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Effects Of Warm-Ups On Time Trials For Elite Ncaa Division I 800-Meter Middle Distance Runners: Establishing A Priming Warm-Up For Optimum Results In A Peak Performance

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Effects of warm-ups on time trials for elite NCAA Division I 800-meter middle distance runners: Establishing a priming warm-up for optimum results in a peak performance

By

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middle distance runners: Establishing a priming warm-up for

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This study utilized an experimental design testing low, medium, and high intensity warm-up protocols for NCAA Division I 800-meter male and female middle distance runners to determine which result in optimal outcomes in a peak performance, i.e., 800-meter time trial. Mississippi State University student athletes on the Track and Field Team who compete in middle distance running events participated. Among males, results of the repeated measures ANOVA found no significant difference among the three warm-up protocols for the first 400 meters completed. For females, repeated measures ANOVA results found no significant difference among the protocols for the first 200 meters completed. However, at the completion of the 800-meter time trial, a statistically significant difference ($p < 0.05$) was seen among both males and females; post hoc analyses indicated that the high intensity warm-up group had a statistically significantly lower (i.e., better) total time than the low intensity warm-up group.

DEDICATION

I would like to dedicate this document to my family as follows, my father, mother, my children, my spouse, and my siblings.

ACKNOWLEDGEMENTS

I would like to thank the Mississippi State University Coaching Staff, Training Staff, and athletes who were involved with this study. I would also like to thank my committee members; Dr. Benjamin Wax, Jr., Dr. John Bradley Vickers, and Dr. Andreas N. Kavazis for their constructive feedback and assistance in completing my thesis research.

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CHAPTER I

INTRODUCTION

An active warm-up creates physiological changes that are important in preparing the body for the intense exertion to follow (Bishop, 2003). Some of these physiological changes include increased heart rate and muscle temperature and changes in oxygen kinetics and the energy system. Likewise, adequate recovery is equally important to restore the body for subsequent exertion (Tomlin & Wenger, 2001). An adequate warm-up can also help prevent injury (Woods, Bishop, & Jones, 2007). However, minimal research has examined what types of warm-ups can work best for specific types of athletes (Fradkin, Zazryn, & Smoliga, 2010). Thus, warm-up protocols utilized by coaches and athletes are often based on "trial and error experience of the athlete or coach, rather than on scientific study" (Bishop, 2003, p. 484).

One athletic arena where optimal warm-ups need to be identified is middle distance running. Middle distance running events range from 800 to 3000 meters and typically take 2 to 10 minutes to complete (Brandon, 1995). A recent study by Ingham, Fudge, Pringle, and Jones (2013) comparing high and low intensity warm-ups among 800-meter runners concluded that while a high intensity warm-up can improve performance, the physiological elements accounting for enhanced performance were not clear.

Therefore, to determine optimal warm-up techniques, the specific physiological changes that occur to account for performance must be identified (Endo, Usui, Fukuoka, Miura, Rossiter, & Fukuba, 2004). As Bishop indicated (2003), "future studies need to develop their warm-up protocols on a sound physiological rationale, rather than merely replicating commonly used warm-up procedures" (p. 496). Research must be broader in the overall scope of components being tested (e.g., assessing more than only one or two physiological elements) as well as the techniques utilized (e.g., warm-up activities that are clearly connected to the particular sport).

In another study, Fradkin et al. (2010) reported

> As evidenced through studies evaluating multiple variations of similar warm-up protocols, the wide variation in results may be attributable to the specifics of the warm-up practices employed…This emphasizes the need for continued research to determine which methods of warm-up are best for a given sport or activity. (p. 146)

Therefore, the purpose of this study was to identify a warm-up protocol for NCAA Division I 800-meter male and female middle distance runners that results in optimal outcomes in a peak performance, i.e., 800-meter time trial.

CHAPTER II

LITERATURE REVIEW

Warm-ups are critical in preparing athletes for intense exertion and optimum performance and helping to prevent injury (Bishop, 2003; Woods et al., 2007). Adequate recovery is just as important in restoring the body prior to subsequent exertion (Tomlin & Wenger, 2001). Warm-ups essentially fall into one of two categories – passive or active. Bishop (2003) explained:

> Passive warm-up involves raising muscle temperature or core temperatures by some external means (e.g., hot showers or baths, saunas, diathermy and heating pads). Active warm-up involves exercise and is likely to induce greater metabolic and cardiovascular changes than passive warm-up. (p. 484)

Active warm-up is more common than passive warm-up (Bishop, 2003). An active warm-up typically involves light jogging, stretching, and/or event-specific exercise that prepares the body for physical exercise or performance (Fradkin et al., 2010).

Components of active warm-ups

Stretching helps to enhance performance and reduce the risk of injury through improving flexibility or range of motion (McMillian, Moore, Hatler, & Taylor, 2006). Two types of stretching that are traditionally included in warm-ups are described as static or dynamic. Static stretches focus on moving a limb to the full extent of its range of motion and then maintaining that position for 15-60 seconds (Young & Behm, 2002). Dynamic stretches consist of controlled movement through the full range of motion for joints (Fletcher & Jones, 2004).

For years, static stretching was included as a standard element in warm-ups (Young & Behm, 2002). However, when studies began to report impairments in performance resulting from static stretches, dynamic stretching became preferred in warm-ups (Behm & Chaouachi, 2011; Fletcher, 2010). Given these conflicting findings, Behm and Chaouachi (2011) reviewed literature on the impact of static and dynamic stretching on performance and concluded that:

> it would seem logical to recommend that prolonged static stretching not be performed prior to a high level or competitive athletic or training performance[...]there is clarity that dynamic stretching does not impair performance[...]the use of dynamic rather than static stretching for the warm-up would tend to be a more judicious choice (p. 2638, 2646).

Light jogging is one of the most common activities done during a warm-up for any athletic event. An event-specific warm-up includes activities that are similar to those that will be performed during the actual event. For example, a baseball player may practice swinging a bat before stepping up to the plate or a football punter may practice kicking the football into a net on the sideline. Some research indicates that such event-specific warm-ups enhance performance. Samson, Button, Chaouachi, and Behm (2012) tested four warm-up conditions involving static and dynamic stretching and general and event-specific warm-up activities on sprint performance. Results showed that including an event-specific warm-up (i.e., high knee skipping, high knee running, and butt kick running) improved performance whether static or dynamic stretching was incorporated. The authors suggested that the results may be due to physiological factors, such as increased muscle temperature and nerve conduction velocity. Additionally, for middle distance runners, Skof and Strojnik (2007) found a warm-up that included slow running, stretching, sprinting, and bounding increased muscle activation more than a warm-up including slow running and stretching only.

However, minimal research describes what types of warm-ups may work best for different athletic events in terms of enhancing performance (Fradkin et al., 2010). For example, in studying a 200-meter time-trial performance among swimmers, Zochowski, Johnson, and Sleivert (2007) found that decreasing the amount of time between warm-up and race from 45 minutes to 10 minutes enhanced performance. Zois, Bishop, Ball, and Aughey (2011) reported that team soccer performance tests were improved when a leg-press and small-sided game warm-up were used rather than a traditional warm-up (e.g., high knees, squats, change of direction movements, sprinting). Burkett, Phillips, and Ziuraitis (2005) determined that a weighted resistance warm-up was most beneficial for performance in the vertical jump test. For rowing time trials, Mujika, Gonzalez de Txabarri, Maldonado-Martin, and Pyne (2012) found that a less intense and shorter duration warm-up was more beneficial to performance than the traditional 60-minute warm-up (e.g., low-intensity rowing with short periods of intense exercise). While some research has studied various warm-up protocols used in different sports, the results show that the most beneficial protocol in each of these sports varies. Therefore, studies should continue to examine the impact of diverse warm-ups on desired performance in different athletic events. One area in need of further research is middle distance running events.

Physiological changes resulting from warm-ups

An active warm-up is likely to induce greater metabolic and cardiovascular changes than a passive warm-up (Bishop, 2003). In a review of research on performance after active warm-up, Bishop (2003) found that "different physiological responses to warm up may be required to optimize performance for different tasks" (p. 492). Thus, to understand what activities could comprise an optimal warm-up, research must demonstrate the specific physiological changes that occur to prime the body for exertion (Endo et al., 2004), such as changes in muscle temperature and function, heart rate, oxygen kinetics, and energy systems.

Muscle temperature and function

A warm-up increases muscle temperature, which in turn, decreases stiffness of muscles and joints (Bishop, 2003). Warming of the muscles improves contractile characteristics as well as produces changes in biomechanical parameters. Additionally, increased muscle temperature may also enhance central nervous system functioning and the transmission speed of nerve impulses (Zochowski et al., 2007).

Active warm-up prepares the muscle function for activity to follow. Warm-ups increase the power output, the velocity of contraction, and rate and amount of muscle fibers firing during physical exertion (Stewart, Macaluso, & De Vito, 2003). As a result, muscle temperature increases, and this increased temperature leads to a swelling of the muscle tissue. This swelling is a key element of a warm-up regimen as it improves the storage of oxygen and prepares the muscles for maximal power output needed for the intense physical activity. According to Skof and Strojnik (2007), warm-up utilizing dynamic explosive-strength exercises results in an athlete being better prepared for optimal performance in competition due to the way it enhances the neuromuscular system. However, in a review of changes in performance resulting from various active warm-up protocols, Bishop (2003) noted active warm-ups that raise temperature can be detrimental to immediate performance if the warm-up was too intense or led to fatigue.

Heart rate

Physical activity increases heart rate (Howard, Blyth, & Thornton, 1966). Heart rate is commonly known as the number of heart beats per minute (bpm). A typical resting heart rate in an untrained adult is 60-80 bpm and in a trained endurance runner is 24-48 bmp (Christensen & Schmidt, 2011). As an athlete increases the intensity of an activity, heart rate will increase. Subsequently, the increase in heart rate increases both blood flow and levels of oxygen being supplied to the muscles. Heart rate is an excellent indicator of the intensity of physical activity, with resting heart rate serving as a measure of training state or state of fatigue (Christensen & Schmidt, 2011).

Oxygen kinetics

Oxygen kinetics refers to the maximal oxygen capacity, capabilities of the respiratory system to meet the oxygen demands of the body, myoglobin content of muscle, and the ability to remove waste products from the muscles and blood through the lungs. VO_2 data, including maximal oxygen uptake (VO_2 max), peak oxygen uptake (VO_2 peak), and lactate threshold (LT), are important parameters in evaluating training programs and preparedness for exercise and competition. As Christensen and Schmidt (2011) indicate, "VO_2 max is considered by most exercise physiologists to be the single most accurate measure of endurance fitness" (Chapter 6, p. 3). Specifically, VO_2 data are used to assess an athlete's fitness, design tailored workouts, and monitor improvements through training over time (Berg, 2003; Burnley, Doust, & Jones, 2002; Draper & Wood, 2005; Endo et al., 2004; Enoksen, Shalfawi, & Tonnessen, 2011; Fradkin et al., 2010; Ingham et al., 2013; Tomlin & Wenger, 2001).

Burnley et al. (2002) compared oxygen kinetics effects in three different warm-ups with heavy exercise, sprint exercise, and passive warming. Results indicated that prior to beginning heavy exercise, both 30 seconds of prior sprint exercise and 6 minutes of prior heavy exercise increased the VO_2 kinetics in a similar fashion even though blood lactate was significantly higher following prior sprint exercise. Passive warming did not impact VO_2 kinetics (Burnley et al., 2002). As mentioned previously, Bishop's (2003) review indicated that performance can be impaired if a warm-up is too intense that it leads to fatigue. Research has shown phosphocreatine (PCr) can be restored to 100% within 3 to 5 minutes of intense physical activity (Tomlin & Wenger, 2001). Thus, warm-ups involving intense physical activity for under 4 minutes must be designed with recovery time so blood lactate is removed, heart rate is reduced, VO_2 can rapidly decline, and depleted PCr and glycogen are restored in muscles.

