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The effect of duration of foam rolling on muscle recovery

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The Effect of Duration of Foam Rolling on Muscle Recovery

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A thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

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Table of Contents

Acknowledgment.....	ii
Table of Contents.....	iii
List of Tables.....	iv
Abstract.....	v
I. Introduction.....	1
Background	
Significance	
Aims and Hypotheses	
II. Methodology.....	9
Subjects	
Experimental Design	
Controlled Variables	
Statistical Analysis	
III. Manuscript.....	13
Introduction	
Methodology	
Results	
Discussion	
IV. Appendices.....	33
References.....	47

List of Tables

Table 1. Descriptive Data.....	29
Table 2. Perceived muscle soreness ($m \pm SD$) over time.....	30
Table 3. Peak torque to body weight ($m \pm SD$) over time.....	31
Table 4. Work fatigue and total work over time.....	32

ABSTRACT

PURPOSE: Foam rollers are commonly used by athletes, trainers, and therapists to accelerate muscle recovery. The current research suggests foam rolling (FR) may be beneficial in reducing muscle soreness. The objectives of this study were to determine the effect of foam rolling duration on muscle soreness and muscle function (isokinetic leg strength and muscle fatigability). **METHODS:** Sixteen males (age: 21.8 ± 2.5 yrs, height: 180.8 ± 8.3 cm, weight: 82.5 ± 9.6 kg) performed 10 sets of 10 reps at 60% 1-RM on a seated leg press machine to induce muscle soreness. For each participant, one leg received no foam rolling treatment; CON (n=16) while the other leg received either 3 minutes (n=8) or 9 minutes of foam rolling; FR (n=8). Changes in muscle soreness and muscle function were evaluated over four consecutive days. Three different 2-way ANOVA with repeated measures were used to determine treatment differences over time at a significance of $p < 0.05$. **RESULTS:** Perceived muscle soreness was lower with FR at 48 ($p = 0.000$) and 72 hours ($p = 0.001$) compared to control legs. There were no differences in soreness in short compared to long duration FR. Further, leg strength was not influenced by FR. **CONCLUSION:** The present data suggest that foam rolling may help attenuate perceived muscle soreness. In contrast to our hypothesis, there appears to be no difference between 3 and 9 total minutes of FR, and muscle function was not affected by either FR treatment. Three minutes of FR may be an effective way to reduce muscle soreness without losses in muscle function.

Chapter One

Introduction

The importance and benefits of exercise are well established. Exercise results in numerous physiological and psychological adaptations that inevitably decrease the risk of all-cause mortality (4). However, delayed-onset muscle soreness (DOMS) is a common outcome following exercise-induced muscle damage (EIMD) (24). DOMS refers to the sensation of muscle soreness and stiffness that is typically felt 24-72 hours post-exercise and which often results in restricted mobility (7). This can interfere with activities of daily living and hinder one's ability to continue performing physical activities. Foam rollers are a tool commonly used by athletes, trainers, and the general population to minimize DOMS and accelerate recovery. The principle behind foam rolling (FR), a common form of self-myofascial release (SMR), is based on myofascial release (MFR) therapy.

MFR and SMR are both techniques aimed to restore myofascia length and pliability (1). Myofascia is a web of connective tissue made of collagen that maintains support and stability to the surrounding muscles and bones. Injury to the myofascia leads to shortening and hardening which results in reduced functional capacity and restricted movement. It is theorized that 90-120 seconds of gentle pressure to the injured myofascia can lead to physiological length changes helping restore the myofascia to its original condition (1). Thus, the principle behind myofascial release is to return the myofascia to its tough but pliable state. FR is one of several ways to accomplish this restoration of the myofascia.

While mechanistically comparable to conventional massage interventions, foam rolling has many advantages versus traditional methods in terms of feasibility, versatility, and

affordability. Foam rolling can be performed without outside assistance from a practitioner and foam rolling devices are inexpensive in comparison. Foam rollers can easily be purchased online and are frequently accessible at local gyms. Furthermore, foam rollers come in a variety of shapes, sizes, and densities allowing them to serve different purposes. Using a foam roller prior to exercise has been shown to improve joint range of motion (ROM) while also showing no evidence of reduced force output (19).

Mechanisms of Delayed-Onset Muscle Soreness

The exact mechanism of delayed onset muscle soreness is not completely understood although there have been a number of theories proposed. The muscle damage theory suggests DOMS is a result of microtears in the muscle (14). Creatine kinase (CK) is an enzyme found exclusively in skeletal and cardiac muscle and is used as an indicator muscle damage (8). However, CK levels cannot fully explain DOMS because there is a time-course difference between peak soreness and peak CK serum levels, whereby peak soreness occurs before CK serum levels peak. (7). Similarly, the inflammation theory asserts that the muscle damage marker CK attracts monocytes and that neutrophils begin to surround the injured site. The monocytes eventually modify into macrophages and this environment stimulates the production of prostaglandin (PGE₂) which make Type III and Type IV nerve endings more sensitive to thermal and mechanical stimulation (7). The enzyme efflux theory, instead, advocates that damage to the sarcolemma inhibits ATP regeneration which prevents calcium from being stored in the sarcoplasmic reticulum (11). This accumulation of calcium activates protease enzymes which weaken the z-line of the sarcomere (7). Researchers seem to agree that a single theory cannot fully explain the mechanism for

DOMS (7), and that is more likely that DOMS results from various aspects of different theories (28).

