recovery).

3. My participation in this study will involve ingesting an ice slurry and water for 30 minutes prior to the repeated sprint protocol. I will participate in a familiarization protocol consisting of 3 maximal sprints. During the next three visits of experimental protocols I will be participating in all three, ingesting either an ice slurry, water or nothing prior to starting a 5x 40 meter repeated sprint protocol with 30 seconds of recovery.

4. I understand that there are foreseeable risks or discomforts to me if I agree to participate in the study. The possible risks include muscle soreness, muscle strains, and the possibility of other minor musculoskeletal injuries during or after the exercise protocols.

5. There are no feasible alternative procedures available for this study.

6. I understand that the possible benefits of my participation in this research include learning my sprint time and power output during running repeated sprint. I will also be aiding the researcher in investigating more about pre-cooling protocols and whether or not it improves athletic performance.

7. I understand that the results of the research study may be published but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Henry A. Castejon will provide me with a subject code and that will be the only way data will be identified. I also understand Henry A. Castejon and the thesis chair will be the only people with accesses to any confidential records.

8. I have been advised that the research in which I will be participating does not involve more than minimal risk. The only foreseeable risk of injury is musculoskeletal in nature

and can be handled by either the University Health Center or a Certified Athletic Trainer. Due to athlete and student status all subjects have access to a certified athletic trainer, access to the university health center located on campus, and access to Pocono Medical Center adjacent to the university.

9. I have been informed that I will not be compensated for my participation.

10. I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by Henry A. Castejon or Matthew Miltenberger, thesis chairperson, 200 Prospect Street, East Stroudsburg Pa, 18301, Office #5 Koehler. mmiltenber@esu.edu

11. I understand that in case of injury, if I have any questions about my rights as a subject/ participant in this research, or if I feel I have been placed at risk, I can contact the Chair of the Institutional Review Board: Dr. Shala Davis at 570-422-3336, East Stroudsburg University.

12. I have read the above information. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me.

Subject's Signature __________________________ Date ________________

13. I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with the participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

14. I have provided the subject/ participant a copy of the signed consent document.

Signature of Investigator __________________________ Date _______________

THIS PROJECT HAS BEEN APPROVED BY THE EAST STROUDSBURG UNIVERSITY OF PENNSYLVANIA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS

APPENDIX C

DATA COLLECTION SHEET

Participant Name:________________ Age:_____ Height (cm):_____ Weight (kg):_____

Precooling	Control	Water	Ice Slurry
10 Min			
20 Min			
30 Min			

Sprint Core Temp	Control	Water	Ice Slurry
S1			
S2			
S3			
S4			
S5			

Sprint	Familiarization
S1	
S2	
S3	

Sprint RPE	Control	Water	Ice Slurry
S1			
S2			
S3			
S4			
S5			

Sprint Time	Control	Water	Ice Slurry
S1			
S2			
S3			
S4			
S5			

APPENDIX D

2019 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ______ DATE ______

SIGNATURE ______ WITNESS ______

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

11-01-2018

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