Energy systems

The human body consists of two primary energy systems, the aerobic and anaerobic systems. The aerobic energy system is quite efficient in providing the needed energy to sustain activity. A primary biological supplier of this energy is stored carbohydrates and fat. In contrast, the anaerobic energy system utilizes glycogen and refers to the ability of the human body to replenish it during exercise or exertion, typically at or above VO_2 max (Spencer & Gastin, 2001). A by-product of the anaerobic energy system is the accumulation of blood lactate (Burnley et al., 2002; Nurmekivi, Karu, Pihl, Jurimae, & Lemberg, 2001). Through the burning of glycogen in the anaerobic glycolosis process, the body can have an elevated level of lactate. The rate of accumulation of residual acidosis is dependent on the velocity of exercise undertaken. If the accumulation of lactate is at a slow rate, a trained athlete can maintain an effective energy system for longer periods. Once accumulation of lactate reaches a certain level, muscle fatigue occurs. The body is able to reduce blood lactate through recovery and restore the muscle to acceptable levels where subsequent physical activity can continue.

Research has demonstrated little consensus in specifically how these energy systems are utilized during an 800-meter run. For example, Hill (1999) described a discussion among eight coaches and sports scientists indicating that an 800-meter run ranged from under 35% anaerobic to 45% anaerobic to 65% anaerobic to primarily anaerobic. Hill (1999) also reported that laboratory investigations have been conflicting on the issue of energy systems in 800-meter events. Despite these differences, the 800-meter race is still quite dependent on the anaerobic energy system. Thus, the anaerobic energy system needs to be a key focus when training an athlete as well as when designing a warm-up procedure for this event.

In summary, enhancement of muscle temperature and function, heart rate, oxygen kinetics, and energy during warm-ups is crucial to preparing an athlete for intense physical activity. The structure of the warm-up needs to be specific with regard to the intensity and volume of the protocol (e.g., activities, duration, recovery period) for the type of activity to follow. For an elite collegiate 800-meter runner, minimal studies identify what could serve as an optimum warm-up. The athlete needs to have an active warm-up that properly prepares him or her for peak competition, yet one that does not leave him or her fatigued. Muscle temperature and heart rate must be in appropriate ranges. In addition, preparing the oxygen kinetics is an integral part of the warm-up. A balance needs to be identified between VO_2 and blood lactate (BL) that might accumulate with a high intensity active warm-up. This balance should be long enough to remove the lactate acidosis (approximately 3-5 minutes), but not so long that VO_2 max is compromised (approximately 15-20 minutes) (Tomlin & Wenger, 2001).

Limitations in existing research

While several studies have examined physiological responses to warm-up, fewer studies have assessed changes in performance after warm-up (Fradkin et al., 2010). Fradkin et al.'s (2010) meta-analysis of 32 studies examining the effects of warm-up on performance in different athletic events found warm-ups improved performance in 79% of studies, led to no change in 3% of studies, and negatively affected performance in 17% of studies. However, the authors reported that when a study was found that showed improved performance in an event, another contradictory study was identified.

One event where research on how warm-up affects performance is needed is 800-meter middle distance running. While the Ingham et al. (2013) study is a good beginning in examining this specific topic, one of the study's main weaknesses was that testing was done on a treadmill. While this indoor setting helps control for issues related to the environment that may impact performance, testing on an outdoor track where these events typically occur may lead to more realistic results. Additionally, Hill (1999) argued that athletes do not perform their personal best times on a treadmill due to lower motivation in laboratory testing than in competition and because they cannot make subtle pace adjustments on a treadmill.

Even when studies do assess performance after warm-up, as Fradkin et al. (2010) note, well-documented studies of the effect of sport-specific warm-up protocols on performance are lacking. For example, some studies have used an actual warm-up procedure as baseline rather than having a "no warm-up" control group or control condition (Fradkin et al., 2010). However, Ingham et al.'s (2013) study of 800-meter runners did not use a control condition group since the researchers felt it was inappropriate to ask the athletes to complete an intense performance without prior warm-up. Thus, a true control condition may work in studies for some events (e.g., baseball, tennis, golf), but not others (e.g., sprinting, middle-distance running, cycling). Additionally, many studies have only included a small number of participants, thus increasing the likelihood that results were due to chance (Fradkin et al., 2010).

CHAPTER III

METHOD

This study used an experimental design to test the effect of three different warm-up protocols on 800-meter time trial results among NCAA Division I middle distance runners. This study was approved by the MSU Human Research Protection Program prior to initiation (see Appendix A). Participants and recruiting methods, design, materials and measures, study procedures, and statistical analyses are described below.

Participants

Mississippi State University (MSU) student athletes on the Track and Field Team who compete in middle distance (400-meter, 800-meter, and 1500-meter) running events were recruited to participate in this study. The MSU Track and Field Team currently has approximately 20 student athletes who compete in middle distance running events. Track and Field student athletes who compete in other events (e.g., jumping and throwing events) were excluded from participation. Fourteen individuals agreed to participate; however, one dropped out during the course of the study due to illness. Seven males and six females completed all aspects of the study.

To recruit participants, the Principal Investigator held a group meeting with student athletes who met the inclusion criteria. At this meeting, the purpose of the study and the procedures involved were explained, and initial questions were answered (see

Appendix B). Consent forms were given to those who were interested in participating to read on their own. A second group meeting was held approximately one week later to answer any additional questions and collected signed consent forms.

Design

To identify a warm-up protocol for NCAA Division I middle distance runners that results in optimal results in a peak performance (i.e., 800-meter time trial), an experimental design testing low, medium, and high intensity warm-up protocols was utilized. Testing occured over a three-week period, with one testing day each week. All of the warm-up protocols were utilized on each of the three testing dates. On the first testing date, participants were randomly assigned into one of the three warm-up protocol groups. On each subsequent testing date, the athletes were randomly assigned into a different warm-up protocol group to ensure that each student athlete participated in all three of the different warm-up protocols by the end of the three-week testing period. Given the small sample size, random assignment was important to help control for threats to internal validity, such as history, maturation, testing, statistical regression, and selection (Thomas, Nelson, & Silverman, 2011).

Materials and measures

Measures used in this study included a diet and activity log (see Appendix C); demographic survey (see Appendix D); Physical Activity Readiness Questionnaire (PAR-Q; (see Appendix E)); and time splits and total time during the 800-meter time trial.

Diet and physical activity log

A log was used to document physical exertion and dietary behaviors during the 24 hours prior to the first testing date. Physical activity items were modified from the National Health and Nutrition Examination Survey (NHANES; Centers for Disease Control and Prevention, 2013a). NHANES is a nationally representative survey of approximately 5,000 individuals conducted annually since 1999 that assesses the health and nutritional status of children and adults in the U.S. (Centers for Disease Control and Prevention, 2013b). Dietary behavior items were developed for this study.

Demographic survey

To understand demographic characteristics of the sample, a brief survey was used to document participants' biological and competitive ages, race/ethnicity, height, weight, gender, and academic year/level (see Appendix D).

Physical activity readiness questionnaire (PAR-Q)

The PAR-Q was originally developed by the British Columbia Ministry of Health and revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology (2002). The questionnaire includes 7 items to be answered by individuals planning to significantly increase their physical activity levels (see Appendix E). If an individual responds positively to any question, it is recommended that he or she consult a physician for clearance prior to engaging in physical activity. The PAR-Q's safety and effectiveness and its ability to identify possible contraindications to exercise have been demonstrated over 30 years (Shephard, 1988, 1994 as cited in Warburton et al., 2011).

800-meter time trials

During the 800-meter time trials, time splits were documented at each 100-meter checkpoint using a standard stopwatch. Total time was also documented.

Procedures

As mentioned, this study occurred over a three-week period from November 24, 2014, to December 10, 2014 with one testing day each week (and make-up days for participants that could not attend the scheduled third testing date due to final exams or another conflict). Testing occurred in the MSU Track and Field Training Room and at the MSU outdoor track. On the first testing day, participating student athletes met in the Training Room. Each participant completed Diet and Physical Activity Log to document his or her physical exertion and dietary behaviors during the previous 24 hours. To reduce threats to internal validity, participants were asked to follow the same physical activity and dietary behavior routine for the 24 hours prior to subsequent testing times. Participants also completed a brief demographic survey at the first testing session to document age, race/ethnicity, height, weight, gender, academic year/level, and competitive age. They also completed the PAR-Q to determine if there were any potential risks associated with physical activity. All physical documents (other than consent forms) used ID numbers only (i.e., no names) to identify/track participants across testing dates. Participants were reminded that participation was completely voluntary and that they could end participation at any time without negative consequences.

Participants then moved outdoors to the MSU Track where the three warm-up protocols were tested (see Table 1). The <u>first</u> warm-up protocol (low intensity) involved a 10-minute jog followed by a series of dynamic stretching exercises for 8-10 minutes.

The dynamic stretching exercises included 4-way leg swings, back to wall – wall touches (hip rotation), forward lunges, backward lunges, donkey kicks, glut bridges, cats to camel, iron crosses, sitting leg raises, side lunges, karaoke's, and side skips with overhead arm swings. This series of stretches was followed by four 40- to 60-meter bounding/striding runs, and ended with a 15-minute resting period prior to the 800-meter time trial. During the 15-minute resting period, participants were allowed to walk at a casual pace or sit down and were able to drink water and/or Gatorade as desired.

The second warm-up protocol (medium intensity) involved a 10-minute jog followed by the same series series of dynamic stretching exercises for 8-10 minutes, and a 40- to 60-meter bounding/striding run. This was followed by four acceleration sprints ranging from 40- to 80-meters in length, a 2-minute rest, and then a 100-meter sprint at race pace (the fourth of the four acceleration sprints). This warm-up protocol ended with a 15-minute resting period (e.g., sitting, walking, drinking water and/or Gatorade) prior to the 800-meter time trial.

The third warm-up protocol (high intensity) involved a 10-minute jog followed by the same series of dynamic stretching exercises for 8-10 minutes. This was followed by a 40- to 60-meter bounding/striding run and then three sprints: one 100-meter, one 200-meter, and one 300-meter run, each at race pace. Each of the three sprints was followed by a 1- to 3-minute walking/jogging recovery. This third warm-up protocol ended with a 15-minute resting period (e.g., sitting, walking, drinking water and/or Gatorade) prior to the 800-meter time trial.

Table 1

Three warm-up protocols to be tested

Activity	Low intensity	Medium intensity	High intensity
10-minute jog	x	x	x
Dynamic stretching exercises	x	x	x
4 x 40-60m bounding/striding runs	x	x	x
4 x 60m acceleration sprints at race pace		x	
2-minute walking/jogging recovery		x	
100m sprint at race pace		x	x
100m, 200m, and 300m sprints at race pace with 30-60 second walking/jogging recovery in between each			x
15-minute rest	x	x	x

As described previously, each participant completed one warm-up protocol on each testing date. After finishing the warm-up protocol, an 800-meter time trial was conducted. During the 800-meter time trial, timed splits were taken at each 100-meter check point. Total time was also documented.

All individuals involved in data collection had valid Human Subjects Training. To control for physical risks associated with this study (e.g., muscle pulls, strains, sprains; fainting; breathing difficulties; bumps, scrapes, or bruises; or other risks that could typically result from physical exertion), at least one MSU Track and Field athletic trainer was present during all testing procedures.

Statistical analyses

First, frequency distributions were calculated on demographic characteristics (biological age (years), gender, race, ethnicity, and academic year/level). Second, measures of central tendency and variability (means, standard deviations, and ranges) were calculated on the following variables: biological age, height (meters), weight/body mass (kilograms), Body Mass Index, and times at each 100-meter checkpoint in the time trials. Third, a repeated measures ANOVA was used to determine if a significant difference was evident in time trial results (dependent variable) among the three warm-up protocols (independent variable). Tukey's multiple comparison post hoc analyses were applied to examine pairwise comparisons between the different warm-up protocols when statistical significance, fixed at $p < 0.05$, was found.

CHAPTER IV

RESULTS

Table 2 (next page) displays frequency distributions for demographic characteristics of participants. Seven males and six females completed all three warm-up protocols. All participants identified their race as White and their ethnicity as non-Hispanic/Latino. Ages of participants ranged from 18 to 23 years, with the majority being age 20 or 21 years. Regarding grade level, 30.8% were freshmen, 7.7% were sophomores, 38.5% were juniors, and 23.1% were seniors at MSU.