Myofascial Release and Delayed-Onset Muscle Soreness

Massage is a common recovery treatment for many athletes. Although its effectiveness is still debatable, several studies have shown massaging to significantly reduce muscle soreness following EIMD. Zainuddin et al., found that 10 minutes of massage 3 hours after eccentric exercise significantly reduced muscle soreness and swelling (32). It was noted that plasma creatine kinase (CK) activity, a marker of muscle damage, was blunted in the massage condition compared to the control condition. The authors explained that this could be a result of increased clearance of CK from the damaged muscle to the circulation due to increased blood flow. Smith et al. also found similar results in a related study (29). Plasma CK, cortisol, neutrophil count, and DOMS were assessed in 14 untrained males. Half the subjects were randomly assigned to a control group while the other half were assigned to a massage treatment group. The control group received no massage intervention whereas the treatment group received a 30-minute massage 2 hours following exercise. Perceived muscle soreness was significantly lower in the massage group at all time post-baseline intervention timepoints. Neutrophil count was 15% above baseline after 24 hours in the massage group subjects whereas it was only 4% above baseline for the control group. It was speculated that this was due to massage interfering with migration of neutrophil to the tissue resulting in higher neutrophil levels in circulation in the massage group. Plasma CK levels were predictably increased following exercise; however, CK levels in the massage treatment group were attenuated at every measurement period compared to the control group. This outcome was expected because of the neutrophil-CK relationship

proposed by Cannon et al., who noted that higher neutrophil counts in the tissue, and the resulting decrease in blood circulation, resulted in higher CK levels in the tissue (5). Smith et al. also showed an augmented post-exercise cortisol level in the massage group (29). As a glucocorticoid, cortisol is believed to exhibit anti-inflammatory effects by inhibiting the transcription of pro-inflammatory cytokines and increasing synthesis of anti-inflammatory proteins (2). Thus, the massage group may have had reduced muscle soreness due to elevated levels of cortisol.

Similarly, Mancinelli investigated the effects of massage on DOMS and physical performance among 22 female basketball and volleyball collegiate athletes. Baseline measurements included vertical jump displacement, shuttle run time, quadriceps femoris length, and pressure-pain threshold (PPT). DOMS was through intense strength training and drills for their respective sport on the first day of pre-season training. The researchers reported reduced perceived soreness in female collegiate athletes in a massage group compared to a control (rested) group (21). However, no mechanisms for the response were hypothesized. Although there is no definitive mechanism by which muscle soreness is blunted in the aforementioned studies, it is speculated that some combination of biochemical changes may play a role in the reduction of pain.

Self-Myofascial Release and Delayed-Onset Muscle Soreness

While research on the effects of massage on DOMS is a bit more substantial, there is some nascent research on foam rolling. Of the limited studies evaluating the effects of foam rolling on DOMS, all of them observed a significant reduction in perceived soreness following EIMD versus control trials. MacDonald et al. completed a study on 20 resistance-

trained males whereby EIMD, and consequently DOMS, was caused by subjects performing 10 sets of 10 repetitions of squats at 60% of the subject's one repetition maximum (1RM) (18). Subjects were divided into two groups – a control group and foam rolling group. Measurements were taken at several different time points – pre-test, immediately post-exercise, 24, 48, and 72 hours post-test. During each post-test session, perceived soreness was evaluated via the BS-11 Numerical Rating Scale (NRS) which ranged from 0 to 10. A rating of zero was considered no muscle soreness whereas a rating of 10 signified an extreme muscle soreness. Subjects in the foam rolling group performed SMR via foam roller whereas the control group did not. The foam rolling group performed 5 foam rolling exercises focusing on anterior, posterior, lateral, medial, and gluteal muscles with each exercise consisting of 2 sets of 60 seconds. This was repeated on both legs for a total of 20 minutes. Their results demonstrated peak soreness occurred 24 hours post-test for the intervention group and 48-hours post-test for the control group. They also noted a significant reduction in perceived soreness at each time point in the foam rolling group. They concluded that the improved recovery rate of the foam rolling group suggest foam rolling benefits for muscle recovery following EIMD.

A similar study was performed by Pearcey et al. in which 8 male subjects performed 10 sets of 10 repetitions at 60% of 1RM (25). After EIMD was induced, a total 20 minutes of foam rolling of the anterior, posterior, lateral, medial, and gluteal muscles ensued. Measurements were taken immediately pre-test and 0 hours, 24 hours, 48 hours, and 72 hours post-test. A major difference between this study and the previous study was this study used a within subjects design – subjects served as both a control and experimental group. The authors observed a substantial reduction in pressure-pain threshold for each

24-hour period after foam rolling was performed. There was a larger effect on PPT at 48 hours compared to a moderate effect at 24 hours.

Jay et al. (15) focused solely on the hamstring muscle using a massager roller instead of a foam roller. Delayed onset muscle soreness was induced in the hamstrings of 22 untrained men through 10 sets of 10 repetitions of stiff-legged deadlifts. For the men in the massage group (n = 11), one leg was used as an intervention leg and the other was used as a control leg. Measurements of soreness and PPT were taken immediately, 10 minutes, 30 minutes and 60 minutes after treatment. Congruent with the previous studies, this study provided further evidence of reduced pain associated with DOMS. Interestingly, a potential cross-over effect was recognized as there was a significant reduction in muscle soreness in the non-massaged limb of the massage group compared to the controls.

Furthermore, no study has evaluated the specific interaction between foam rolling duration and DOMS or muscle recovery. FR duration has varied among the studies previously mentioned, ranging from 10 minutes (15) to approximately 1 minute per FR set (18, 19, 25). Therefore, the purpose of this study is to investigate the effect of foam rolling duration on delayed onset muscle soreness and leg strength recovery.

Significance

Foam rolling is a popular practice both pre- and post-workout by the general population and athletes. Limited research suggests foam rolling can aid in reducing muscle soreness. However, no research to date has considered duration of foam rolling and how it may affect muscle soreness and leg strength and fatigability recovery. Further investigation could also lead to better standardized recommendations for duration of foam rolling for athletes, the general population, and physical therapy patients alike.

Aims and Hypotheses:

Aim 1: To investigate the effect of foam rolling on muscle soreness.

Hypothesis 1: Muscle soreness will be reduced after foam rolling compared to no foam rolling.

Aim 2: To investigate the effect of foam rolling on leg strength recovery via measurement of peak torque to body weight differences compared to baseline.