Table 2

Frequency distributions for demographic characteristics of study participants

Characteristic	N	%
Gender		
Male	7	54%
Female	6	46%
Ethnicity		
Hispanic or Latino	0	0%
Not Hispanic or Latino	13	100%
Race		
American Indian or Alaska Native	0	0%
Asian	0	0%
Black or African American	0	0%
Native Hawaiian or Other Pacific Islander	0	0%
White	13	100%
Age		
18	3	23.1%
19	1	7.7%
20	4	30.8%
21	4	30.8%
22	0	0%
23	1	7.7%
Academic Year/Level		
Freshman	4	30.8%
Sophomore	1	7.7%
Junior	5	38.5%
Senior	3	23.1%
Graduate Student	0	0%

Table 3 displays means and standard deviations for demographic and anthropometric characteristics (biological age, height, weight/body mass, and Body Mass Index) for male and female participants.

Table 3

Means and standard deviations for demographic and anthropometric characteristics of study participants

Characteristic	Male ($M \pm SD$)	Female ($M \pm SD$)
Age (years)	20.0 ± 1.8	20.0 ± 1.1
Height (meters)	1.76 ± 0.05	1.66 ± 0.05
Weight/Body Mass (kilograms)	62.1 ± 3.8	57.7 ± 3.2
Body Mass Index	20.0 ± 0.8	20.9 ± 0.7

Among males, results of the repeated measures ANOVA found no significant difference ($p > 0.05$) among low, medium, and high intensity warm-up protocols for the first 400 meters completed (low = 62.19 ± 4.61 seconds; moderate = 60.59 ± 3.68 seconds; high = 59.13 ± 2.84 seconds) (see Figures 1-4). However, at the completion of the 800-meter time trial, a statistically significant difference ($p < 0.05$) was seen among the protocols (low = 128.98 ± 9.72 seconds; moderate = 125.53 ± 6.92 seconds; high = 122.89 ± 6.91 seconds) (see Figures 5-8). Tukey's multiple comparison post hoc analyses indicated that the high intensity warm-up group had a statistically significantly lower (i.e., better) total time than the low intensity warm-up group.

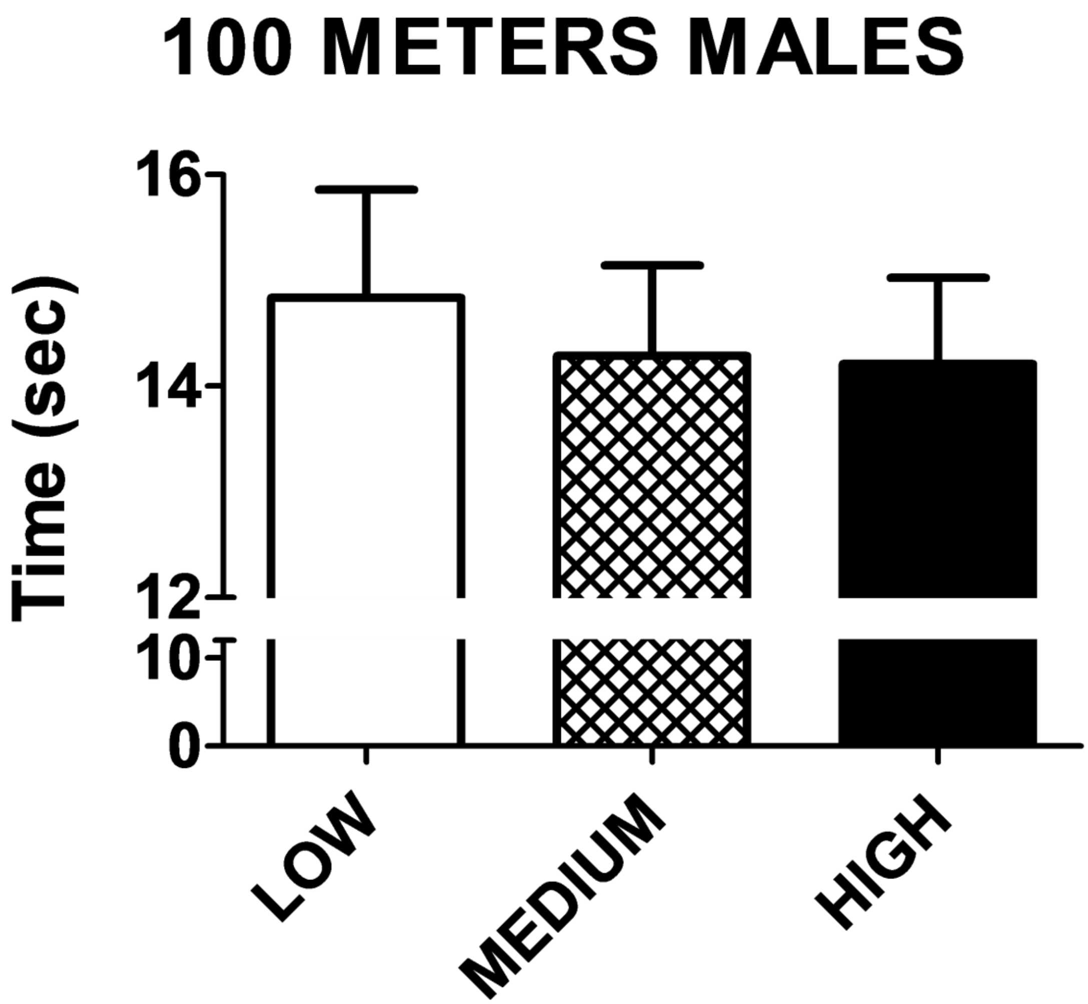

Figure 1. Time in seconds at the 100-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

No significant (p>0.05) differences existed between warm-up protocols.

Figure 2. Time in seconds at the 200-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

No significant (p>0.05) differences existed between warm-up protocols.

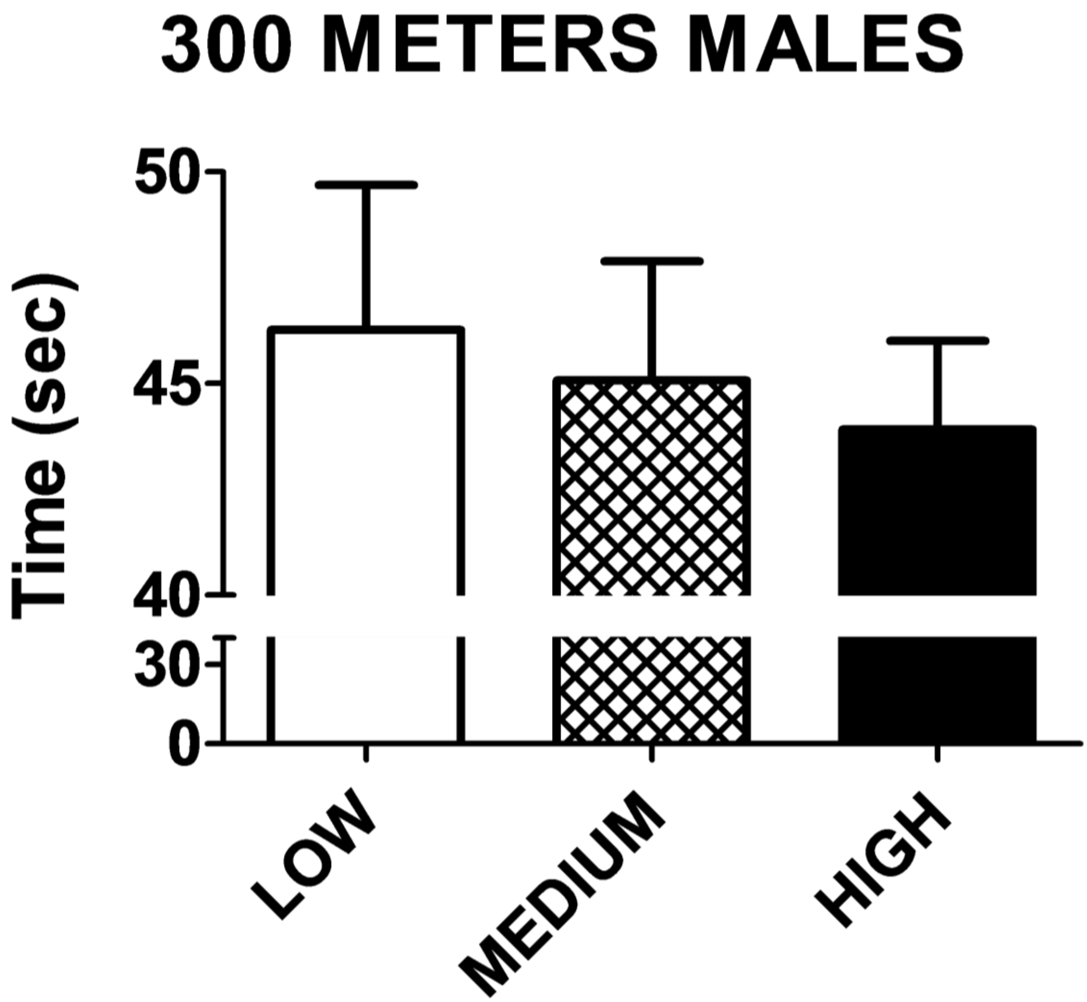

Figure 3. Time in seconds at the 300-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

No significant (p>0.05) differences existed between warm-up protocols.

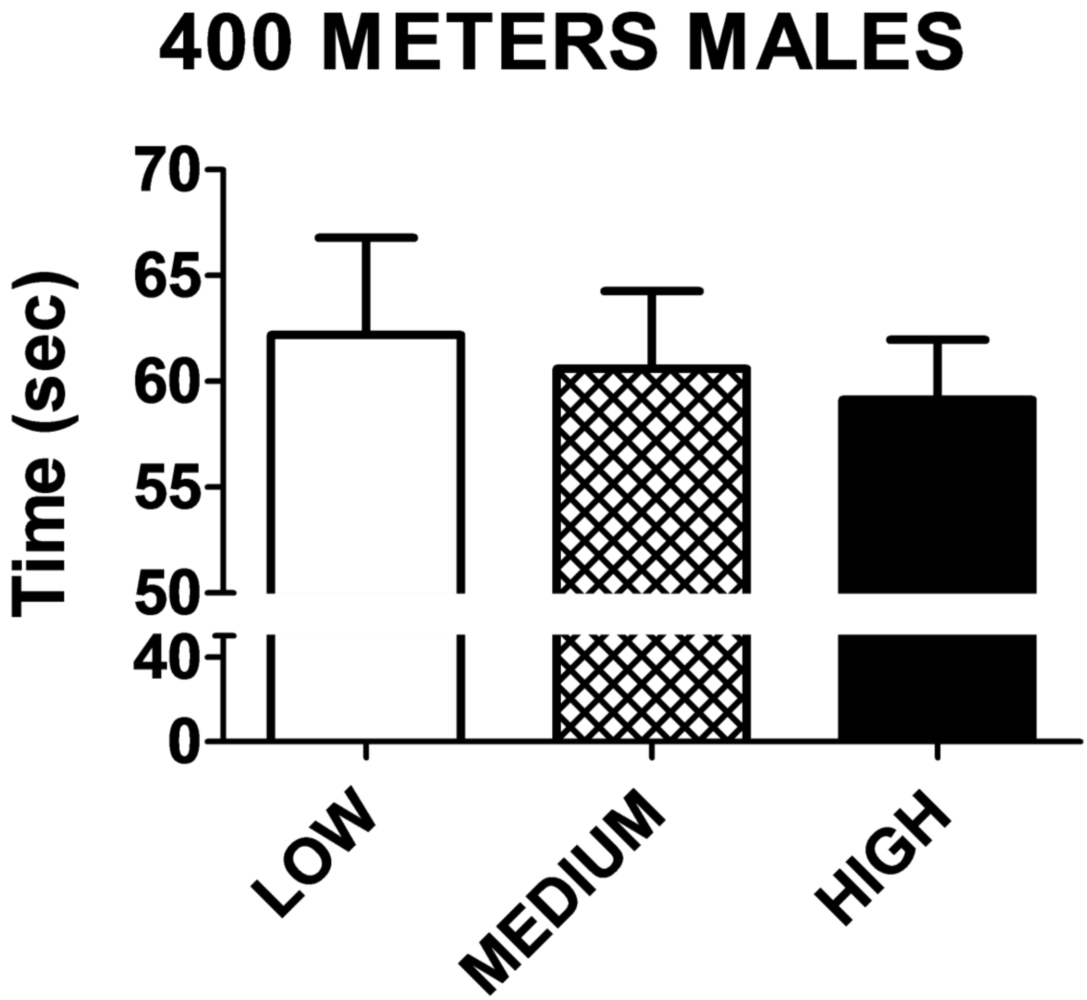

Figure 4. Time in seconds at the 400-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

No significant (p>0.05) differences existed between warm-up protocols.

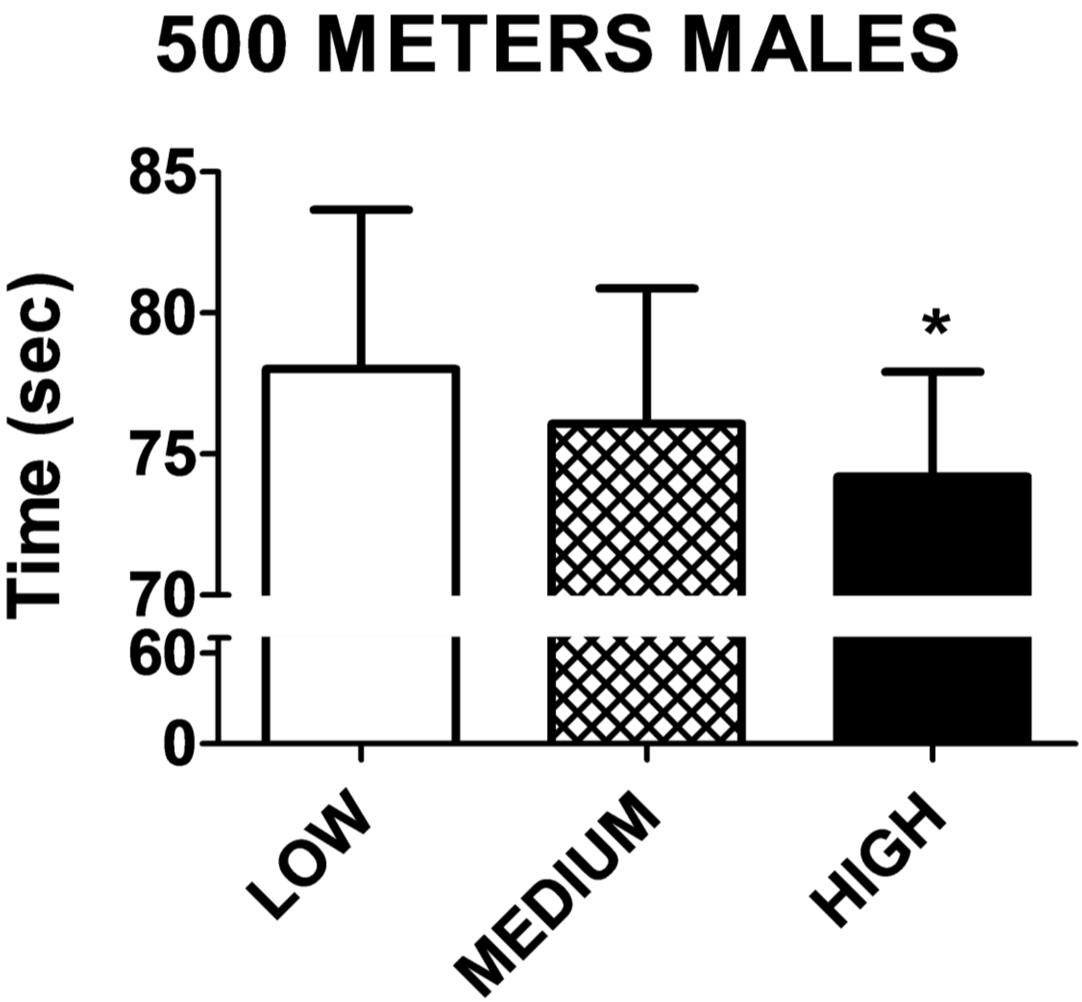

Figure 5. Time in seconds at the 500-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

* p<0.05 between warm-up protocols.

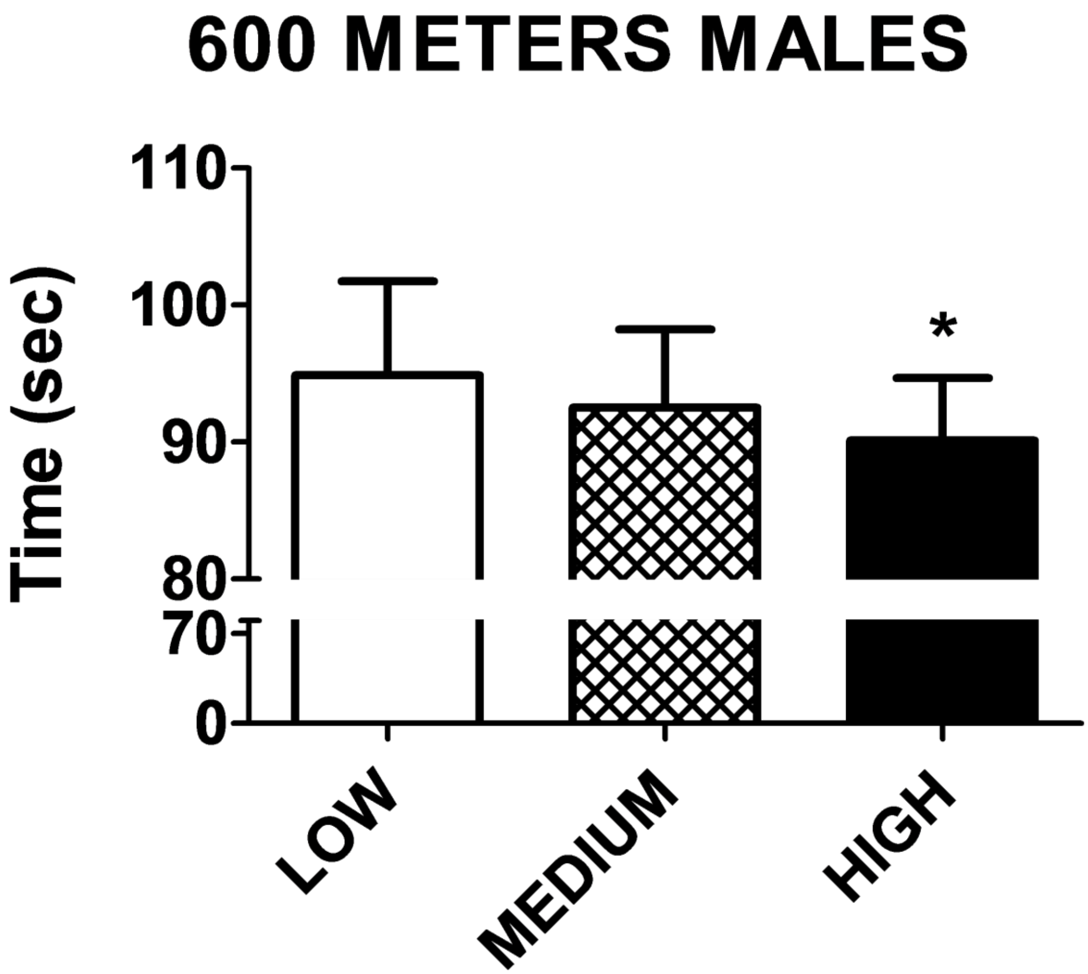

Figure 6. Time in seconds at the 600-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

* $p<0.05$ between warm-up protocols.

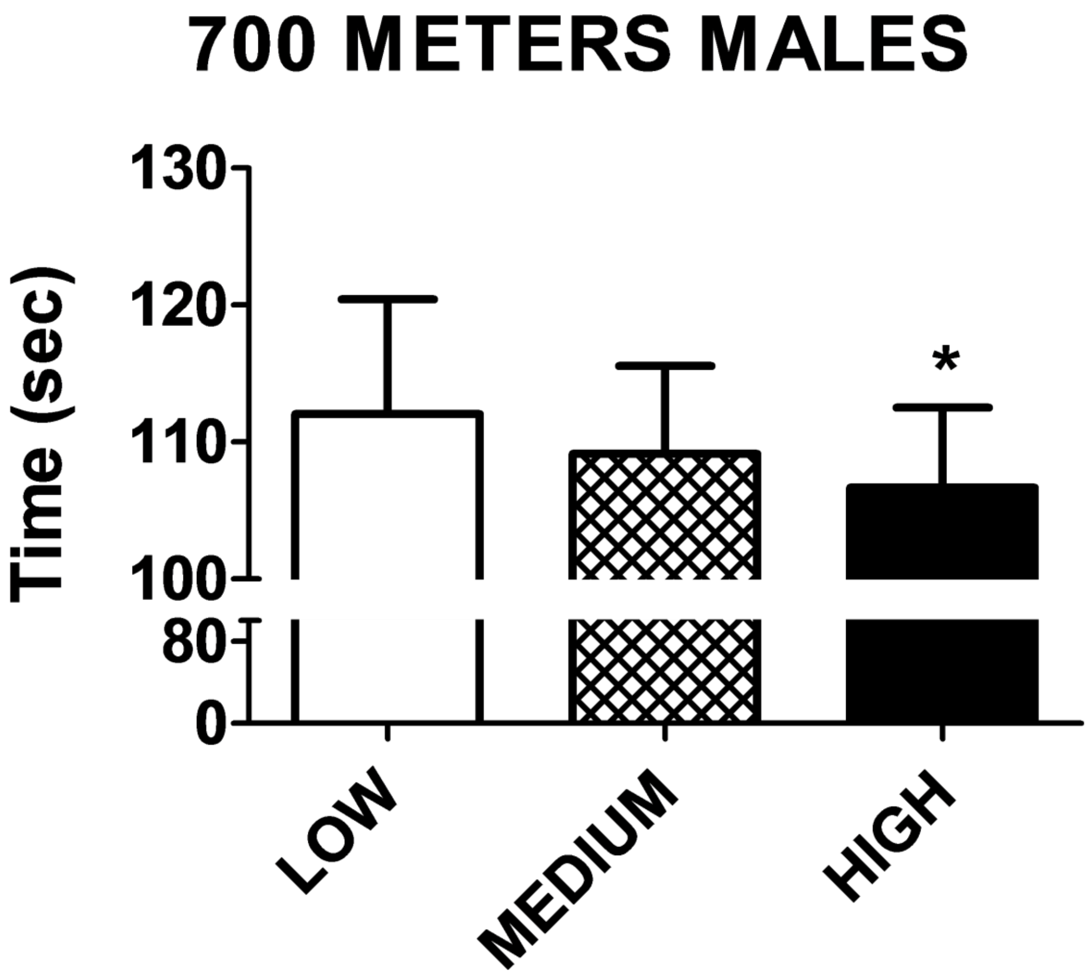

Figure 7. Time in seconds at the 700-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

* $p<0.05$ between warm-up protocols.