Hypothesis 2: Leg strength differences will be reduced after foam rolling compared to no foam rolling.

Aim 3: To investigate the effect of foam rolling on fatigability via measurement of work fatigue differences compared to baseline.

Hypothesis 3: Fatigability will be reduced after foam rolling compared to no foam rolling.

Aim 4: To investigate the effect of duration of foam rolling on muscle soreness.

Hypothesis 4: There will be a greater reduction of muscle soreness following the longer duration of foam rolling compared to the shorter duration foam rolling and no foam rolling.

Aim 5: To investigate the effect of duration of foam rolling on leg strength recovery.

Hypothesis 5: There will be a greater reduction in leg strength difference following longer duration of foam rolling compared to shorter duration of foam rolling and no foam rolling.

Aim 6: To investigate the effect of duration of foam rolling on fatigability.

Hypothesis 6: There will be a greater reduction in fatigability difference following longer duration of foam rolling

Chapter Two

Methodology

Subjects

Twenty male participants ($n = 20$) will be recruited for this study. Ten of the participants will take part in the long duration foam rolling (FR) treatment and ten subjects will participate in the short duration foam rolling treatment. Subjects will be randomly allocated to treatment groups. The sample size was determined through power curve analysis (17) with power set at 0.8 and with an estimated effect size of 0.8. The participants will be recruited via convenience sampling. The subjects will consist of students attending James Madison University. To be selected for this study, participants must be over the age of 18. Participants will also be given an informed consent form which they will read and sign prior to any testing. Any participant with a history of major lower body injury (including major knee surgery) will be excluded from this study. Subjects will be randomly placed in the long duration FR treatment (9 minutes) or short duration FR treatment (3 minutes). These durations were determined based on the theory that 90-120 seconds of myofascial release can restore damaged myofascia to its normal state (1).

Experimental Design

This study will utilize a “leg-to-leg” model where one of the subjects’ legs will serve as the experimental limb and receive foam rolling treatment (either 3 minutes or 9 minutes) while the same subject’s other leg will serve as the control and receive no foam rolling treatment. To control for possible variations in recovery in the dominant and non-dominant legs, the treatment and control legs will be counterbalanced so that half the subjects will have their dominant leg serve as the control limb while the other half will

have their non-dominant leg serve as the control limb. Subjects will meet with investigators on 4 consecutive mornings (baseline and 24, 48, and 72 hours post-baseline). All testing procedures will take place in Godwin 209 and Godwin 218.

During the first meeting, the investigator will go through the written informed consent form and disclose appropriate information to the subject. Once completed, the subject will be assessed for baseline muscle soreness. Subjects will be asked to ascend and descend a flight of stairs while focusing on their left quadricep and then must indicate their perceived soreness after being shown a 100mm visual analog scale (VAS). A visual analog scale (VAS) is another tool used to measure muscle soreness. VAS typically range from 0 to 100, 0 being no pain at all, while 100 refers to the worst imaginable pain. Studies on the reliability of the VAS for measuring muscle soreness have shown very high reliability (3, 16). This procedure will be repeated while focusing on the right quadricep. Afterwards, subjects' baseline leg strength and fatigability will be evaluated on a System 4 Biodex machine (Biodex Medical Systems, Inc., Shirley, NY) by assessing peak torque per body weight (PT/BW) on each leg. Each leg will be assessed under an isokinetic strength and endurance protocol for knee extension and flexion. Subjects will begin with a warm-up trial period consisting of 10 submaximal repetitions of knee extension and flexion at 60 degrees per second. Then, subjects will complete strength tests which consists of 6 maximal repetitions of knee extension and flexion at 60 degrees per second. This is followed by a 20 second rest period. Then, subjects will be allowed to perform 10 submaximal trial repetitions at 180 degrees per second. Finally, subjects will complete the endurance protocol which consists of 12 maximal repetitions of knee extension and flexion at 180 degrees per second. Thereafter, the subject will be asked to perform a 1 repetition

maximum (1-RM) test on a Cybex VR-3 leg press machine (Cybex International, Medway, MA). Subjects will begin by warming-up with 10 seated leg presses at approximately 50% 1RM. Following the warm-up, the subject will perform the 1RM leg press test adhering to American College of Sports Medicine (ACSM) 1-RM testing protocols (23). After the 1-RM test, subjects will perform 10 sets of 10 repetitions at 60% 1-RM on the same Cybex machine. This exercise protocol has been shown to induce DOMS in prior studies. Subjects will be given 2 minutes of rest between sets. At the end of the first meeting, the investigator will explain the foam rolling protocol to the subject. Foam rolling will begin at the end of meeting two. Subjects will be given a food log to record all foods and drinks consumed on day 1. They will need to include: time of meal, brand of food/drink, amount of food/drink, and method of food preparation.

During the second meeting (24-hours post baseline), subjects will again be assessed for muscle soreness with a 100mm VAS in same manner as the first meeting. Leg strength and fatigability will be assessed once again using the same protocol as meeting one. Finally, subjects will begin the foam rolling protocol. The foam roller that will be used is a 6x18 inch high-density foam roller (Luxfit, Brookly, NY). Subjects will be asked to place their body weight onto the foam roller beginning at the proximal end of the thigh. They will then be asked to roll until they reach the distal end of the thigh at which point roll until they return to the starting position and repeat this sequence for the designated amount of time. The foam rolling exercise will target three regions of the thigh (medial, anterior, and lateral). The short duration FR legs will receive the foam rolling treatment for a total of 3 minutes (1 minute of foam rolling on each region) whereas long duration FR legs will

receive the foam rolling treatment for a total of 9 minutes (1 minute of foam rolling on each region followed by a 1-minute rest, performed a total of 3 times).

The third meeting will follow the same procedure as the second meeting. The final meeting will also be like meeting two and three, however, subjects will not foam roll.

The procedures will go through JMU's Institutional Review Board and must be approved prior to data collection.

Controlled Variables

The investigator will ask the subjects to refrain from using painkilling medication, receiving outside massage or any pain reducing modalities, and performing any additional exercise 48 hours prior to the first meeting and throughout the duration of the study to prevent any confounding muscle soreness. Furthermore, subjects will be asked to maintain and record their regular dietary habits throughout the study.

Statistical Analysis

A 2-way ANOVA (treatment vs time) with repeated measures (time) will be used to determine any interaction effects. Post-hoc tests will be performed when applicable using t-tests. Bonferroni correction will be applied to adjust for multiple comparisons. Paired sample t-tests will be used to compare means between control legs and FR legs. Independent t-tests will be used to compare the means of the short FR legs and long FR legs. Statistical analysis will be performed using the software package SPSS. For all analyses, statistical significance will be set at $p < .05$.

Chapter Three

Manuscript

The Effect of Foam Rolling Duration on Muscle Soreness and Muscle Function

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ABSTRACT

PURPOSE: Foam rollers are commonly used by athletes, trainers, and therapists to accelerate muscle recovery. The current research suggests foam rolling (FR) may be beneficial in reducing muscle soreness. The objectives of this study were to determine the effect of foam rolling duration on muscle soreness and muscle function (isokinetic leg strength and muscle fatigability). **METHODS:** Sixteen males (age: 21.8 ± 2.5 yrs, height: 180.8 ± 8.3 cm, weight: 82.5 ± 9.6 kg) performed 10 sets of 10 reps at 60% 1-RM on a seated leg press machine to induce muscle soreness. For each participant, one leg received no foam rolling treatment; CON (n=16) while the other leg received either 3 minutes (n=8) or 9 minutes of foam rolling; FR (n=8). Changes in muscle soreness and muscle function were evaluated over four consecutive days. Three different 2-way ANOVA with repeated measures were used to determine treatment differences over time at a significance of $p < 0.05$. **RESULTS:** Perceived muscle soreness was lower with FR at 48 ($p=0.000$) and 72 hours ($p=0.001$) compared to control legs. There were no differences in soreness in short compared to long duration FR. Further, leg strength was not influenced by FR. **CONCLUSION:** The present data suggest that foam rolling may help attenuate perceived muscle soreness. In contrast to our hypothesis, there appears to be no difference between 3 and 9 total minutes of FR, and muscle function was not affected by either FR treatment. Three minutes of FR may be an effective way to reduce muscle soreness without losses in muscle function.

INTRODUCTION

Delayed onset muscle soreness (DOMS) is a common result of exercise induced muscle damage (EIMD) (18, 24). Peak soreness usually occurs between 24 and 72 hours after exercise and muscle function is impaired for several days post exercise as a consequence of both muscle tenderness and muscle stiffness (7, 11, 25). Foam rolling (FR) is a form of self-myofascial release (SMR) believed to quicken recovery from DOMS and reduce perceived muscle soreness. It is based on myofascial release (MFR) which is aimed at restoring the myofascial, a web of connective tissue that surrounds muscle and bone, to its natural tough and pliable state. It has also been suggested that 90-120 seconds of MFR is enough to elicit changes to the myofascial (1).

Despite the popularity of foam rollers and its effect on muscle soreness, there are only a handful of studies that have investigated the effect of foam rolling and on DOMS (6, 18, 19, 25–27). These studies have found FR to reduce perceived muscle soreness. Impaired muscular function is detrimental to athletes and can be problematic for activities of daily living in clinical populations. Despite the lack of quantity of evidence, the limited findings suggest foam rolling may help avoid strength loss due to DOMS (20, 25). Massage, a form of MFR, is an effective technique to attenuate muscle soreness (13, 29, 32). Furthermore, a meta-analysis investigating the effect of massage on DOMS concluded that most, 8 out of 11, supported the notion that massage is helpful for attenuating muscle soreness (12).

The overall lack of evidence in this growing topic highlights the importance of this study attempting to investigate the effect of foam rolling duration on muscle soreness and muscle function. While FR does appear to reduce muscle soreness, it is still unknown whether FR duration influences the magnitude of this effect as FR durations used in prior studies have been varied. Thus, one of the primary aims of this study is to evaluate whether differing foam rolling durations can effect muscle soreness and muscle function (isokinetic leg strength and fatigability). Knowing the appropriate FR duration could help maximize the effectiveness of an athletes FR treatment.

METHODOLOGY

Subjects

Sixteen male participants (n = 16) from James Madison University, Virginia performed all experiments. Descriptive data are shown in *Table 1*. Participants were given an informed consent form which they read and signed prior to any testing. All procedures were approved by the James Madison Institutional Review Board.

Experimental Design

This study utilized a “leg-to-leg” model where one leg (n = 16) legs received either 3 minutes (n = 8) or 9 minutes (n = 8) of foam rolling (FR) while the other leg served as the control and received no foam rolling (CON) (n = 16). To control for possible variations in recovery in the dominant and non-dominant legs, the treatment and control legs were counterbalanced so that half the subjects had their dominant leg serve as the control limb while the other half had their non-dominant leg serve as the control limb. These durations were determined based on the theory that 90-120 seconds of myofascial release can restore damaged myofascia to its normal state (1). Subjects met with investigators on 4 consecutive mornings (baseline and 24, 48, and 72 hours post-baseline). During the first meeting, there was assessment for perceived muscle soreness and leg strength, 1-RM was determined, DOMS was induced, and a foam rolling tutorial was given. At the end of the first meeting, subjects were given a food log to record all foods and drinks consumed on day 1 including: time of meal, brand of food/drink, amount of food/drink, and method of food preparation. The second and third meeting was similar except for there was no 1-RM test, DOMS induction and the foam rolling tutorial was replaced with the actual FR

treatment of either 3 or 9 minutes. The final meeting consisted of an assessment of perceived muscle soreness and leg strength only.