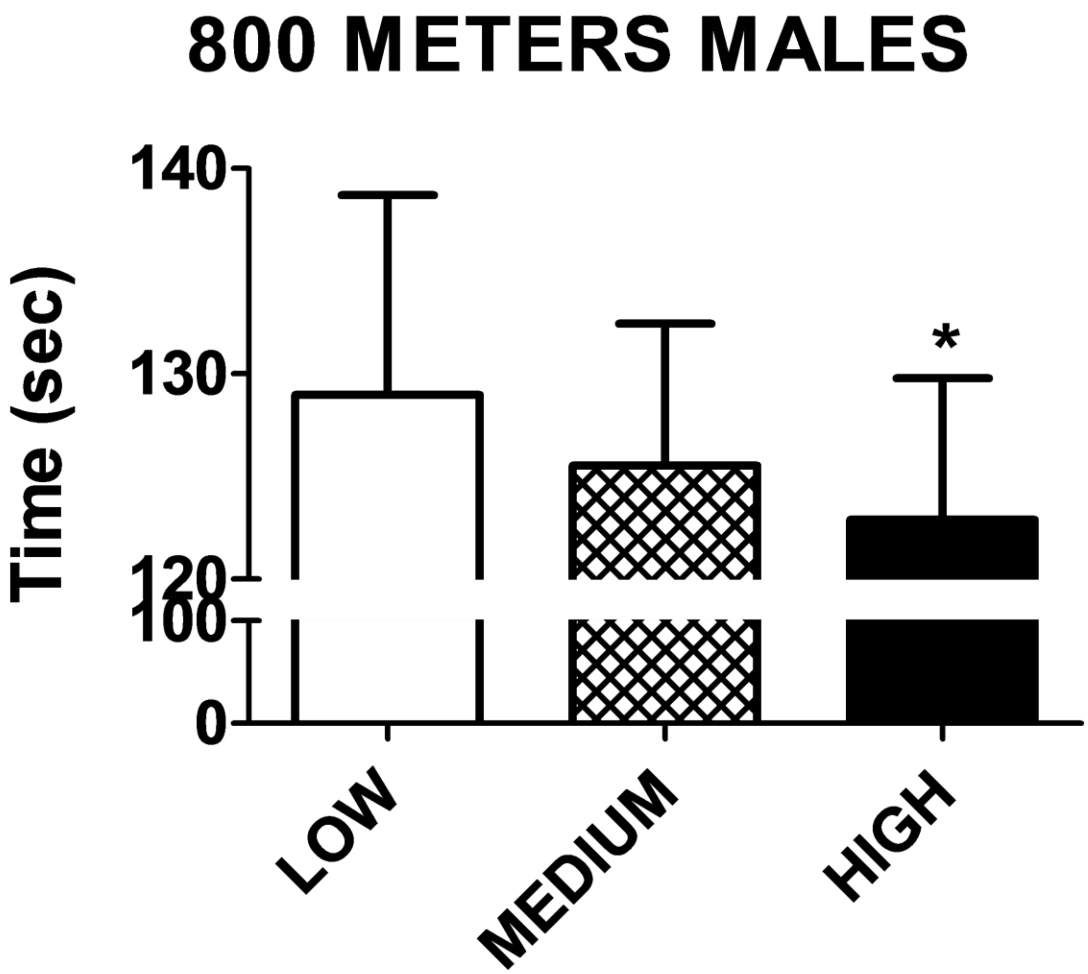

Figure 8. Time in seconds at the 800-meter checkpoint in the 800-meter time trial for each warm-up protocol for males.

* $p<0.05$ between warm-up protocols.

For females, repeated measures ANOVA results found no significant difference ($p > 0.05$) among low, medium, and high intensity warm-up protocols for the first 200 meters completed (see Figures 9-10). However, a statistically significant difference ($p < 0.05$) was first seen at the completion of 300 meters (see Figure 11). This difference remained at the completion of 400 meters (low = 70.15 ± 3.56 seconds; moderate = 67.50 ± 3.64 seconds; high = 67.19 ± 3.82 seconds) and 800 meters (low = 145.20 ± 8.33 seconds; moderate = 143.39 ± 7.99 seconds; high = 140.46 ± 8.83 seconds) (see Figures

12-16). As with males, Tukey's multiple comparison post hoc analyses indicated that the high intensity warm-up group had a statistically significantly lower (i.e., better) total time than the low intensity warm-up group.

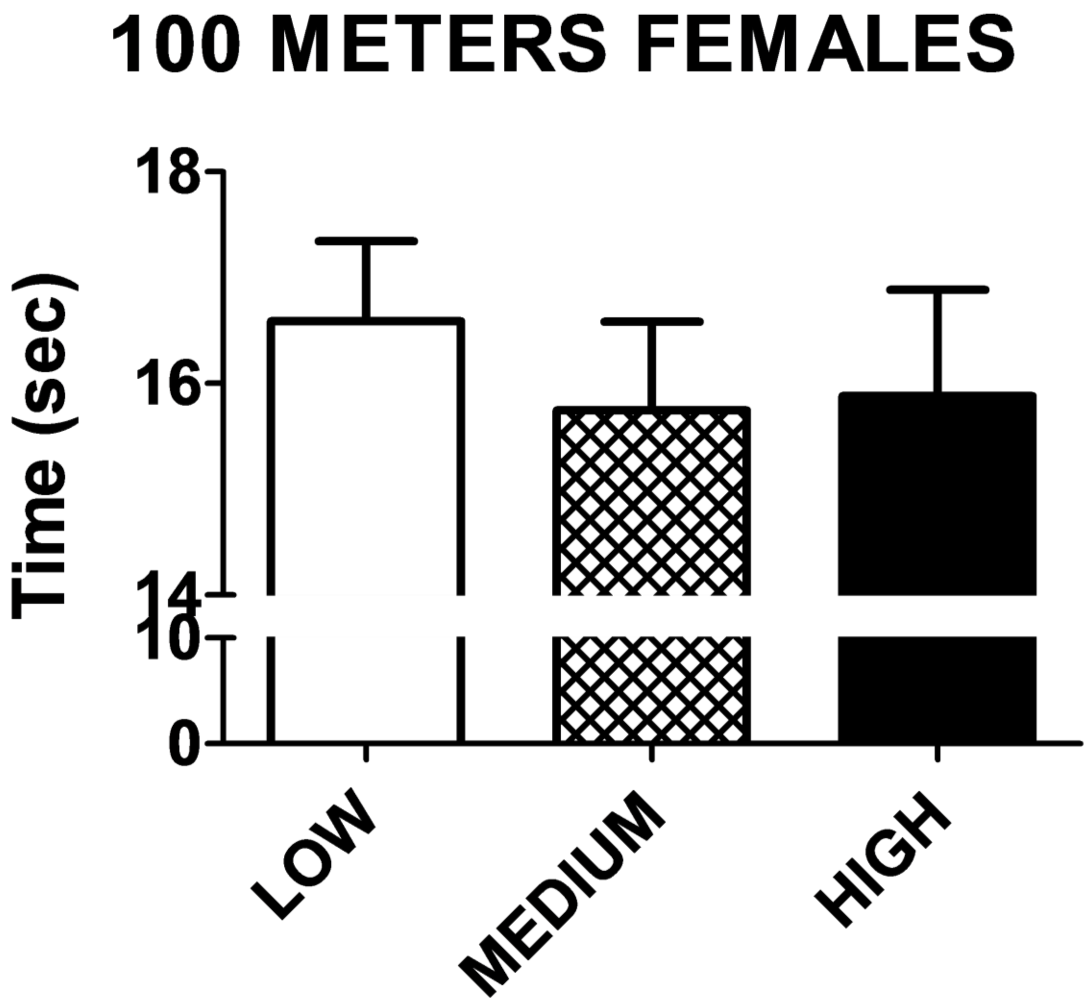

Figure 9. Time in seconds at the 100-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

No significant (p>0.05) differences existed between warm-up protocols.

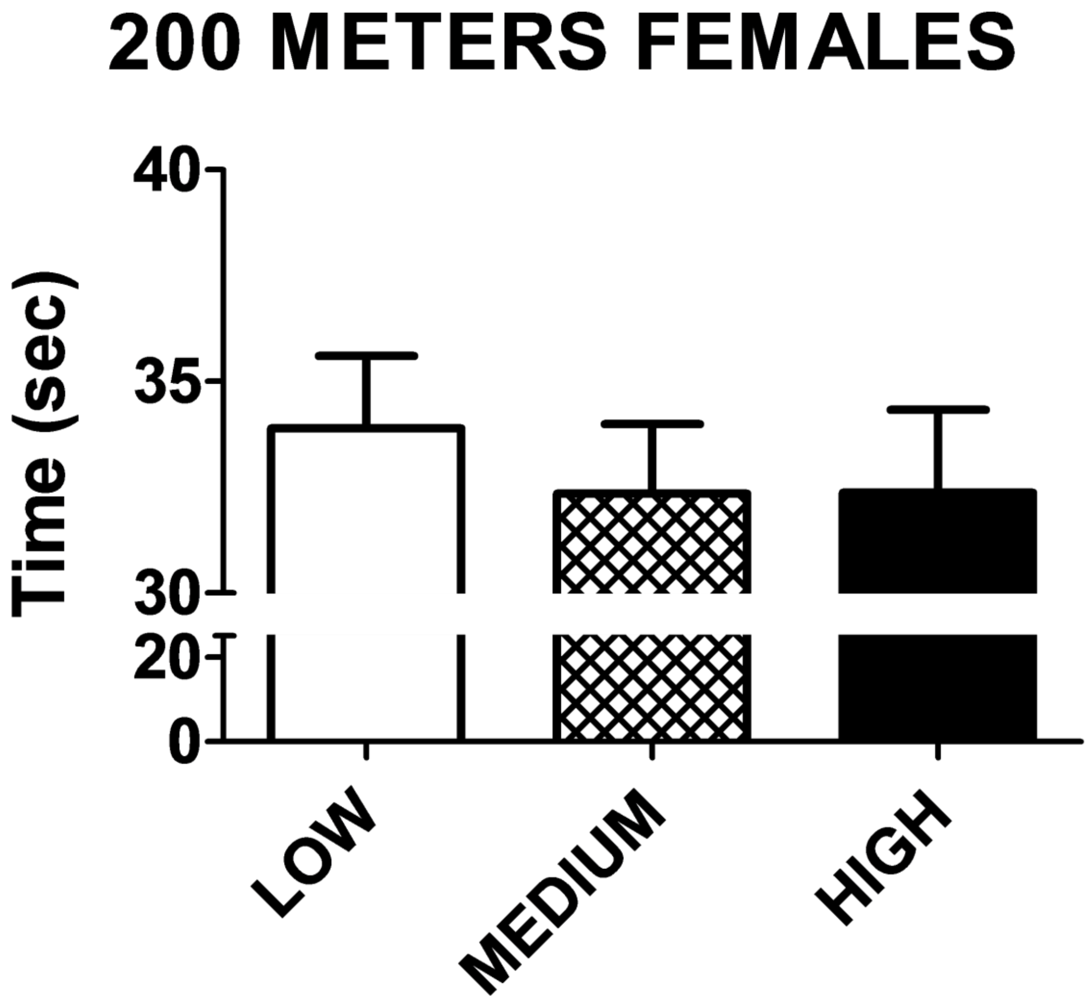

Figure 10. Time in seconds at the 200-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

No significant (p>0.05) differences existed between warm-up protocols.

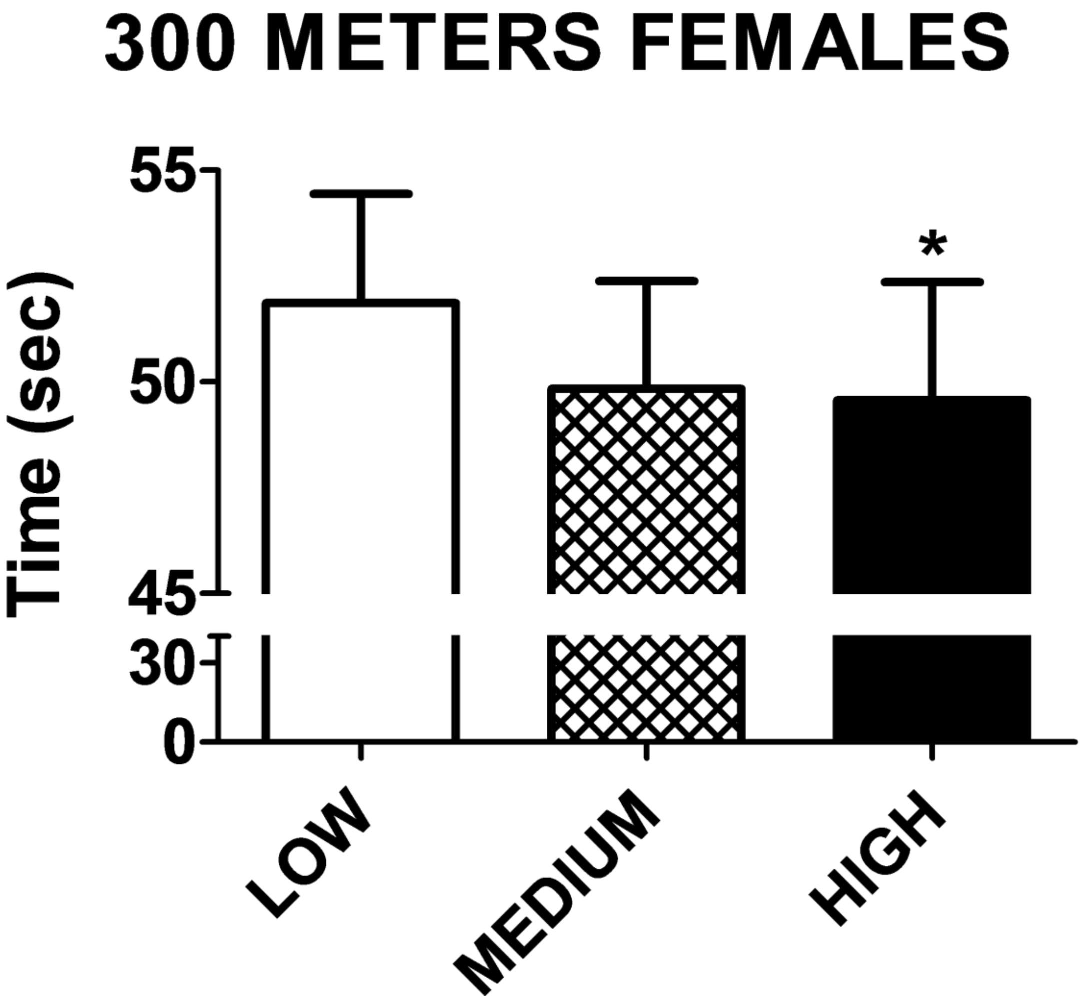

Figure 11. Time in seconds at the 300-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

* $p<0.05$ between warm-up protocols.

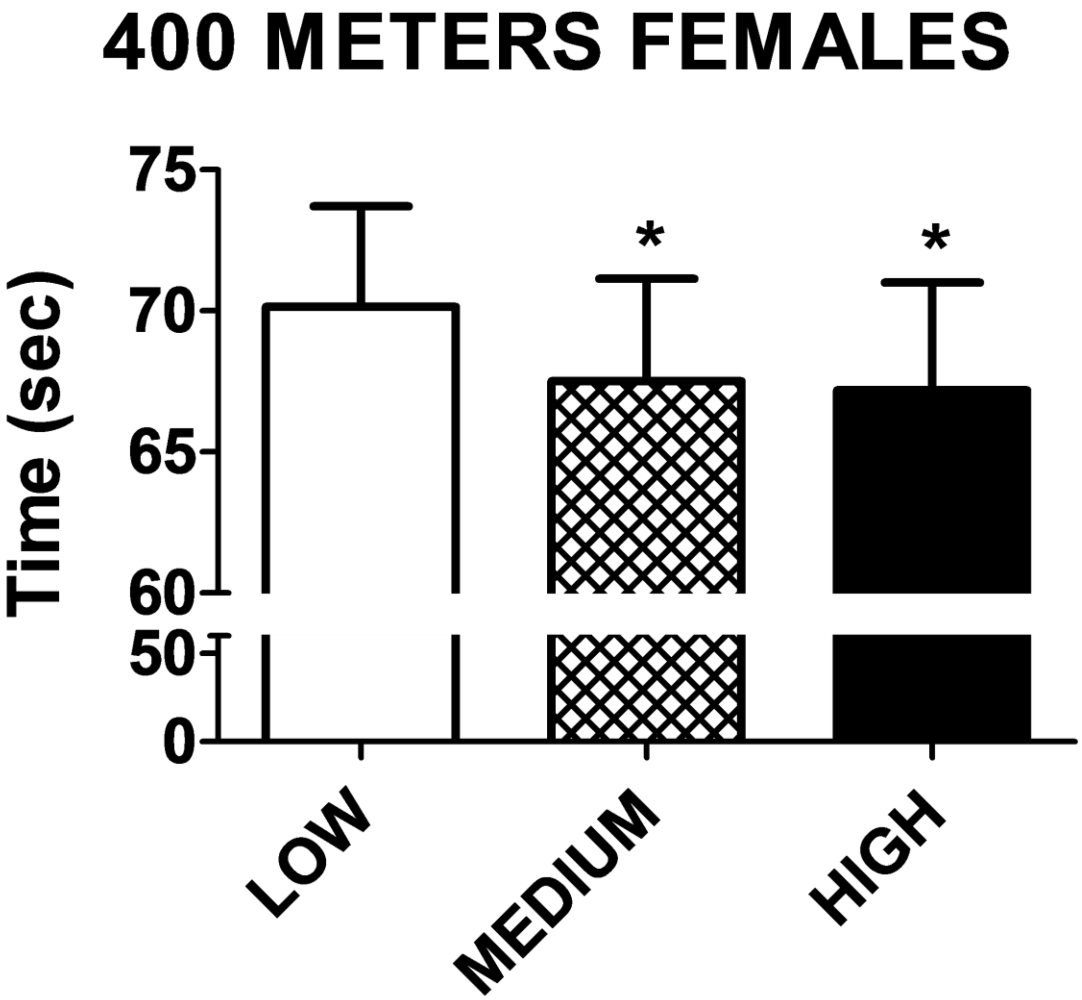

Figure 12. Time in seconds at the 400-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

* $p<0.05$ between warm-up protocols.

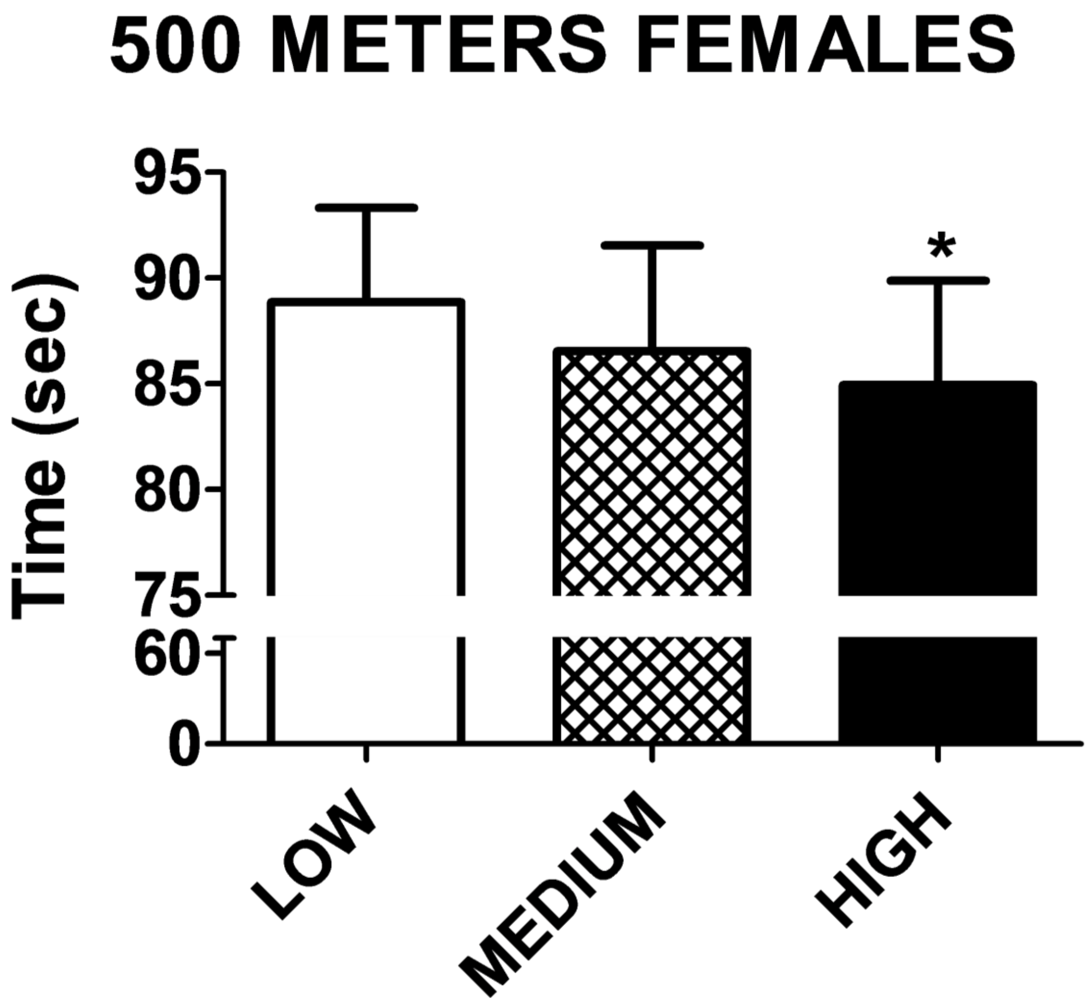

Figure 13. Time in seconds at the 500-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

* p<0.05 between warm-up protocols.

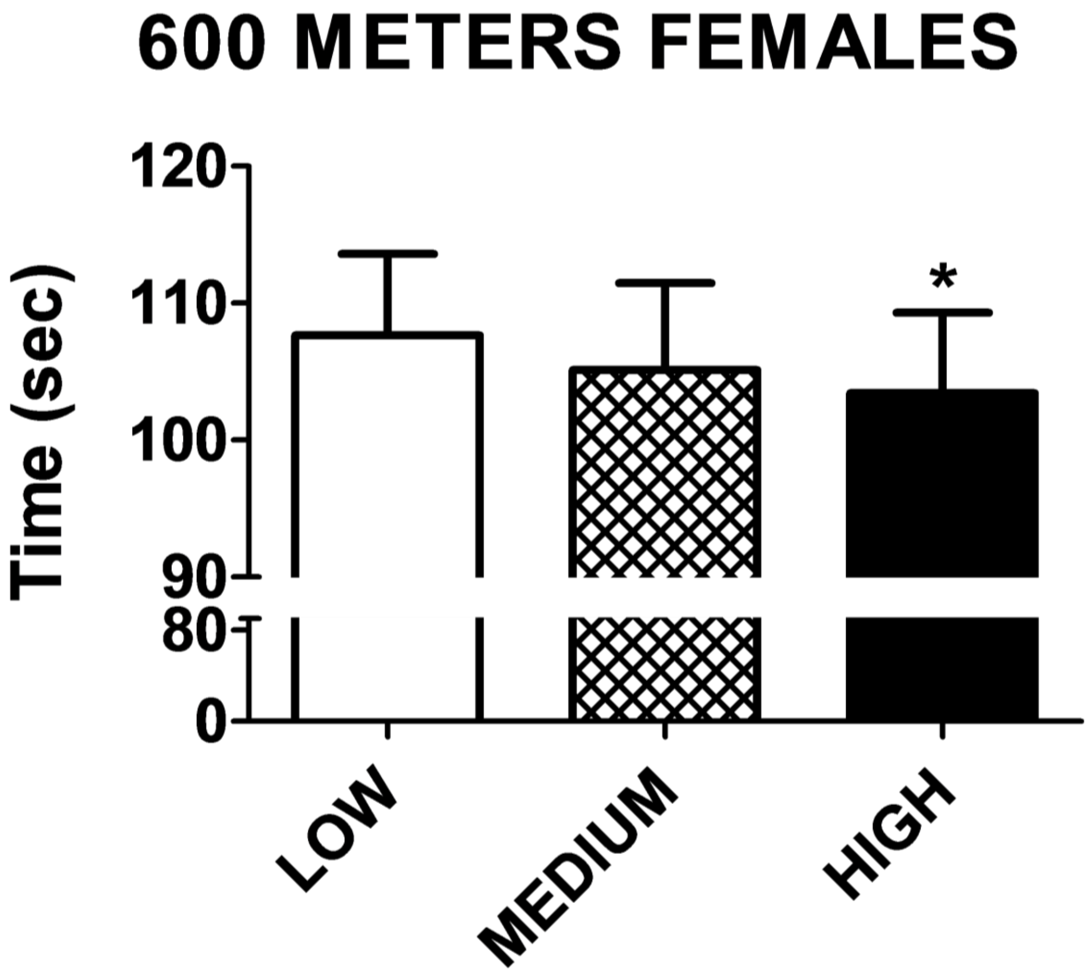

Figure 14. Time in seconds at the 600-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

* $p<0.05$ between warm-up protocols.