Perceived muscle soreness

Perceived muscle soreness was assessed using a 100mm visual analog scale (VAS). Subjects were asked to ascend and descend a flight of stairs while focusing on their left quadricep and then indicated their perceived soreness using a VAS ranging from 0 to 100. Studies on the reliability of the VAS for measuring muscle soreness and pain have demonstrated high reliability (3, 16). This procedure was repeated with subjects now focused on their right quadricep.

Muscle function

Leg strength and fatigability were evaluated on a System 4 Biodex machine (Biodex Medical Systems, Inc., Shirley, NY) by assessing peak torque per body weight (PT/BW) and work fatigue of each leg, respectively. Work fatigue (%) is the percentage of the difference between the work done in the first 1/3 of the test and the work done in the last 1/3 of the test. Each leg was assessed with an isokinetic strength and endurance protocol for knee extension and flexion. Subjects began with a warm-up trial consisting of 10 submaximal repetitions of knee extension and flexion at 60 degrees per second. Subjects then completed strength tests consisting of 6 maximal repetitions of knee extension and flexion at 60 degrees per second. This was followed by a 20 second rest period. Then, subjects performed 10 submaximal trial repetitions at 180 degrees per second. Finally, subjects completed the endurance protocol consisting of 12 maximal repetitions of knee extension and flexion at 180 degrees per second.

1-RM

Subjects performed a 1 repetition maximum (1-RM) test on a Cybex VR-3 leg press machine (Cybex International, Medway, MA). Subject began by warming-up with 10 seated leg presses at approximately 50% 1RM. Following the warm-up, the subject performed the 1-RM leg press test adhering to all ACSM 1RM testing protocols (23). After the 1-RM test, subjects performed 10 sets of 10 repetitions with weight equivalent 60% 1-RM on the same Cybex machine. Subjects were given 2 minutes of rest between sets.

FR protocol

The foam roller used was a 6x18 inch high-density foam roller (Luxfit, Brooklyn, NY). Subjects placed their body weight onto the foam roller beginning at the proximal end of the thigh. They rolled until they reached the distal end of the thigh at which point they rolled again until they returned to the starting position. This sequence was repeated for the designated amount of time. The foam rolling exercise targeted three regions of the thigh (medial, anterior, and lateral). The short duration FR legs received the foam rolling treatment for a total of 3 minutes (1 minute of foam rolling on each region) whereas long duration FR legs received the foam rolling treatment for a total of 9 minutes (1 minute of foam rolling on each region followed by a 1-minute rest, performed a total of 3 times).

Statistical Analysis

Three separate 2-way ANOVAs (treatment vs time) with repeated measures were used to determine any main or interaction effects. First, a 2-way ANOVA (2x4) with

repeated measures was used to assess differences between the control and FR legs over time (baseline, 24, 48, and 72 hours). Then a 2-way ANOVA (2x2) with repeated measures was used to determine differences in change scores between control and FR legs over time (24 hours was used as the comparison time because it was the first time period after EIMD). Finally, a 2-way ANOVA (2x4) with repeated measures was used to assess differences between the short FR and long FR over time. Post-hoc tests were performed when applicable using t-tests. A Bonferroni correction was applied to adjust for multiple comparisons. Paired sample t-tests were used to compare means between control legs and FR legs. Independent t-tests were used to compare the means of the short FR legs and long FR legs. Statistical analysis was performed using SPSS. For all analyses, statistical significance was set at $p < 0.05$.

RESULTS

Muscle Soreness

In general, there was a similar increase in perceived muscle soreness in both the control and FR leg 24 hours following EIMD. The perceived muscle soreness scores over time are reported in *Table 2*. A main effect for both time ($p=0.000$) and treatment ($p=0.000$) as well as an interaction effect between treatment and time ($p=0.000$) was determined for control compared to FR treatment. A main effect for time ($p=0.000$) and interaction effect between treatment and time ($p=0.002$) was determined for when analyzing the change scores between control and FR legs. Only a main effect for time ($p=0.000$) was determined between short FR and long FR legs.

There was an increase at 48 hours and decrease at 72 hours when compared to 24 hours in the control legs. Only a decrease in muscle soreness at 72 hours compared to 24 hours was determined in the FR legs.

In terms of between leg differences, at both 48 hours ($p=0.000$) and 72 hours ($p=0.001$), perceived muscle soreness was lower in the FR legs compared to the control legs.

When comparing the change scores (using 24 hours as the baseline), perceived muscle soreness was greater at 48 hours ($p=0.003$) in the control legs ($8.9 \pm 12.2\text{mm}$) compared to the FR legs ($3.4 \pm 10.2\text{mm}$). However, there was a similar decrease in perceived muscle soreness at 72 hours ($p=0.077$) between the control legs ($-14.3 \pm 8.7\text{mm}$) and FR legs ($-16.9 \pm 8.4\text{mm}$).

Muscle Function

There were no differences within-limb or between-limb for leg strength as shown in *Table 3*. No interaction effect between treatment and time were reported ($p=0.305$)

All work fatigue and corresponding total work data can be seen in *Table 4*. There was no interaction effect between treatment and time reported ($p=0.517$). Among the FR legs, work fatigue was lower at 72 hours than at 24 hours. Work fatigue was higher at 24 hours in the long FR legs compared to the short FR legs. No other differences were reported.

DISCUSSION

The purpose of this study was to investigate the effect of duration of foam rolling on muscle soreness and muscle function. The main findings suggest that foam rolling initiated 24 hours after EIMD reduces perceived muscle soreness compared to no foam rolling. Furthermore, longer foam rolling duration had the same effect on perceived muscle soreness than did the shorter foam rolling duration. Regarding muscle function, foam rolling had no effect on leg strength (as measured by peak torque per body weight) or work fatigue when compared to no foam rolling.

Most prior research on foam rolling and DOMS suggests foam rolling may help reduce muscle soreness compared to no foam rolling (18, 19, 25, 26) and this current study supports those findings. It is important to note that, although the general findings are similar, there are minor differences in findings. Macdonald *et al.* (18) reported peak soreness occurring at 24 hours in FR condition and 48 hours in the control condition

whereas this study reports peak soreness occurring at 48 hours in both FR and control legs. Perhaps this difference can be explained by the timing of treatment initiation. In the Macdonald *et al.* study, FR was started immediately following EIMD, suggesting FR was used as a preventative measure against muscle soreness. The current study used FR as a restorative measure, beginning FR 24 hours after EIMD. A study conducted by Pearcey *et al.* (25) differed slightly in the way they measured muscle soreness, opting instead to use an algometer to measure pressure-pain threshold (or the minimum amount of pressure to elicit pain).

To our knowledge, this is the first study to examine differences in foam rolling duration on muscle soreness. There were no differences in perceived muscle soreness between the short duration FR and long duration FR. Barnes suggested that 90-120 seconds is enough to elicit restorative property changes in the fascia surrounding the muscles allowing it to return to its normal state (1). For this reason, our initial hypothesis was that longer duration of FR (180 seconds per region of thigh) would result in greater reduction of muscle soreness compared to short duration FR (60 seconds per region of the thigh). There are a couple possible explanations for this outcome. First, the long FR duration was not long enough to exhibit noticeable change between groups. Or perhaps, the short duration was enough to maximize benefits.

It has been previously reported that symptoms of DOMS typically result in strength loss (9, 10). However, our finding that foam rolling has no effect on muscle strength compared to no foam rolling is not novel (19, 30, 31). A possible explanation for this finding is the repeated bout effect (22). The repeated bout effect suggests a single bout of

exercise can protect the muscle from damage from subsequent bouts of exercise. Since all but one participant were regular lifters the effect of DOMS was likely to be reduced.

To our knowledge, no other study has evaluated the effect of duration of foam rolling on isokinetic leg strength. Our findings suggest that short duration FR (at least 1 minute per region of the thigh) is sufficient enough to reduce DOMS.

Due to the nature of the study, one major limitation is subject bias. It is difficult, if not impossible, to be blind to receiving the foam rolling treatment. Thus, a placebo effect may have influenced the findings.

In conclusion, foam rolling helps reduce perceived muscle soreness compared to no foam rolling and there are no differences between FR durations. FR also does not appear to affect isokinetic leg strength or work fatigue. This overall finding can be explained by the principle behind foam rolling, myofascial release. MFR, as previously explained, is a technique used to return the myofascial to its natural state after it has been damaged. If foam rolling influences changes in connective tissue rather than muscle. This would explain why there can be a reduction in DOMS but no change in muscle function. Future research should consider when foam rolling is initiated: either prior to or post EIMD. Furthermore, some consideration should be made toward the cadence of foam rolling, foam rolling angle, time, pressure applied, and foam roller density as these could influence results.

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Table 1. Descriptive data

	Age (years)	Height (cm)	Weight (kg)
Short FR (n=8)	20.8 ± 1.6	183.5 ± 7.1	84.2 ± 11.1
Long FR (n=8)	22.8 ± 3.0	178.1 ± 9.9	80.8 ± 8.8

Descriptive data reported as means ± SD.

Table 2. Perceived muscle soreness (m ± SD) over time

	Perceived Muscle Soreness (mm)			
	Baseline	24 hours	48 hours	72 hours
Control Leg	4.0 ± 5.3 [†]	28.9 ± 11.6	37.9 ± 18.1 [†]	14.6 ± 9.8 [†]
FR Leg	4.3 ± 5.8 [†]	27.4 ± 11.9	30.8 ± 15.7 [*]	10.5 ± 9.5 ^{*†}
Short FR Leg	1.9 ± 2.6 [†]	28.3 ± 13.9	31.8 ± 18.1	14.3 ± 10.8 [†]
Long FR Leg	6.8 ± 7.2 [†]	26.5 ± 10.5	29.8 ± 14.2	6.8 ± 6.7 [†]

Shaded area signifies data recorded after foam rolling (FR) started.

* significance at $p < 0.05$ between control and FR legs, [†] significance at $p < 0.05$ compared to 24 hours

Table 3 Peak torque to body weight (m ± SD) over time

	Peak torque to body weight (%)			
	Baseline	24 hours	48 hours	72 hours
Control Leg	264.77 ± 39.64	265.94 ± 36.77	247.25 ± 45.41	260.02 ± 32.29
FR Leg	276.21 ± 37.56	259.72 ± 45.21	246.5 ± 37.2	272.16 ± 37.89
Short FR Leg	268.48 ± 36.86	260.63 ± 37.79	233.25 ± 40.95	259.86 ± 37.99
Long FR Leg	283.48 ± 39.09	258.81 ± 54.31	259.75 ± 29.77	284.45 ± 35.89

Shaded area reflects data recorded after FR started.

Table 4 Work fatigue and total work over time

	Work Fatigue (%) and Total Work (J)							
	Baseline		24 hours		48 hours		72 hours	
	Work Fatigue	Total Work	Work Fatigue	Total Work	Work Fatigue	Total Work	Work Fatigue	Total Work
Control Leg	18.94 ± 8.63	1685.58 ± 436.99	21.84 ± 11.08	1735.22 ± 523.21	21.42 ± 10.53	1636.01 ± 584.48	15.36 ± 9.87	1747.22 ± 498.78
FR Leg	20.41 ± 9.94	1737.52 ± 446.50	22.22 ± 10.47	1802.3 ± 470.21	21.28 ± 10.66	1724.51 ± 448.39	13.24 ± 11.98 [†]	1785.42 ± 369.78
Short FR Leg	17.25 ± 6.4	1426.53 ± 318.68	17.13 ± 8.58	1631.38 ± 458.69	21.35 ± 9.02	1681.88 ± 546.61	9.36 ± 9.48	1663.18 ± 360.53
Long FR Leg	23.56 ± 12.17	1986.32 ± 385.3108	27.31 ± 10.1*	1939.04 ± 481.46	21.2 ± 12.73	1758.62 ± 368.23	17.13 ± 13.53	1883.22 ± 386.11

Shaded area reflects data recorded after FR started

* significance at $p < 0.05$ between control and FR legs, [†] significance at $p < 0.05$ compared to 24 hours

Appendix A

Consent to Participate in Research

Identification of Investigators & Purpose of Study

You are being asked to participate in a research study conducted by Dr. David Wenos, Dr. Nick Luden, Dr. Mike Saunders, Dr. Chris Womack, and Vincent Lam Ting Luk from James Madison University. The purpose of this study is to examine the effects of foam rolling duration of muscle soreness and muscular fitness. This study will contribute to the researcher's completion of his Master's thesis.