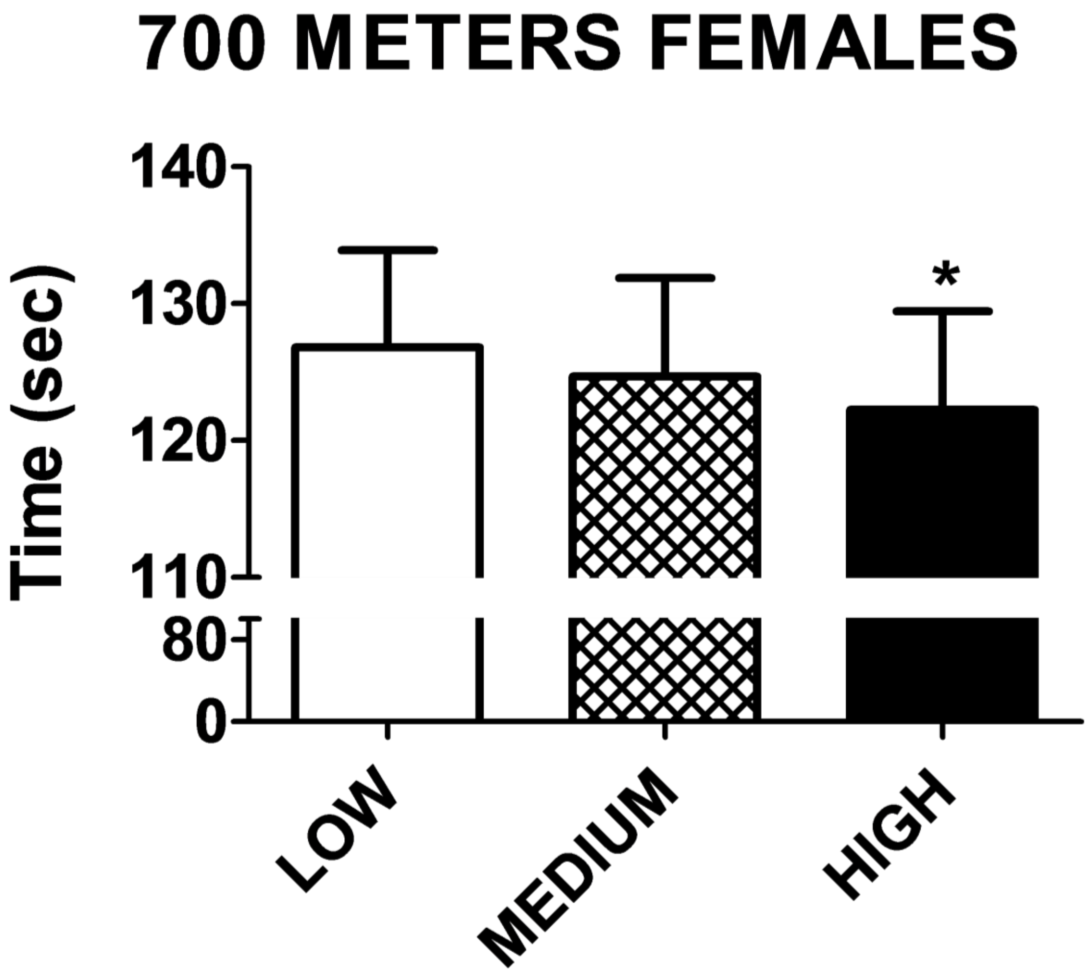

Figure 15. Time in seconds at the 700-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

* p<0.05 between warm-up protocols.

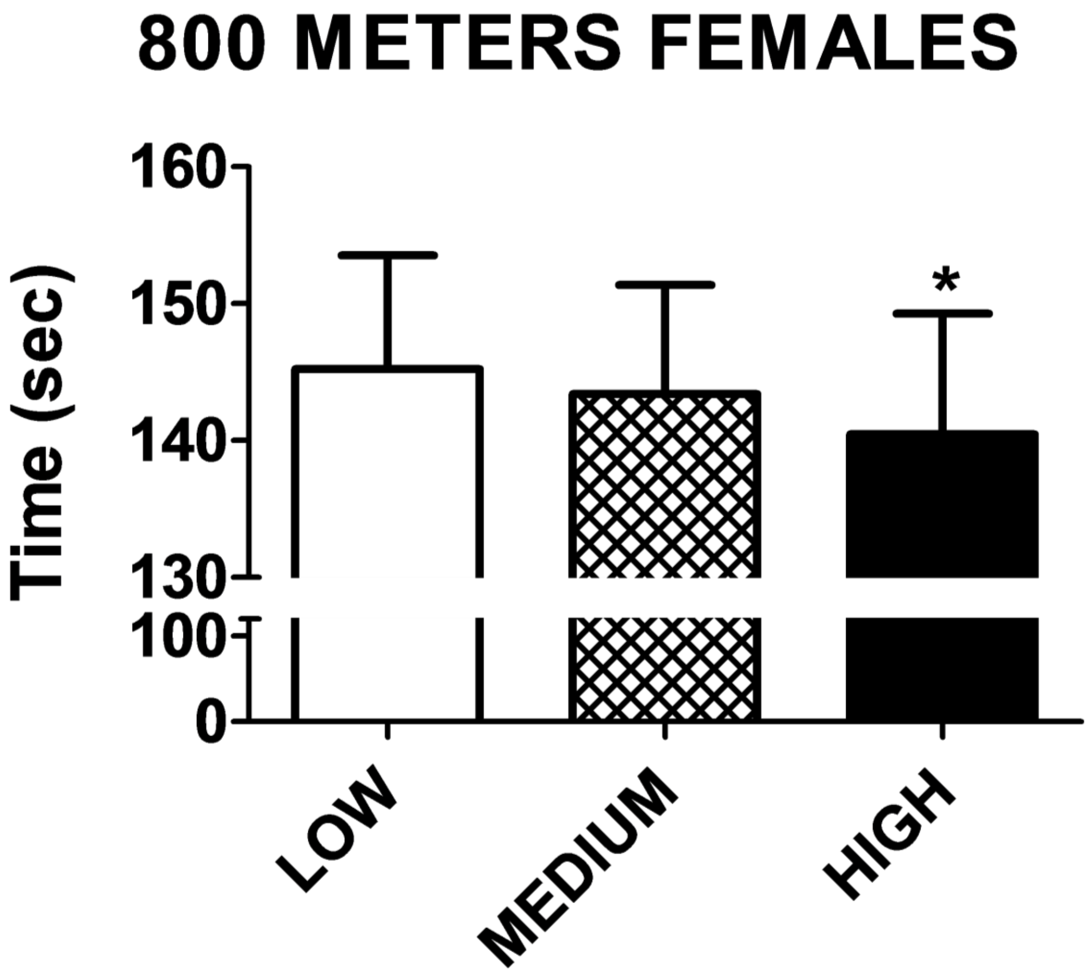

Figure 16. Time in seconds at the 800-meter checkpoint in the 800-meter time trial for each warm-up protocol for females.

* $p<0.05$ between warm-up protocols.

The results confirmed that for both males and females – a well-designed high intensity warm-up was more beneficial for optimal results in the 800-meter time trial than a low or medium intensity warm-up.

CHAPTER V

DISCUSSION

Limited research describes the types of warm-ups that may best prime individuals for enhanced performance in different athletic events (Fradkin et al., 2010). Findings from the present study suggest that high intensity warm-up may be more prudent for elite level male and female athletes during 800-meter races. These findings support those from a recent study by Ingham et al. (2013) that concluded a high intensity warm-up can improve performance among 800-meter runners. While the Ingham et al. (2013) study utilized treadmills to test performance, the present study adds to the literature through its use of an outdoor track for time trials. Athletes do not compete on treadmills; they compete on indoor or outdoor tracks. Hill (1999) suggested that athletes do not perform their best on a treadmill due to lower motivation in the laboratory setting than in competition and the inability to make subtle pace adjustments. Thus, conducting the present study in an outdoor setting may have resulted in findings that are more applicable to real-life settings.

Although physiological elements related to warm-up were not tested in the present study, based on research by Skof and Strojnik (2007), one could possibly conclude that the enhanced performance by athletes who completed the high intensity warm-up was due to increased muscle activation resulting from the warm-up that included slow running, stretching, sprinting, and bounding. The present study expanded

Ingham et al.'s (2013) design through testing three warm-up protocols (low, medium, and high intensity) rather than only two. This three-protocol, randomized design allowed for additional distinctions in warm-up intensity levels to better discern the most effective warm-up protocol for elite 800-meter runners in an NCAA Division 1 university.

Limitations

The present study has some limitations. First, only 13 student athletes participated – 7 males and 6 females. While statistically significant differences on time trial results were still found for the three warm-up protocols, a small sample size limits generalizability. Second, time trials were performed outside on a track where weather conditions (e.g., wind, air temperature, humidity) could have affected performance. However, while temperatures varied across testing days, wind direction and speed and humidity were relatively similar across testing days (Day 1: 59 degrees, west wind at 6mph, 61% humidity; Day 2: 73 degrees, south wind at 5mph, 66% humidity; Day 3: 59 degrees, south/southwest wind at 5mph, 58% humidity; Make-up Days: 45 degrees, north/northeast wind at 5mph, 61% humidity; 43 degrees, north wind at 3mph, 65% humidity; 61 degrees, north/northwest wind at 8mph, 41% humidity; and 45 degrees, calm wind, 75% humidity). Third, this study did not assess how the different warm-up protocols affected physiological elements that account for enhanced performance.

Future research

Related to the limitations just described, future research should include a larger sample of student athletes. Additionally, future studies should assess how multiple physiological elements (e.g., muscle temperature only, blood lactate and heart rate, VO_2 max only) impact performance as suggested by Endo et al. (2004).

Conclusions

Warm-ups are essential to prepare athletes for exertion and optimum performance (Bishop, 2003). The findings of the present study suggest that high intensity warm-up may be most prudent for elite level male and female athletes preceding racing distances of 800 meters. Given the connection between warm-up protocols and performance, as well as knowing that warm-up protocols are often based on "trial and error experience of the athlete or coach" (Bishop, 2003, p. 484), training on the most effective event-specific warm-up protocols could be provided to coaches through certification courses which have been shown to be an effective way to communicate such information (Judge et al., 2013). Identifying the best warm-up protocol (e.g., intensity and volume) to prime an 800-meter runner for peak performance can help prevent injury, enhance performance and sense of achievement, and increase an athlete's confidence in his or her personal skills and abilities.

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APPENDIX A

IRB APPROVAL

BULLY MAIL powered by Google

Roger Keesling <rlk158@msstate.edu>

Study 14-363: The Effects of Warm-up Protocols on 800-Meter Time Trials

nmorse@orc.msstate.edu <nmorse@orc.msstate.edu> Fri, Nov 21, 2014 at 2:53 PM
To: rlk158@msstate.edu
Cc: nmorse@orc.msstate.edu, bwax@colled.msstate.edu

November 21, 2014

Roger Keesling
Kinesiology
Mailstop 9300

RE: HRPP Study #14-363: The Effects of Warm-up Protocols on 800-Meter Time Trials

Dear Mr. Keesling:

This email serves as official documentation that the above referenced project was reviewed and approved via expedited review for a period of 11/21/2014 through 11/15/2015 in accordance with 45 CFR 46.110 #4. Please note the expiration date for approval of this project is 11/15/2015. If additional time is needed to complete the project, you will need to submit a Continuing Review Request form 30 days prior to the date of expiration. Any modifications made to this project must be submitted for approval prior to implementation. Forms for both Continuing Review and Modifications are located on our website at http://www.orc.msstate.edu/humansubjects/forms/.