Research Procedures

Should you decide to participate in this research study, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. This study consists of a series of leg strength tests and assessments that will be administered to individual participants in Godwin 218 and 209. You will be asked to report to both locations for 4 consecutive days. The initial meeting will last approximately 2 hours while the 3 remaining meetings will take approximately 1 hour each. Total time commitment will be approximately 5 hours.

Initial meeting: Day 1 – Approximately 2 hours

You will get a chance to read and review the consent forms. Thereafter, you will be asked to complete the following tasks:

1. Be evaluated for baseline muscle soreness. This will involve descending a flight of stairs and pointing to a scale that ranges from 0 to 100 to determine current muscle soreness
2. Perform muscular fitness test. This test will require you to perform maximal knee extension and flexion movements at a constant speed. It is used to evaluate muscle strength and endurance.
3. Perform 1-repetition maximum test. This is to evaluate the heaviest weight you can perform on a leg press machine for a single repetition. I will use this value to determine how much weight you will perform in the following task.
4. Perform 10x10 leg press protocol designed to induce muscle soreness. This study is designed to see the effects of foam rolling duration of muscle recovery. Therefore, it is necessary to induce muscle soreness and this task is meant to do so
5. Learn foam rolling procedure. This final task will be used to give you a chance to learn how to use a foam roller and get used to how I have designed the foam rolling procedure. It will also give you a chance to practice using a foam roller.

Meeting 2,3, and 4 – approximately 1 hour each

On day 2, you may be experiencing some muscle soreness. This is completely normal. The 3 remaining meetings will be the exact same. It will be comprised of the following tasks:

1. Assessment of muscle soreness. You will be required to descend a flight of stairs while pointing to a scale that ranges from 0 to 100 just as you do during the initial meeting.
2. You will again be performing the same muscular fitness test as you did yesterday.
3. Finally, you will be performing the foam rolling protocol you learn and practice during the initial meeting. Depending on the duration group you are assigned to, this will consist of either 1 minute per region of the thigh (3 minutes total) or 3 minutes per region of the thigh (9 minutes total).

Risks

The investigator perceives the following are possible risks arising from your involvement with this study

1. Muscle soreness: The study revolves around inducing muscle soreness in order to investigate whether foam roll duration may help reduce muscle soreness.
2. Muscle fatigue: The exercises used to induce muscle soreness may result in muscular fatigue.

Benefits

Potential benefits from participation in this study include:

1. A free assessment of one's 1-repetition max which is a reliable indicator for muscular strength.
2. The Biodex can provide subjects with important information regarding possible limb strength and endurance imbalances. This information can be used to tailor an exercise program that may reduce the imbalance and reduce risk of injury.

Confidentiality

The results of this research may be presented at conferences or in peer-reviewed journals. The results of this project will be coded in such a way that the respondent's identity will not be attached to the final form of this study. The researcher retains the right to use and publish non-identifiable data. While individual responses are confidential, aggregate data will be presented representing averages or generalizations about the responses as a whole. All data will be stored in a secure location accessible only to the researcher. Upon completion of the

study, all information that matches up individual respondents with their answers will be destroyed.

Participation & Withdrawal

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind.

Questions about the Study

If you have questions or concerns during the time of your participation in this study, or after its completion or you would like to receive a copy of the final aggregate results of this study, please contact Vincent Lam Ting Luk, lamtinvx@dukes.jmu.edu.

Questions about Your Rights as a Research Subject

Dr. David Cockley
 Chair, Institutional Review Board
 James Madison University
 (540) 568-2834
cocklede@jmu.edu

Giving of Consent

I have read this consent form and I understand what is being requested of me as a participant in this study. I freely consent to participate. I have been given satisfactory answers to my questions. The investigator provided me with a copy of this form. I certify that I am at least 18 years of age.

Name of Participant (Printed)

Name of Participant (Signed)

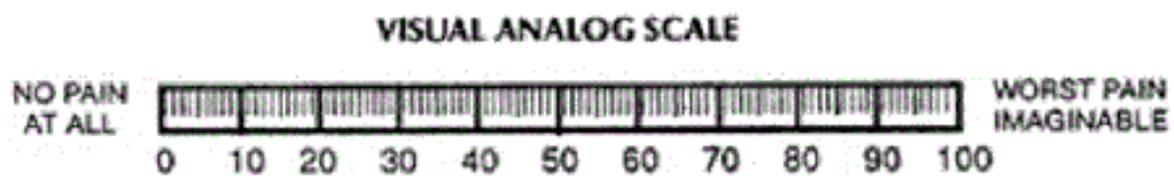
Date

Name of Researcher (Signed)

Date

Date

Appendix B



Appendix D

INSTRUCTIONS FOR KEEPING YOUR 24-HOUR FOOD RECORD

Keep your record for 1 day. You will include the day before meeting #2. Include all meals, snacks, nibbling, and beverages including water and cocktails

1. Fill out the date and day of the week at the top of food record sheet
2. Record the time you consumed your food and/or drink. To be most accurate, fill out the food record as soon as you finish eating.
3. List the first food and/or drink you consumed when you began your day and continue to record until you consume your last food and/or drink of your day (usually before bedtime)

4. List each food and/or drink on a separate line

Example: cereal with milk, cereal and milk should each be on separate lines

spaghetti, noodles, and sauce should each be on separate lines

Combination foods:

List parts of food on separate lines

Include preparation method, quantity, and brand name of each food

Example: Sandwich (4 oz healthy choice turkey, 2 slices Sara Lee wheat bread, 1 tbsp Hellman's light mayo, 2 oz Kraft American cheese, 1 slice of red fresh tomato)

5. Record the method of preparation

Example: fried, baked, grilled

salt, oil (olive, canola, corn, other) butter or margarine, spices, etc.

6. Record quantity consumed

Do not record any food not eaten

Example: made two cups of vegetables but ate half so you would record one

cup

Quantity of food and/or drink

Example: cups, ounces, liters, grams, each, or other unit of measure

Example: 1 cup of vegetables, 4 ounces of meat, one medium apple

7. Record brand name

Example: fast food chain name and/or package name

Example: Wendy's, Betty Crocker, Lean Cuisine, Gatorade, Thomas Bagel

8. Place any helpful food labels in manila envelope that is attached to folder

Appendix E

Helpful Hints with Portion Sizes

- 1 teaspoon (5 ml)
 - about the size of the top half / tip of your thumb
- 1oz (28g)
 - approximately inch cube of cheese
 - volume of four stacked dice
 - slice of cheese is about the size of a 3 1/2 inch computer disk
 - chunk of cheese is about as thick as 2 dominoes
 - 1 handful (palm) of nuts
- 2 ounces (57 g)
 - 1 small chicken leg or thigh
 - 1/2 cup of cottage cheese or tuna
- 3 ounces (85 g)
 - serving of meat is about the size of a deck of playing cards (3 exchanges)
 - the size of the palm of your hand
 - 1/2 of whole chicken breast
 - 1 medium pork chop
 - 1 small hamburger
 - unbreaded fish fillet
- 1/2 cup (118 ml)
 - fruit or vegetables can fit in the palm of your hand
 - about the volume of a tennis ball
- 1 cup (236 ml)
 - about the size of a woman's fist
 - breakfast cereal goes halfway up the side of a standard cereal bowl
 - broccoli is about the size of a light bulb
- 1 medium apple = A tennis ball

Appendix F

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?	o	o
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	o	o
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).	o	o
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE: _____	o	o
5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:	o	o
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:	o	o
7) Has your doctor ever said that you should only do medically supervised physical activity?	o	o

If you answered NO to all of the questions above, you are cleared for physical activity.

Go to Page 4 to 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.

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.

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Collaboration	1 / 4

01-01-2017

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c If NOO go to question 2

1a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NOO (Answer NO if you are not currently taking medications or other treatments)

1b. have joint problems causing Pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced a (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the YESO NOO back spinal column)?

1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months? YESO NOO

2.

Do you currently have Cancer of any kind?

2a. If the above condition(s) is/are present, answer questions 2a-2b If NO go to question 3

Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of YES O NOO plasma cells), head, and/or neck?

2b. Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)? YESO NOO

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm

If the above condition(s) is/are present, answer questions 3a-3d If NO go to question 4

3a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YESO NOO (Answer NO if you are not currently taking medications or other treatments)

3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction) YESO NOO

3c. Do you have chronic heart failure? YESO NOO

3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? YESO NOO

4. Do you have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b If NO go to question 5

4a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YESO NOO (Answer NO if you are not currently taking medications or other treatments)

4b

(Answer Do you have YES a if resting you do blood not know pressure your resting equal to blood or greater pressure) than 160/90 mmHg with or without medication? YESO NOO

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes

If the above condition(s) is/are present, answer questions 5a-5e If NO go to question 6

5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-**YES** **NOO** prescribed therapies?

5b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. YESO NOO

Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, OR the sensation in your toes and feet? YESO NOO

5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? YESO NOO

5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? YESO NOO



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Collaboration
2 / 4

01-01-2017

6. Do you have any Mental Health Problems or Learning Difficulties? This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome

If the above condition(s) is/are present, answer questions 6a-6b If NO go to question 7

6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YESO NOO

(Answer NO if you are not currently taking medications or other treatments)

6b. Do you have Down Syndrome AND back problems affecting nerves or muscles? YESO NOO

7. Do you have a Respiratory Disease? This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure

If the above condition(s) is/are present, answer questions 7a-7d If NO go to question 8

7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YESO NOO (Answer NO if you are not currently taking medications or other treatments)

-
- 7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require YESO NOO supplemental oxygen therapy?
-
- 7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough YESO NOO (more than 2 days/week), or have you used your rescue medication more than twice in the last week?
-
- 7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? YESO NOO
-
- Do you have a Spinal Cord Injury? This includes Tetraplegia and Paraplegia
8. If the above condition(s) is/are present, answer questions 8a-8c If NO go to question 9
- 8a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YESO NOO (Answer NO if you are not currently taking medications or other treatments)
-
- 8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, YESO NOO and/or fainting?
-
- 8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic YESO NOO Dysreflexia)?
-
9. Have you had a Stroke? This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event
- If the above condition(s) is/are present, answer questions 9a-9c If NO go to question 10
- 9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies?
- (Answer NO if you are not currently taking medications or other treatments) YESO NOO
-
- 9b. Do you have any impairment in walking or mobility? YESO NOO
-
- 9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? YESO NOO
-
10. Do you have any other medical condition not listed above or do you have two or more medical conditions? If you have other medical conditions, answer questions 10a-10c If NO read the Page 4 recommendations
- Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 YESO NOO months OR have you had a diagnosed concussion within the last 12 months?
-
- 10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? YESO NOO
-
- Do you currently live with two or more medical conditions? YESO NOO

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE:

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.



Collaboration 3 / 4

01-01-2017

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