Any failure to adhere to the approved protocol could result in suspension or termination of your project. Pl! ease note that the HRPP reserves the right, at anytime, to observe you and any associated researchers as they conduct the project and audit research records associated with this project.

Please note that the MSU HRPP accreditation for our human subjects protection program requires an approval stamp for consent forms. The approval stamp will assist in ensuring the HRPP approved version of the consent form is used in the actual conduct of research. Your stamped consent form will be attached in a separate email. **You must use the stamped consent form for obtaining consent from participants.**

Please refer to your study number (#14-363) when contacting our office regarding this project.

We wish you the very best of luck in your research and look forward to working with you again. If you have questions or concerns, please contact Nicole Morse at nmorse@orc.msstate.edu or call 662-325-5220. In addition, we would greatly appreciate your feedback on! the HRPP approval process. Please take a few minutes to complete our survey at http://www.surveymonkey.com/s/YZC7QQD.

Sincerely,

Nicole Morse, CIP
IRB Compliance Administrator

cc: Ben Wax (Advisor)

APPENDIX B

SCRIPT FOR RECRUITING PARTICIPANTS

Thank you for taking the time to come to this meeting to learn more about my study on warm-up protocols for 800-meter time trials for collegiate middle distance runners.

The purpose of my study is to identify an effective warm-up protocol to produce maximum performance in an 800-meter time trial for NCAA Division I middle distance runners.

I am inviting you to participate in my study because you are an MSU Track and Field athlete who competes in middle distance running events. I anticipate that 10 to 25 athletes will ultimately participate. Keep in mind that participation is completely voluntary.

If you participate in this study, you will be asked to complete a brief demographic survey, activity logs, and three different warm-up protocols. Testing will occur over a three-week period, with one testing day each week.

On the first testing day, you will be asked to complete a brief survey to report biological and competitive ages, race/ethnicity, height, weight, gender, and academic year/level.

On the first testing day, you will be asked to report your daily routine related to physical exertion and eating/diet during the 24 hours prior to each testing date. You will be asked to follow the same daily routine for the 24 hours prior to the next two testing dates. I will ask that you minimize your physical exertion during the 24 priors prior to each of the three testing dates.

Three warm-up protocols will be tested. All of the warm-up protocols will be utilized on each of the three testing dates. You will be randomly assigned into one of the three warm-up protocol groups, ensuring that you have participated in all three of the warm-up protocols by the end of the three-week testing period.

The first warm-up protocol will involve a 10-minute jog followed by a series of dynamic stretching exercises for 8-10 minutes. These stretches will be followed by four 40- to 60-meter bounding/striding runs and will end with a 15-minute resting period prior to an 800-meter time trial.

The second warm-up protocol will also involve a 10-minute jog followed by the same series of dynamic stretching exercises for 8-10 minutes, and a 40- to 60-meter bounding/striding run. This will be followed by four acceleration sprints ranging from 40- to 80-meters in length, a 2-minute rest, and then a 100-meter sprint at race pace (the fourth of the four acceleration sprints). This warm-up will also end with a 15-minute resting period.

The third warm-up protocol (high intensity) involved a 10-minute jog followed by the same series of dynamic stretching exercises for 8-10 minutes. This will be followed by a 40- to 60-meter bounding/striding run and then three sprints: one 100-meter, one

200-meter, and one 300-meter run, each at race pace. Each of these sprints will be followed by a 1- to 3-minute walking/jogging recovery and end with a 15-minute resting period.

Potential risks associated with this study include muscle pulls, strains, sprains; fainting; breathing difficulties; bumps, scrapes, or bruises; or other risks that could typically result from physical exertion; and embarrassment if your activities and performance are not achieved as you had anticipated.

To control for physical risks, at least one athletic trainer will be present during all testing procedures that can intervene if needed. Remember that your participation is voluntary, and you can end your participation in the study at any point without consequences.

Potential benefits from this study include identifying the type of warm-up intensity and volume that would best prime an athlete for peak performance, helping reduce/prevent injury, increasing confidence in your personal skills and abilities, and increasing your sense of achievement.

No incentives will be provided for your participation.

I will keep your information confidential. The signed consent form will include your name, but all other physical documents and electronic files will contain your assigned ID number only.

Do you have any questions? [respond to questions]

[hand out consent forms]

Here is a copy of the consent form if you may be interested in participating in this study. Please take the consent form with you and read through it carefully. We will meet again (date / time / location) to answer any questions that come up after you have read through the form. I will also collect signed consent forms at that time.

Thanks again for your time.

APPENDIX C

DIET AND PHYSICAL ACTIVITY LOG

Diet and Physical Activity Log

ID Number: ____________________

Please answer the following questions for activities in which you participated during the **previous 24 hours.**

1. How much time did you spend walking or biking for **at least 10 minutes continuously** to get to and from places?

______ hours ______ minutes

2. How much time did you spend doing moderate-intensity sports, fitness, or recreational activities that cause a **small increase** in breathing or heart rate such as brisk walking, bicycling, swimming, or golf for **at least 10 minutes continuously**?

______ hours ______ minutes

List the activities:

3. How much time did you spend doing **vigorous**-intensity sports, fitness, or recreational activities that cause **large increases** in breathing or heart rate like running or basketball for **at least 10 minutes continuously**?

______ hours ______ minutes

List the activities:

4. How much time did you spend playing **active** video games such as Wii Sports, Wii Fit, Xbox 360, Xbox Kinect, Playstation 3, or Dance, Dance Revolution?

______ hours ______ minutes

5. How much time did you spend in paid or unpaid work, household chores, and yard work that involved **moderate**-intensity activity that causes **small increases** in breathing or heart rate such as brisk walking or carrying light loads for **at least 10 minutes continuously?**

______ hours ______ minutes

List the activities:

6. How much time did you spend in paid or unpaid work, household chores, and yard work that involved **vigorous**-intensity activity that causes **large increases** in breathing or heart rate like carrying or lifting heavy loads, digging or construction work for **at least 10 minutes continuously**?

______ hours ______ minutes

List the activities:

Please answer the following questions about your dietary behaviors during the **previous 24 hours.**

7. What and how much did you eat and drink for breakfast (e.g., 3 eggs, 2 pieces of toast, 4 strips of bacon, 8 ounces of orange juice, 8 ounces of milk)?

8. What and how much did you eat and drink for a morning snack?

9. What and how much did you eat and drink for lunch?

10. What and how much did you eat and drink for an afternoon snack?

11. What and how much did you eat and drink for supper?

12. What and how much did you eat and drink for an evening snack?

13. Please list any other items you ate or drank that are not listed above (what and how much):

*Physical activity items modified from the National Health and Nutrition Examination Survey (NHANES)

APPENDIX D

DEMOGRAPHIC SURVEY

Demographic Survey

ID Number: ________________________

1. What is your biological age? _______________
2. What is your competitive age? _______________
3. What is your gender?

   ______ Male

   ______ Female

4. What is your ethnicity?

   ______ Hispanic or Latino

   ______ Not Hispanic or Latino

5. How do you describe yourself? Select one or more.

   ______ American Indian or Alaska Native

   ______ Asian

   ______ Black or African American

   ______ Native Hawaiian or Other Pacific Islander

   ______ White

6. What is your height? ______ feet _______ inches
7. What is your weight? _______ pounds
8. What is your academic year/level?

   ______ Freshman

   ______ Sophomore

   ______ Junior

   ______ Senior

   ______ Graduate Student

APPENDIX E

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

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

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

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

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

If you answered

YES to one or more questions

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

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

NO to all questions

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

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

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

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

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

NAME ______________________

SIGNATURE ______________________ DATE ______________________

SIGNATURE OF PARENT ______________________ WITNESS ______________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

...continued from other side

PAR-Q & YOU

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

Canada's Physical Activity Guide to Healthy Active Living

Physical activity improves health.

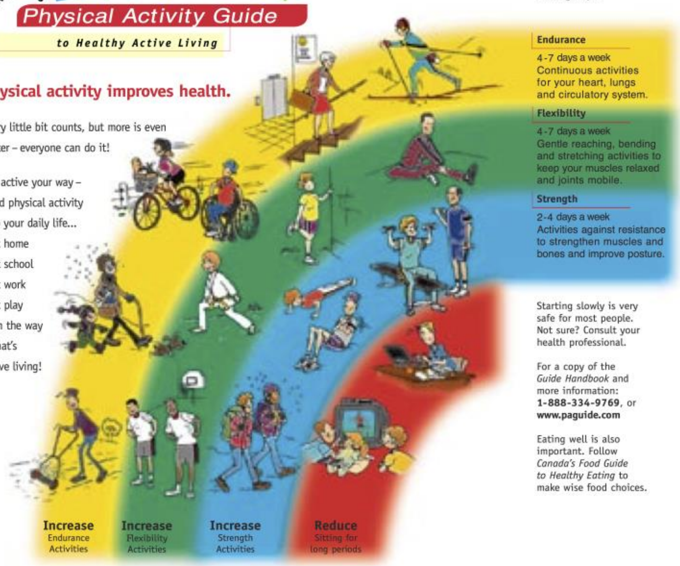
Every little bit counts, but more is even better – everyone can do it!

Get active your way – build physical activity into your daily life...

- at home
- at school
- at work
- at play
- on the way

...that's active living!

Choose a variety of activities from these three groups:



Starting slowly is very safe for most people. Not sure? Consult your health professional.

For a copy of the *Guide Handbook* and more information: **1-888-334-9769**, or **www.paguide.com**

Eating well is also important. Follow *Canada's Food Guide to Healthy Eating* to make wise food choices.

Get Active Your Way, Every Day—For Life!

Scientists say accumulate 60 minutes of physical activity every day to stay healthy or improve your health. As you progress to moderate activities you can cut down to 30 minutes, 4 days a week. Add-up your activities in periods of at least 10 minutes each. Start slowly... and build up.

Time needed depends on effort

Very Light Effort	Light Effort *60 minutes*	Moderate Effort *30-60 minutes*	Vigorous Effort *20-30 minutes*	Maximum Effort
• Strolling • Dusting	• Light walking • Volleyball • Easy gardening • Stretching	• Brisk walking • Biking • Raking leaves • Swimming • Dancing • Water aerobics	• Aerobics • Jogging • Hockey • Basketball • Fast swimming • Fast dancing	• Sprinting • Racing

Range needed to stay healthy

You Can Do It – Getting started is easier than you think

Physical activity doesn t have to be very hard. Build physical activities into your daily routine.

- Walk whenever you can – get off the bus early, use the stairs instead of the elevator.
- Reduce inactivity for long periods, like watching TV.
- Get up from the couch and stretch and bend for a few minutes every hour.
- Play actively with your kids.
- Choose to walk, wheel or cycle for short trips.
- Start with a 10 minute walk – gradually increase the time.
- Find out about walking and cycling paths nearby and use them.
- Observe a physical activity class to see if you want to try it.
- Try one class to start – you don t have to make a long-term commitment.
- Do the activities you are doing now, more often.

Benefits of regular activity:	Health risks of inactivity:
• better health • improved fitness • better posture and balance • better self-esteem • weight control • stronger muscles and bones • feeling more energetic • relaxation and reduced stress • continued independent living in later life	• premature death • heart disease • obesity • high blood pressure • adult-onset diabetes • osteoporosis • stroke • depression • colon cancer

Health Canada Sante Canada

Canadian Society for Exercise Physiology

Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf

FITNESS AND HEALTH PROFESSIONALS MAY BE INTERESTED IN THE INFORMATION BELOW:

The following companion forms are available for doctors' use by contacting the Canadian Society for Exercise Physiology (address below):

The **Physical Activity Readiness Medical Examination (PARmed-X)** – to be used by doctors with people who answer YES to one or more questions on the PAR-Q.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy)** – to be used by doctors with pregnant patients who wish to become more active.

References:

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Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy, In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health**. Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). **Can. J. Spt. Sci.** 17:4 338-345.

For more information, please contact the:

Canadian Society for Exercise Physiology
202-185 Somerset Street West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565
Online: www.csep.ca

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Questionnaire sur l'aptitude à l'activité physique - Q-AAP (revisé 2002)».

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